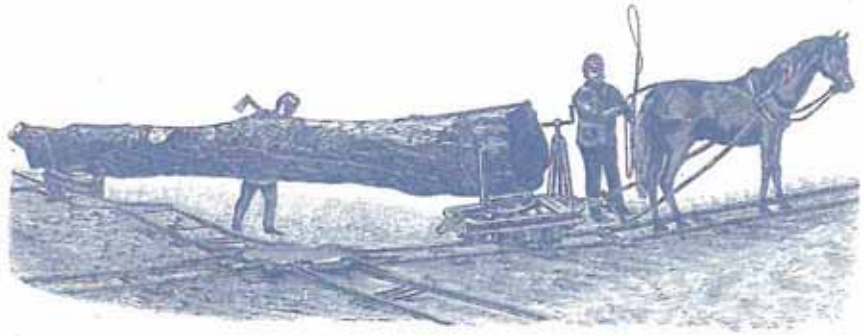
History of the International Ergonomics Association

IEA
International Ergonomics Association

History of the International Ergonomics Association : *The First Quarter of a Century*

Ilkka Kuorinka, Editor



The IEA Press
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Illustration on cover page: "A new direction", unknown artist, 19th century

Preface

This book presents historical perspectives highlighting the first 25 years in the life of the International Ergonomics Association (IEA), and the formative years of a new science, as recounted by individuals who played a key role during this period. Although the word "history" is derived from the Greek histories, meaning learning by inquiry, it strikes me as particularly appropriate to think of the word history as 'his story', ignoring the unintended gender bias. Students of history know that actual historical events are multifaceted and cannot be known completely or accurately. Consequently, our knowledge of the past derives from the accounts of eye witnesses or through analyses of scholars who infer the story from available evidence. However construed, an historical account is the product of human effort and invariably reflects the perspectives and interpretations of the individuals telling the story. Historical accounts are thus enriched by the author's elaboration of events and they tell as much about the story teller as they do about the story. The approach taken in developing this historical account of the IEA gives explicit recognition to this view of history. This text is thus more absorbing and perhaps more honest than a formal historiography of the IEA. The contributions to the text were provided by individuals who had a direct role in the organization of a community of ergonomists, in addition to their role in the evolution of the science. This historical work is thus a fascinating compilation of their stories, reflecting the aspirations and challenges of pioneers in an emerging discipline that was being devoted to improving the human condition through the scientific study of human-technology interactions and its application to design. This history is thus their story, their vision, their experiences, their contribution - it is a celebration of their achievements. It only suffers from the missing testimony of prominent early leaders who are no longer alive to share in this venture.

Although it started as an association of individuals, the IEA today is the federation of ergonomics and human factors societies around the world. Working closely with its constituent societies and related international organizations, its mission is to elaborate and advance ergonomics science and practice, and to expand its scope of application and contribution to society to improve the quality of life.

I have had the personal privilege to know many of the authors who contributed to this text. What has always fascinated me about them and other leaders of our field was that they came from highly diverse backgrounds and through a remarkable confluence of events and circumstances were brought together to share a common goal, to enhance the human enterprise through the science of human-system interactions. None were trained as ergonomists, yet they all shared a philosophy based on human-centred principles and they understood the power of systems theory. They all achieved illustrious and creative roles in the field of ergonomics; they all recognized the value of an international association in facilitating scientific dialogue and cooperation. The history of the IEA is inextricably intertwined with the history of ergonomics and it will no doubt be difficult for readers to disentangle the two. The chapters deal with the conditions that led to the establishment of a formal discipline and its initial period of development. We thus have in this book a rare glimpse into the founding of a science and a profession.

Of course, the formal discipline of ergonomics is rather young in comparison with less formalized approaches to work sciences, which probably predate civilized society. In its most rudimentary form, work science pertains to the design and use of tools to extend human capacity to survive and shape the physical environment. Although the use of tools has also been observed in certain species of animals, humans clearly excel in producing complex, elegant and very effective tools. The evolution of technology from simple implements to large-scale engineering systems corresponded to a shift from the human need to survive to a drive to prevail.

It is evident that work science was already developed thousands of years ago. How else could massive projects such as the pyramids of ancient Egypt

be organized and carried out (1). How else could enormous Roman aqueducts be built across the Middle East and Europe? It required sophisticated methods to plan, organize, train and manage labour. We know, of course, that worker safety and comfort were not paramount in the management style of those great builders. Indeed, much of the labour force comprised slaves who suffered unimaginable afflictions from their work as they did from their unsympathetic masters. In other parts of the ancient world, it is clear that ergonomics knowledge was relatively advanced. For example, archeological discoveries imputed to ancient Greece attests to the application of human-centred principles in design of temples, theatres, tools and household implements, and methods relating to construction and medicine (2). In 400 B.C.E., Hippocrates, the father of Western medicine, formulated a set of ergonomics guidelines for surgical work in a hospital. An excerpt of his writing illustrates that the workplace, the use of tools and posture were recognized as important factors affecting the surgeon's performance.

"One must also consider the surgeon's position in relation to the point of operation, that is whether he is close or far, at a higher or lower plane, to left right or at the center. The surgeon must be at such a distance that his elbows are behind his knees and in front of his torso. As for seating height, his hands must not be higher than his breasts, while at the same time his chest must not touch his knees and the arms must be at an angle of more than 90°. The same rule applies for the center. Movements to the left or to the right must not cause him to leave his seat. If, however, he needs to turn, the patient's body and the area of operation must be repositioned. As regards the tools, we will state how and when they should be used; they must be positioned in such a way as to not obstruct the surgeon, and also be within easy reach when required. They must be close to the surgeon's operating hand. If an assistant passes on the tools, he must be prepared to pass them as soon as they are asked for" (3).

The first appearance of the term ergonomics can be traced back to 1857, about one hundred years before the founding of the IEA, when Wojciech Jastrzebowski, the Polish naturalist wrote a treatise entitled "An outline of ergonomics, or the science of

work, based upon truths drawn from the Science of Nature". Although this treatise had little direct influence on the formation of the discipline or the creation of the IEA, it is significant in that this is the first known reference to the term ergonomics. It is also significant in that it indicates that people had been thinking about formalizing a branch of science devoted to work (defined by Jastrzebowski in the. widest possible sense) long before it actually came to pass.

The idea that things (tools, artifacts, dwellings, etc.) should be designed to support human activity is implicit. Prior to the industrial revolution, for example, things were built for individual users, often by the users themselves. Therefore, user needs and product specifications were not an issue. The user commissioned or built the item to suit his/her wishes. Craftsmen often created their own tools; weapons and armour were often built to suit the individual soldier.

The industrial revolution changed all that. Things were now mass produced for unknown users users who had different needs, were of variable size and had different preferences. The challenge was to design things that would be functional and/or appealing to a wide market. The industrial revolution also created the modern institution of labour - a large number of workers employed to produce these things under conditions established by their employers.

The first application of the scientific method to work can probably be attributed to Taylor who outlined what is widely known as MTM, methods time measurement, in the early years of the 20th century. His purpose, however, was to quantify work and to determine how productivity might be improved. Ergonomics as we know it emerged as a discipline during World War II when the human operator became increasingly the weakest link in modern sophisticated military systems. Human error was linked to human-machine incompatibilities inherent in design. After the war, the discipline continued to grow to meet the challenge of civilian applications. The emphasis in the early days was on human productivity, aviation psychology, and work physiology. As the discipline matured, other fundamental objectives were recognized, such as the provision for safer and healthier working environments and the improvement of the quality of working life. The conditions were ripe

for the expansion of a new branch of science, work science, that encompassed physical, physiological, psychological and social factors that affected workers and their work.

Ergonomics as a science has evolved considerably since its formative years not so long ago, alongside developments in technology. The first 25 years, however, are the cornerstone of the discipline, establishing both a foundation and a vision that continues to guide us to this day. This first volume in a series of historical works is devoted to this important period. It documents the political, scientific and social context of an era that began to experiment with international cooperation as a means to achieving greater prosperity and other societal benefits. By the end of the 20' century, that experiment has resulted in extensive globalization of the economy and universal, high speed access to information and communication through the Internet. Similarly, it has entrenched the IEA as the organization that promotes international cooperation in advancing the science and practice of ergonomics to enhance human quality of life.

I would like to express the gratitude of the IEA to Ilkka Kuorinka for having embraced the task of creating and editing this text. Dr. Kuorinka's reverence for history has guided the careful preparation of this book. We also wish to thank the authors who not only played a key role in the history of the IEA but have agreed to share with us their fascinating stories.

The IEA is proud to present this first volume of its history. It is testament to the success' of ergonomics science, the IEA and its federated societies that the scope of ergonomics applications is expanding at an accelerated rate to encompass virtually all aspects of human activity at work, at home and at play. We hope you derive much pleasure and inspiration from this book.

(1) Each pyramid had to be completed during the lifetime of the reining Pharaoh. When he died the Pharaoh was buried in the pyramid, whatever its state of completion, and work began anew for his successor.

(2) Marmaras, N., Poulakakis, G. and Papakostopoulos, V. (1999). Ergonomic design in ancient Greece. Applied Ergonomics, 30 (4), pp. 361-368

(3) Extracts from Hippocrates (460 - 370 BC) with ergonomic interest. Source document: About the hospital.

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Dr. Ian Noy is Chief of the Ergonomics Division at Transport Canada. He is also president of Systems Ergonomics, Inc., a consulting firm specializing in industrial and forensic ergonomics. He is a Board certified professional ergonomist (CPE) with over 25 years of professional experience in a variety of private and public sector applications. He holds a doctorate degree in Industrial Engineering from the University of Toronto, specializing in human factors.

His career began in 1973 as a behavioural scientist at the Canadian Defence and Civil Institute of Environmental Medicine (DCIEM) working on a variety of military manmachine systems. In 1982 he joined Transport Canada to undertake traffic safety research to support the development of vehicle safety standards and other interventions.

Dr. Noy's R&D experience covers a broad range of areas, including workplace evaluation, human-machine interface design and evaluation, human performance and training, and behavioural research. He has published over 100 scientific and technical reports, conference and journal articles. He has prepared and presented numerous lectures in human factors on a variety of topics, serves on the editorial board of scientific journals and has served as Director on the Board of Certification in Professional Ergonomics. His applied research experience spans applications in the air, on the ground, and underwater, including military R&D. He has recently edited a book entitled, The Ergonomics and Safety of Intelligent Driver Interfaces (Lawrence Erlbaum & Associates, 1997).

Dr. Noy currently holds the office of President of the International Ergonomics Association (IEA). He is a Fellow of the Human Factors and Ergonomics Society (HFES), a past president and Fellow of the

Association of Canadian Ergonon-tists/Association canadienne d'ergonomic (ACE), and a member of the Association of Professional Engineers of the Province of Ontario (PEO). He is also a member of the Transportation Research Board Committee on Simulation and the Measurement of Driving. Dr. Noy was the chairman of the 12th Congress of the IEA held in Toronto in 1994. In 1998, he was leader of the People to People Ambassador Programs' Ergonon-dcs Delegation to the People's Republic of China.

1 Founding of the International Ergonomics Association: A Great Narrative

Ilkka Kuorinka

Introduction

The history of the International Ergonomics Association has several points of interest. Two of them have been prime driving forces in the production of a first comprehensive historical document about the Association: first, an interest per se in an Association, which through its member societies, numbers tens of thousands of ergonomists worldwide and, second, the fact that the history of the Association reflects changes in the private, social and technological spheres of human work. During the International Ergonomics Society's nearly half a century of existence, human work has undergone profound changes, as have social and political conditions.

This historical work is not a formal or academic historiography of the International Ergonomics Association. The time for such a work has not yet arrived, although with the growing interest in the history of ergonomics and human factors, we believe that a complete historiography may not be very far off. The first national society, the Ergonomics (Research) Society, had its fiftieth anniversary last year; others will soon follow. Many of the societies have already produced historical reviews and recollections. Anniversaries and other memorable days will lead to the production and have already produced historical documents that increase our understanding of the past. New books have been published about the history of ergonomics. All these are witness to the new historical interest in ergonomics.

There is a dilemma in editing a history of an association: Will the document be a story about the organisation, its founding, be a report about important events and players, or should it be a narrative about the entire discipline and science? A report containing just facts about the history of an organisation would likely be dull, except when the said organisation has played a very important role in society. Writing a complete history about a discipline is not without problems, considering the heterogeneous nature of our discipline and the need to cover different cultures and countries.

Microhistory

"Microhistory" or "history from below" is a concept that to a certain extent applies to the structure of this book. The "microhistory" paradigm (Ginzburg, 1993) is not a recent invention, but seems to be receiving renewed attention in the wake of post-modern philosophy. Quantitative and deterministic historiographies did not satisfy everyone, and many turned back to stories, the "narrative" history. The historical material for a "micro historian" is not time series and statistics, but unusual and extraordinary examples that are supposed to reveal issues, ideas and mentalities that have passed through the macrohistorian's sieve.

About this book

The History of the IEA has not been written in the pure sense of microhistory, but contains elements close to that approach. However, a "macrohistorical" view of ergonomics and the IEA is in no way excluded. It may be that the future will show what type of approach yields results that best illustrate the advent of the IEA.

The IEA Executive Committee's recommendation has been that the main emphasis should be on the history of the association. From a historian's point of view, this decision simplifies the task but does not eliminate the problem that an association is not created in a non-contextual vacuum, which should be described. The solution has been to organise the content chronologically as much as possible, while making links to context and extra-ergonomic developments wherever necessary.

The emphasis is on the first quarter of a century from the 1950's on. Not all the articles' authors have chosen to limit themselves exactly to that period of time. This is both understandable and acceptable. For example, some of the articles describe events that have been maturating for a long time, coming to a climax only later. Artificial abridgment of such stories would reduce their interest. Some articles describe historical trends and characteristics of certain approaches that hold a special place in ergonomics, as for example "human factors" and "arbeitswissenschaft", which are not limited to a specific period.

The content of this historical work comes to a large extent from narratives and recollections of individuals who have been players in the IEA founding process or who later served in an outlook position within the association. It is only natural that a balance of views or representations has not been the goal. Many of the key persons who founded the IEA are no longer with us to tell their story, and as well, not all potential authors were available, considering the relatively tight production schedule.

That is why this work should be considered as the first volume—hopefully—in a series of works that would finally cover ergonomics as comprehensively as possible.

Context or paradigm of the IEA history: Is there one?

The title's question is partly academic. Scholars have a tendency to associate themselves—in spite of the attempt at objectivity—to a certain way of looking at the problem to be investigated. Historians are no exception. Although there is no definite paradigm nor context in this work, two background ideas have influenced the way the history of the IEA has been explored: the Industrial Revolution, and the "small history" context.

In retrospect, the various steps taken to found the International Ergonomics Association can be organised chronologically. This is traditional and pragmatic. As the various articles in this book show, the events, although in chronological order, did not in reality follow a progressive logic that we may recognize afterwards. Nor is there a complete consensus on the significance of each founding meeting. Furthermore, a question may arise whether there is a seamless continuity between the different phases of the IEA from the first ideas more than fifty years ago to the present IEA, covering an important part of the industrialised and developing world. For example, did the change in 1976 from a scientific society of individuals to a federated structure mean that after 1976, the IEA was no longer the same society as before that date? Whatever the view, a convention is that we speak of the same IEA from the start to today.

Short Chronology of the Founding of the IEA

1949 The Ergonomics Research Society, ERS, was founded in England. ERS was the first national (and supranational) ergonomics society. It had a major influence on various events in the founding process of the future IEA.

1953 The European Productivity Agency, EPA, started activities to implement human factors in productivity through the "Fitting the task to the worker" project. The aim of these activities was not the founding of the IEA, but they attracted individuals who came to play key roles in the founding process. A number of events synchronized the discussion and debate in the process.

1956 EPA fact-finding mission to the United States. Report by Hywell Murrel in 1958.

1957 EPA seminar in Leyden, Holland, which is considered as the meeting where actual decisions about exploring the feasibility of an international association were made.

1959 EPA conference in Zurich, Switzerland. Participation of various international organisations including employers' and workers' representatives. Debate on the name of the future international ergonomics body. Report by Bernard Metz in 1960.

1959 Meetings of the steering (preparatory) committee of the future International Ergonomics Association in Oxford, England, in conjunction with the ERS symposium. The steering committee decided on the founding of the International Ergonomics Association.

1961 First meeting of the International Ergonomics Association's General Assembly in conjunction with the first international conference on ergonomics held in Stockholm, Sweden. This meeting formally completed the preparatory phase of the association and started the regular activities of the IEA.

1976 A major organisational change took place: the IEA became the association of federated societies worldwide. It ended the period when the IEA was a society of individuals (the federation process started insidiously earlier, but was formally approved in 1976).

Founding of the IEA was not necessarily a straightforward process, but the result of much debate and energetic promotion of the idea. Many opinions had to be reconciled and de facto mutual interests demonstrated before Professor Etienne Grandjean, the corresponding secretary of the informal committee, could solemnly declare "the International Ergonomics Association is founded". This took place on Monday, April 6, 1959, at 6.50 p.m. in Oxford, England (Stansfield, 1979).

The informal steering committee consisted of H.S. Belding (USA), G.C.E. Burger (Holland), S. Forssman (Sweden), E. Grandjean (Switzerland), G. Lehman (Germany), B. Metz (France), K.U. Smith (USA), and R.G. Stansfield (UK).

The founding of the IEA was preceded by several meetings and initiatives on the part of various individuals. One group seems to have been scholars and members of academia, many of whom had served in the armed forces of their countries and had been working on solving human-related problems, as for example in the design of technical systems and organisations. Others seem to have found their inspiration during wartime and after the war industry. The productivity and social conditions of workers were important issues that shaped

ergonomics in the post-war economic, social and political situation.

One of the important players was the *European Productivity Agency, EPA*, a subdivision of the Organisation for European Economy and Co-operation, OEEC (OECD: anon., 1996). The EPA, founded in 1952, launched a project to introduce human factors into productivity: "Fitting the task to the worker". In the framework of this project, several meetings and other actions took place and in the preparation of the founding of the International Ergonomics Association.

The Second World War left many countries—on both the winning and losing sides—in bad shape in 1945. The devastated industrial, economic and social structures had to be reconstructed. The Organisation for European Co-operation (OEEC, predecessor of the OECD) was one of the players in European reconstruction, closely related to the so-called Marshall Plan. In 1952, the OEEC started a new body, the European Productivity Agency, EPA, which came to play an important role in the founding process of the IEA.

The efficiency of industrial production was a key concern in post-war reconstruction and rapid recovery. The essential task of the EPA was to improve productivity in industries. The reference point for productivity at that time was the United States, which largely financed the OEEC/EPA. Thus, it is quite natural that in the beginning, the central concern of ergonomics was industrial efficiency.

The EPA organised several meetings and a fact-finding mission to advance the application of human factors in post-war reconstruction. These meetings were consistent with the EPA's objectives and did not anticipate the founding of the IEA. But during these meetings and as a sort of spin-off, debates and contacts, and ideas about an international association, began to take shape.

Quite interestingly, the EPA had recognized relatively early in 1953 the importance of human factors. Mme Denise Lecoultre was one of the driving forces in the OEEC who decided in 1956 on a fact-finding mission to the USA. A group of nine people (H.S. Belding from the USA was the tenth) representing seven OEEC countries visited various companies, governement agencies and universities, meeting colleagues (by the way, the Human Factors Society was founded in 1957) in the United States in the fall of 1956. The results of this mission were discussed at two meetings, in 1957 in Leyden, Holland, and in 1959 in Zürich, Switzerland. It was at the seminar in Leyden that the decision to start the founding process for an international ergonomics body was formally taken. Professor K. U. Smith from the USA has been mentioned as one of those who strongly promoted the idea.

The mission has been described in more detail in other articles in this book.

The OEEC and the EPA were not the only actors that influenced the future of ergonomics. The European Coal and Steel Community, ECSC, seems to have played an important role, for example by financing various ergonomics projects.

The ERS and the IEA

The founding of the International Ergonomics Association is closely related to the earlier establishment of another international body, the Ergonomics Research Society, ERS (1949; from 1976 The Ergonomics Society) in the UK. The Ergonomics Research Society had, since its founding, attracted members not only from Great Britain, but also from many other countries and had become a truly international body. Already in 1954, the Ergonomics Society planned to have its annual meeting outside the U.K., in Dortmund, West Germany. Although these plans did not materialise, the contacts between the ERS and other European colleagues intensified. The ERS also developed close relations with the EPA, which further intensified its international contacts and activities.

Converging and mutual interests

In the nascent field of international ergonomics, there were two trends of different origins: the international dimension of the Ergonomics Research Society, and the EPA activities. These interests progressively converged, for instance because they shared the same people in different phases of the project, as for example R. G. Stansfield, H. Murrel, and others. In 1957 the ERS Council expressed the great international interest

in ergonomics and the importance of the EPA project on the European scene. After some debate, the ERS Council agreed that "The Society is willing to co-operate fully in developing and running any international body created to co-ordinate similar schemes" (Edholm and Murrel, 1973). This was an important decision because it allowed a coherent development of ergonomics on the international scene.

Preconditions to the advent of organised ergonomics

For organised ergonomics to be considered as interesting and important at the international level, necessary and sufficient conditions had to exist. Some of the conditions are by nature practical and organisational: there had to be sufficient awareness of the subject matter, and also a number of individuals that had the necessary skills and competence.

An interesting question is whether there was, in society, in scientific debate and at the level of ideas and values, something that promoted the interest of a number of key individuals in "human factors" (in the general sense). Were there conditions that had to be present, without which a sounding board for novel ideas and initiatives concerning human work could not exist?

Was the real advancement in ergonomics related to the Second World War?

It is customary to consider that organised ergonomics began after, and was a consequence of the wars, more specifically the Second World War. Although this view may be challenged with well-founded arguments, the claim has generally been accepted.
The first question that is raised is: Were the post WW II developments, the foundation of national societies and the IEA, for example, derivatives of some elements of war?

Concerning scientific innovations in general, opinions seem to vary. Some opinions are that the war truly created new ideas and innovations. Others feel that the military industry and research essentially exploited pre-war innovations without creating anything new. In any case, an important number of future ergonomists/human factors specialists started their careers

in wartime laboratories, design departments and also in the field.

The author has not found any convincing analysis or evidence about the role of war on the creation of ergonomics. Whether the war efforts catalyzed ergonomics must be considered a question needing further analysis. In an historical text, speculation about events that did not occur is not well received. Thus, it remains to the reader to reflect on the question whether ergonomics would have advanced without the war.

Considering the role that the European Productivity Agency played in the post-war era (see articles about the EPA period), we could also hypothesize that the industrial, economic and social conditions and reconstruction were more important factors than the war itself in the creation of ergonomics. If that hypothesis proves to be valid, war would in any case have had an indirect effect on ergonomics.

Operator versus worker. Was the beginning of the 20th century a turning point?

Historians interested in medieval societies point out that "individual" with its current meaning did not exist in earlier societies. A human being was part of the group, village or tribe and got his value as its member.

In military history, a group, a centurion, a phalanx etc. was the operational unit, not an individual soldier. The First World War may have been a turning point in this respect. Radios and telephones replaced the trumpets and flag signals used for guiding maneuvers. Trucks began to replace horses, and the first aircraft entered the battlefield. All this meant that an individual operator, truck driver, aircraft pilot, communications and other specialist was responsible for critical tasks. The value of a skilled individual increased.

A question arises: Could the reappraisal of an individual's value be one of the factors that promoted ergonomics?

The history of occupational diseases and accidents seems to indicate that before the 20th century, problems were dealt with at a non-individual level. Vauban, the well-known builder of fortifications at the end of

the 17th century, showed interest in the conditions of the work force at large. The aim was to maximize output while minimizing energy consumption (consequently, the need for food). The physiologists of the 19th century were interested in the movements and energy aspects of various groups of interest. The individual entered the picture only later.

F.W. Taylor (see Hendrick's article) was one of the work organisers who, at the beginning of the twentieth century, saw the importance of selecting and training an individual in contrast to considering workers as masses. Furthermore, human factor investigations during the Second World War concentrated on selecting "the right individual for the right place" and on redesigning the cockpits of various war machines to match the operator and the task. Thus, interest had turned towards the individual.

If the role of an individual (as contrasted to groups and masses) as a promoter of ergonomics is to be confirmed, many of the post Second World War ideas on ergonomics need to be reconsidered.

The Industrial Revolution

The Industrial Revolution as an historical issue seems to offer a natural backdrop for the analysis of the creation of ergonomics (Verle, 1997). New technology and new ways of work organisation modify human work and shape ergonomic issues. For example, the advent of information technology has been largely considered as a turning point for ergonomics and human factors. However, earlier discontinuities in technology also seem to have revolutionized human work, and by the domino effect, the potential need for ergonomics. Dembe (1996) has described in an interesting way the effects of technological breaks, such as the invention of railroads or telegraphy, on occupational problems.

A closer look at the history of the Industrial Revolution reveals, however, that it was a multifaceted phenomenon, and contrary to recent popular pamphlets (e.g. Rifkin and Heilbroner, 1996), not necessarily a uniform independent variable. Some historians even refuse to accept the relevance of such a concept. The reasons are many: technological changes also occurred earlier than during or after the "first industrial revolution" beginning in the 18th century. The use of horses, three times more efficient than cows and oxen, and the ploughing of fields with deep ploughs instead of with a fork was one revolutionary improvement in agricultural technology introduced late in the Middle Ages (Duby, 1962). Using paper instead of clayboards or parchment must have been a revolution comparable to the invention of computers. Paper was invented in China nearly two thousand years ago.

Another argument tending to relativise the concept of the Industrial Revolution is that the invention, development and exploitation of new technology have been inconsistent and isolated, with their effects varying from one situation to the next (Nef, 1943).

From the ergonomics standpoint, questions about the effects of the industrial revolution are worth asking but remain partly unanswered.

Protoergonomics

Monod (in this book) uses the term "protoergonomics" for the era when ergonomics with its current meaning did not exist, but where we can, however, identify scholars, practitioners and philosophers whose texts clearly contain elements that would today be called ergonomics.

Monod presents an interesting review of "protoergonomic" actors and trends from a French perspective. Most authors in this book touch on the same issue, adding the names of early actors and their ideas as seen from the authors' perspectives.

It seems necessary, however, to explore another issue related to "protoergonomics". The problem of protoergonomics (and "precursor" ergonomists) is not simply the question of who was first to use the term or concept of ergonomics. The Polish naturalist Jastrzebowski) used "ergonomia" in the mid 19th century to generally describe work science in the same terms found in ergonomics today. The general concept of "adapting the work to the man" might be traced back as far as Leonardo da Vinci, to the ancient Greeks (see Noy's article in this book) and even further.

Therefore, the question of "who was the first ergonomist?" is not terribly important. The interest is in the context in which the concept was invented and in the way it was used. Here Jastrzebowski's writings get a new dimension. He carried out his activities in the mid-nineteenth century during the period of "technooptimisme". Steam engines were the common source of mechanical energy, electricity made its appearance, and railways linked increasingly distant places. It seemed that technology made everything possible. Were Jastrzebovski's writings a type of criticism or warning about that development, or did he find that technology could not be taken to new heights if the "operator" were not considered? The Polish historians may clarify this for us.

History of the IEA: Great narrative or historiography?

How should we write and understand the history of the International Ergonomics Association? Should it be a *narrative*, a sort of product of immersion journalism which tells—more or less in depth—the various events, experiences, views and stories related to the advent of ergonomics and the creation of the IEA. This type of approach, which is not very far from fictional literature, seems to be very fashionable nowadays. We find the roots of such "telling the truth of history" in the works of postmodern writers who have been disappointed with the more structural approach of statistics and quantitative analysis.

An ergonomist has in many cases a scientific and/or technical type of education, more often than in the humanities. He might find a narrative approach verbose, devoid of content. An ergonomist might prefer a classical *historiography* where documented events, background factors, actors and actions are presented in an orderly manner, leaving far-fetched speculations aside. A well-structured historiography is indeed an important source for all who want to go deeper into the subject. The problem is that available documentary material is generally scarce and biased. This is especially true for ergonomics, which has only recently gained the status of independent discipline with its own records and archives, etc.

There is no need to meddle in historians' debates and to be partisan to any approach. An ergonomist is, after all, a pragmatic person who mainly asks, I think,

what can be learned from history. As peculiar as it may sound from the ergonomics standpoint, there is no major difference between narrative and historiography. Both may open people's eyes to a better understanding of human work, its determinants and its relationship to technology and society. From a pragmatic point of view, one can say that if historical issues (on ergonomics) do not enrich today's ergonomic practice to some extent, then it is not a major loss if they remain the professional historians' erudite exercise and subject of debate. This is undoubtedly an extreme standpoint because we do not know what will be important tomorrow. Therefore, questions about history must be asked again and again, not just because each new generation wants to ask its own questions to be answered by historical documents, analysis and/or narration.

Literature and further reading

Appleby, J., Hunt, L., Jacob, M. 1994. Telling the truth about history. W.W. Norton&Company, New York, London. 322 pp.

Chapanis, A. 1999. The Chapanis Chronicles. Aegean Publishing Company, Santa Barbara. 255 pp.

Dembe, A.E. 1996. Occupation and Disease. How Social Factors Affect the Conception of Work Related Disorders. Yale University Press, New Haven and London. 340 pp.

Duby, G., 1962. L'économie rurale et la vie des campagnes dans l'occident médiéval I. Flammarion, 285 pp.

Edholm, O.G., Murrel, K.F.H., 1973, The Ergonomics Research Society. A History 1949 - 1970. An Ergonomics Society Publication.

Ginzburg, C. 1993. Microhistory: Two or Three Things that I Know about it. Critical Inquiry 20. Autumn 1993, pp 10-35.

Jastrzebowski, W., 1857. An Outline of Ergonomics. A reprint published by CIOP 1997. 48 pp.

Meister, D. 1999. The History of Human Factors and Ergonomics. Lawrence Erlbaum Associates, Publishers. Mahwah, New Jersey; London. 382 pp.

Nef, J.U., 1943. The Industrial Revolution Reconsidered. J. of Economic History, vol III, 1943.

The European Reconstruction 1948 - 1961. Bibliography on the Marshall Plan and the Organisation for European Economic Co-operation (OEEC). OECD Historical Series. 1996. 175 pp.

Rifkin, J., Heilbroner, R.L. 1996. The End of Work: The Decline of the Global Labor Force and the Dawn of the Post-Market Era. Putnam Pub Group.

Stansfield, R.G., 1979, The origins of the International Ergonomics Association. Paper presented to the 7th IEA Congress, held in Warsaw, Poland, of the International Ergonomics Association 27th August 1979.

Valentin, M., 1978. Travail des hommes et savants oubliés. Editions Docis. Paris. 329 pp.

Verley, P. 1997. La révolution industrielle. Gallimard, Paris. 543 pp.

Mr. Ilkka A. Kuorinka, M.D., Ph.D.

After graduating in medicine in 1967, he worked as a general practitioner, joining the ergonomics unit of the Institute of Occupational Health in Helsinki, Finland, in 1968. He later became the head of the unit. His doctoral thesis in 1976 was on fatigue and EMG in repetitive movements. He did research on the biomechanics and epidemiology of repetitive tasks in an ergonomic context.

He was permanent occupational health advisor at Rautaruukki Ltd., a major steel company in Finland from 1970 to 1982.

In 1989 he was invited as a researcher, and later became the director of the Safety-Ergonomics Programme at the Institut de recherche en santé et en sécurité du travail du Québec in Montréal, Canada.

Since 1997, he has worked as a consultant and lecturer at various universities and institutions internationally.

He is a former president and fellow of the International Ergonomics Association. He was the recipient of the "Grand Prize" of the Nordic Ergonomics Society and "Distinguished Foreign Colleague Award of the Human Factors Society".

In 1998, he was appointed Historian of the International Ergonomics Association.

2 Proto-Ergonomics

Hugues Monod

Embryology of a discipline

The term "ergonomia" or "ergonomie" made its appearance in 1857 in "An Outline of Ergonomics or the Science of Work, based upon the Truths Drawn from the Science of Nature" of a Polish engineer, W. Jastrzebowski (1799-1882). The next year, it appeared in the now obscure text of an economist, J. Courselle-Seneuil (1833-1893). However, it is J.K.F. Murrel, engineer and psychologist, who gets credit for coining "ergonomics" in 1949. Ergonomics was to be the name of the nascent discipline of "fitting the task to the man".

Now, fifty years later, ergonomics is taught in universities and studied in laboratories. It is also being applied in the field. Meetings are attended by many participants. The period before the last half century can appropriately be considered as an era of "proto-ergonomics". The 200 years preceding the foundation of the Ergonomics Research Society were rich in thoughts, ideas and observations aimed at a better understanding of man at work. It was also a period for improving working conditions, protecting the worker's health and physical capacities, as well as for trying to achieve the best possible working efficiency. The emergence of ergonomics as knowledge and intervention, and even science and art, is therefore the result of a long gestation.

Work as a mechanical concept

The spirit of ergonomics is present in the mechanical approach to man at work. Today, what several engineers and learned men developed in the 17th and 18th centuries might be called "biomechanics". Already in the 1500's, Leonardo da Vinci had described the movement of limbs around joints and explored changes in the body's center of gravity. Later, Jean Borelli (1608-1679) developed algorithms for calculating the forces in the body arm levers.

The exploitation of the forests and the handling of the timber needed for shipbuilding and the construction of fortifications requires human power. Work may be evaluated only in terms of the power involved and the time used to complete the job. Vauban (1633-1707) pointed out the allowable limits for excavation work, working hours and breaks, underlining the need for Sunday rest. The English philosopher Thomas Hobbes wrote in 1668: "the value of man lies, like of any other thing, in his price, that is, in compensation for the use of his force".

Guillaume Amontons (1763-1705) measured maximum mechanical human power by letting his subjects work at a fast pace until exhaustion. Philippe de La Hire (1640-1718) studied human force in material transport, establishing limit values for lifting and manual transport. He noted the favorable postures and recommended correct leg use for reducing excessive lumbar strain. Joseph Sauveur (1653-1706) studied uninterrupted cranking work that lasted hours. Desagulier (1683-1743) presented, in his Cours de physique expérimental, methods for measuring human force during work. Several years later, Daniel Bernoulli (1700-1782) developed a mathematical formula for calculating man's maximum forces during work. It was only at the end of the 18th century that Edme Régnier (1751-1825) constructed the first elliptical spring dynamometer.

Work and fatigue

Engineers and public health physicians, through field observation, were able to note the fatigue effect of work, which could also cause disease. Bernard Bélidor (1697-1749), who followed the ideas of Vauban, fought against excessively arduous tasks that undermined the health of workers and caused incapacity. He demanded better living conditions for workers because of "the high cost of food", among others.

The name of Charles-Auguste Coulomb (1736-1806), author of "Mémoire sur la force des hommes", emerged during the enlightenment era. He was not interested in maximum performances, but in man's working capacity to do "a fair days work". He evaluated the quantity of action (we would now use the word "work") that a man could produce in a day. Several variables were taken into account: loads transported, and work rate and duration. Coulomb further developed the idea

that the worker, through his experience, finds the most economical way of performing the task. Adam Smith (1723-1790), a contemporary of Coulomb and creator of the notion of national economy, proposed that man's work is the basis of all mercantile values. He wrote in 1766, in An Inquiry into the Nature and Causes of the Wealth of Nations: "If one type of work is more arduous than another, one takes into account that the increased fatigue and production in one hour's arduous work may be exchanged for two hours in the other type of work".

Coulomb incorporates the force used with the concomitant fatigue, with the word "work" meaning both the result of workers' activity and the effect on the body ("stress" and "strain" would now be used instead). Coulomb insisted that observations must be carried out for several months. He thought that fatigue was constant, regardless of the modality of the work, for an ordinary working day at normal wage. He suggested investigating working conditions that would increase productivity but not fatigue. However, he did not master methods for evaluating fatigue.

Occupational health

In the middle of the 18th century, a number of public health physicians pointed out the deleterious effects of work on man. In 1701, Ramazzini (1635-1714) published his De morbis artificum Diatriba ("Diseases of Workers"), an important publication dealing with diseases caused by various crafts of that time. This work became known in France relatively late through the translation of Fourcroy (1777). This was probably the event that prompted numerous communications on occupational diseases at the French Royal Academy of Medicine.

Communications were presented by physicians whose names have long since been lost. They preceded Villermé (1782-1863) whose name is linked to the improvement of working conditions of women and children. In his book "L'état physique et moral des ouvriers employés dans les manufactures" (1840), unhealthy working conditions were denounced.

Energetics of work

Scientific ideas evolved from physics to chemistry. By the end of the 18th century, Antoine Lavoisier (1743-1794) focused his work on cellular combustion. Together with Priestly in England and C.W. Scheele in Sweden, he joined the "oxygen battle". Lavoisier was a chemist, jurist, biologist and economist. He showed the importance of energy transfer in human and animal functions. He was also the first to measure the energy consumed in leg work. Thus, a new method for evaluating human work was found, but the relationship with mechanical functions still remained obscure. The early death of Lavoisier brought research in that area to a halt in France, to be resumed only in the next century, based on the development of physiology by Dulong, and later, G.A. Hirn.

The contribution of physiology

The concepts of Claude Bernard (1813-1878) on experimental research in the mid 19th century served as a model for his students and successors who developed methods for measuring man at work. These methods helped in understanding the mechanisms of human work and related fatigue.

"La machine animale, locomotion terrestre et aérienne" (1873), the work of J.E. Marey (1830-1904), was published the same year as S. Houghton's "Principles of animal mechanism". Marey presented the principles of a graphic method and invented several mechanical and pneumatic devices for recording movements. He also developed optics-based techniques for recording events beyond the eye's visual ability. In parallel in the USA, his contemporary J.E. Muybridge (1830-1904), with Thomas Eakins, developed cinematographic techniques which were published in his book "Animal locomotion". These techniques were used after Marey in the first experimental studies on professional work. Paul Bert (1833-1886) published "La pression barométrique" and laid the foundations for work in caissons.

Jean-Baptiste Chauveau, a true inventor of work physiology, showed that glucose is burned in the muscles during work. He developed the concept of physiological work, as opposed to mechanical work in physics. He also separated static and dynamic work, as well as positive and negative work. He wrote several texts on muscular work, published in the series "Physiologie appliquée à l'économie sociale dans la

recherche des meilleurs conditions de la production des moteurs animés". The aim was to identify the conditions of lowest energy consumption that yield the best muscular efficiency. The basics of thermodynamics were laid with the work of Liebig (1803-1873), Mayer (1814-1878) and Helmholtz (1819-1892), which shed light on the energy in humán work.

The introduction of ergospirometry

Research on ergospirometry (analysis of breathed gases during graded exercise) continued in France and elsewhere in Europe with the contributions of W. Prout (1785-1850), Edvard Scharling in Denmark, and Edvard Smith (1818-1874) in London, England. In his experiments, Smith used the huge wheels employed as means of punishment in prisons. M. Pettenkofer (1818-1901) and C. Voit (1837-1909) in Munich, Germany; G. Gaertner in Vienna, Austria; and W.O Atwater and F.G. Benedict in the United States improved the techniques. The first bicycle ergometer was built in 1897 by Bouny, who was Marey's pupil.

The energy of muscular work was studied by N. Zunz and M. Rubner in Germany. M. Krogh in Denmark and A. Lindhard in Sweden carried out respiratory and circulatory studies with a bicycle ergometer and a running mill. A. Asmussen and E.H. Christensen in Denmark did field investigations during sports activities.

A new vision of work

During the last half of the 19th century, the science of work emerged. The principles of work organization originate from the 1848 revolutionary period. The debate about work was due to the increase in salaried populations, the emergence of industrial enterprises, and production needs. The progress in mechanization, and work accidents and their prevention, were other factors. Questions were raised about the fatigue created by mental activities that was present after physical efforts as well. Claims were even made that fatigue was only a sign of neural dysfunction. The conditions were therefore favorable for a trend that suggested the principle of using physiological knowledge to better organize human work. The time was also ripe for moving from physiology towards psychology. Wundt's "L'Ecole de psycho-physiologie expérimental" was instrumental in that transition.

The early French pre-ergonomists

The era of the first pioneers, sometimes called pre-ergonomists, was from the end of the 19th century to the First World War. Basically, they all had an education in physiology, but later, some did move towards psychology. Five names were more prominent than others.

Armand Imbert (1850-1922) was a professor of medical physics in the medical faculty at Montpellier. He adhered to the ideas of Coulomb, but stressed the role of the central nervous system in the organization of motor functions. In this respect he may be considered as one of the precursors of work psychology in France. He discovered the detrimental situation of dock workers and described the problems in manual materials handling. He also observed the arduous work of wine shoot cutters. Imbert was a keen observer of field conditions, and demonstrated the relationship between working conditions and accidents, which varied from one field of activity to another. He also showed interest in occupational overexertion, thus paving the way for occupational medicine. The social considerations related to the conflict between capital and work brought him to the Congrès d'hygiène et de démographie where he defended the idea of body self-regulation as a means of reducing energy consumption in manual work.

Charles Frémont (1879-1936) was a self-taught engineer who studied with Marey. He adapted his tutors' methods, and cinematography first of all, to the study of workers' postures and movements (e.g., blacksmith, finisher, etc.). Work tool technology was his special interest, including work efficiency. He also demonstrated the large variation in workers' physical and psychological qualities.

Jules Amar (1879-1936) was one of the personalities whose work marked an entire era. He had become interested in heavy physical work and collected experimental data in Algiers on walking, pedaling and load-carrying. The results were published in his thesis, "Rendement de la machine humain". He became director of the research laboratory on professional work at the Conservatoire National des Arts et Métiers, founded in 1913 on the initiative of the Ministry of Labor. Amar continued his movement studies as well as studies on muscular work and the concomitant changes. Before the war, he published "Le moteur humain" (1914) which is considered as the first treatise on ergonomics. The book has been translated into German, English, Spanish, Japanese and Russian. Opposing Taylor's concept of work organization, he published a second book "Les bases scientifiques du travail professionnel", (1923) reprinted in the USA in the 1980's.

Josepha Joteyko (1866-1928) was Polish in origin and a physiologist and psychologist who studied with Charles Richet (1850-1935) in France. She took part in "social energetics", a project organized by the Solvay Institute in Brussels. The end of the century was marked by an increasing number of studies on muscular fatigue. One of the investigators was Angello Mosso (1846-1910), the inventor of the ergograph for muscular contraction studies. Several authors found that it was the ultimate means of testing the working capacity of workers and of measuring their fatigue. Josepha Joteyko was one of them, attempting to describe various modalities of work until exhaustion, whose origin was either peripheral or central. As a professor in experimental psychology at the Université libre de Bruxelles, she founded in 1908 "La revue psychologique", which she directed until 1913.

Jean-Maurice Lahy (1872-1943) joined, in 1902, the experimental psychology laboratory headed by Edouard Toulouse (1865-1947), the founder of the French school of psychotechnics. Toulouse introduced professional counseling, which moved him away from studies on work. Lahy was convinced that biological sciences, by using objective analysis methods, may help solve social problems, by guiding collective and individual life. In this context, he proposed the term "biocratie". As a physiologist by education, he initiated research on psychophysiology. He developed a battery of tests to determine psychological work aptitude. In contrast to some others, he did not limit himself only to tests, but encouraged direct field observation of the worker. The areas of his work included typists, linotypists and tramway drivers. Later, Lahy focused his interest on radiotelegraphists and locomotive engineers and continued to work until the period between the wars.

Considering human factors

Human problems in work were first considered in the USA by engineers. In the early 1900's, Simon Lake studied psychological factors that determined operators' capacity to manage difficult situations. The dawn of professional selection can be seen, whose objectives were not necessarily the same as those of ergonomics. The purpose of scientifically studying work is more

efficient research on the human operator. Since 1898, F.W. Taylor had excelled in that area, promoting selection, training and the organization of breaks. In 1903, he published "Shop Management", translated into French in 1907, in which he presented the concepts of work organization. Frank and Lilian Gilbreth developed the "method-time-movement" (MTM) system, based on observation of operator performance.

Taylorian doctrine, whose promoter was Henry Le Chatelier, was introduced in France and Belgium at a time when the consideration of human factors was growing in popularity. Taylorism attracted the traditional work organization groups, but provoked debate and protests in proto-ergonomic circles. Taylorism was considered as being linked to the empirical approach, which focused on physical work but ignored the relationship between man and his work tools.

The year 1913 was eventful: Jules Amar's laboratory on human work was created in Paris, France, and Rubner's institute on work physiology was created in Berlin, Germany. Foundations were laid in Domeldange, Luxembourg, for the Institut Emile Metz, an institution that was a professional school and training center as well as a laboratory for physiological psychology. The laboratory was established by J. Amar in 1920. One year later, it became an ergological laboratory, and the following year, the Belgian centre for ergological studies.

Between 1880 and 1917, psychological research was undertaken in the field of aeronautics in Russia by Mendeleev, Arendt and Rudnev.

The 1914-1918 war was a period of innovation. Jules Amar concentrated his efforts on the rehabilitation of handicapped veterans and their return to work, as well as on the development of prostheses for the severely handicapped. On the other side of the Atlantic, aircraft and tank design advanced and gave rise to organizations that carried out aptitude tests for the selection of pilots and drivers. The same trend was seen in Germany, Italy and Great Britain. In Great Britain, ergonomic investigations concentrated on the manual handling of ammunition.

The period between the First and Second World Wars: ergology

This was the period when psychology, already separated from philosophy, was trying to find its direction. The boom in psychotechnics was not well received by experimental psychology. Some described psychology as "applied", and others, as "industrial", ending with the "psychology of work" only later in the 1970's.

When the dust had settled, a French psychiatrist, Paul Sollier, established the "Science du travail", a section in the Institute of Advanced Studies in Belgium. He proposed the term "ergology". In 1925, that section became the "Laboratoire d'Ergologie", and later the "Centre Belge d'études ergologiques" or the "Institut d'ergologie". It also had its own journal, "Le travail rationel", beginning in 1936. According to Paul Sollier, ergology was related first to physiology and psychology, but also to medicine, hygiene, technology, ethics and sociology. Machine and man should be aspects of this new science. It was not yet ergonomics, but was not very far from it either. The term "ergology" has not survived except in the journal of that name published in Southeast Asia.

Since the beginning of the 20th century, work has continued in many countries, with the aim of a better understanding of human machines, following the work of Chauveau and Marey. It led to the creation of many laboratories before and after the First World War. In Germany, Atzler headed a work physiology laboratory; E.A. Müller ran the "Kaiser Wilhelm Institut für Arbeitsphysiologie"; and later, G. Lehman ran the "Max Planck Institut für Arbeitsphysiologie". Their practical aims involved workers' physical capacities and environmental conditions (such as heat and lighting, etc.) which were important in coal mining and in the metallurgical industry. Several names from that period can be mentioned: P. Dolgin, Th. Hettinger, H. Spitzer, K. Karasch, H. Kraut, H. Straub, Kofrani and Michaelis. The results were published in a new journal: "Arbeitsphysiologie". There were also universities or institutes dealing with work problems in Charleroi, Charkow, Odessa, Mariupol, Dniepopetrovsk, etc.

Several complementary research themes can be identified: The product from work and remuneration, evaluated according to mechanical or energetic criteria. Other themes were: the capability for heavy work, the rationalization of work in order to achieve the best production with the least fatigue, and the creation of the best possible physical working conditions.

Studies also addressed accident prevention and occupational diseases, which led to tests of drivers and studies on the effects of the environment on psychomotor performance, as proposed by Vernon in the U.K. In 1921, the National Institute for Industrial Psychology, under the leadership of C.S. Myers, was created in the U.K. The Industrial Health Research Board was also involved, but the unfavorable economic situation prevented in-depth studies.

In France, Jean-Maurice Lahy continued his studies begun before the war. In 1920 he created the first vocational counseling service. Furthermore, he started the psychotechnical public transport laboratory in Paris, and later, with Suzanne Pacaud (1902 - 1988; a psychologist of Polish origin), the French Railway Laboratory. Lahy started the short-lived "Revue des Sciences du Travail" journal with P. Sollier and J.-P. Arend (Luxembourg). He remains in history as the co-founder of "Le Travail Humain" with Henri Laugier in 1933. Le Travail Humain, still going strong, set its goals: "Le Travail Humain would like to reach biologists, physiologists, psychologists, physicians and hygienists who are interested in the application of biology in the social sphere. We would also like to inspire interest in our journal of industrial and commercial enterprises, agriculture and management ... in fact, all engineers who recognize the importance of the role of human factors in improving of working conditions." The ergonomic spirit was clearly present.

Consequences of gradual internationalization

The International Labour Office, presently the ILO, has played an important role by introducing worldwide legislation on occupational diseases and work organization. The fields of activity pertaining to the relationship between man and work were defined as follows: Designing work, taking care of aptitudes, finding the best possible efficacy without undue strain, studies on environmental conditions (such as temperature, humidity, etc.), nutrition (remuneration should allow 3000 kcal to be bought—a worker's daily requirement), working hours, and adapting the machine to the worker.

As often happens, dangerous and emergency situations promote research for new solutions and encourage investigations helping to cope with the situation. In this respect, the threat of a worldwide conflict in Great Britain in 1939 led to the creation of the "Industrial Fatigue Board", and in the USA, to the "Committee on Psychological Problems of Aviation". It was in that context that Alphonse Chapanis joined the "Aero-medical Laboratory" in 1942. The themes studied involved pilot safety, the arrangement of cockpits, the location of controls, adapting to night vision, visual and auditory discrimination, and the effects of anoxia and altitude—all themes that had practical significance in warfare. In retrospect, as Chapanis pointed out, the scientific results were modest.

During the same period, Lucien Brouha left Belgium in 1940 and settled in the United States, working in D.B. Dill's "Fatigue Laboratory " at Harvard. After that, he started a pioneering field of work in Canada. He demonstrated the importance of physiological studies in workshops in motivating changes in work organization. Brouha's significant experience is crystallized in "Physiology in Industry" (1955), which has had a considerable impact in Europe.

Conclusions

In the aftermath of the Second World War, applied research in human physiology and psychology led to the emergence of modern ergonomics. It was promoted by contacts between Europe and the New World that remained active between Great Britain and the USA throughout the war, explaining the lead gained by the latter.

A certain number of scientists, work physiologists and psychologists took part in meetings organized by the "European Productivity Agency", having launched a project on "Fitting the job to the worker". With a number of European colleagues, they attended the meetings of the newly established "Ergonomics Research Society" (1950) with great interest.

This society was founded by a number of individuals from varied backgrounds, but all having an interest in human work. The founding members included H. Murrel, Broadbent, Bedford, Burger, Hill and Lovatt Evans. ERS meetings attracted colleagues from neighboring countries, for example from Belgium (Bastenier), Denmark (Asmussen, Christensen, Högberg), Finland (Karvonen), the Netherlands (Bonjer, de Jong), and the USA (McFarlane, Karlin). These meetings were actu-

ally the melting pot that gradually shaped European ergonomics, preceding the IEA and today's national and regional ergonomics associations.

Literature

Chapanis, A. - Chronicles, Aegean Pub. Co, 255 p.

Clot, Y. (1996) - Les histoires de la psychologie., Octares 6d., Toulouse, 201 p.

Cremieux-Brilhac, J.-L. , Picard, J.-F. (1995) - Henri Laugier en son siècle. CNRS 6d., Paris, 157 p.

Drabs, J. La recherche scientifique et le travail, Le travail rationnel, 1936, 1,4-15.

Meister,D. - The history of human factors and ergonomics, Lawrence Erlbaum Associates, 382 p.

Monod, H. (1994) - Amar, Jules (1889-1935), in C.Fontanon et A.Grelon, Les professeurs du Conservatoire National des Arts et Métiers, Paris, A 97-A 107.

Ribeill, Gf. (1980). - Les débuts de 1'ergonomie en France à la veille de la Première Guerre mondiale, Le mouvement social, no 113, 3-36.

Valentin, M. (1978) - Travail des hommes et savants oubliés, histoire de la médecine du travail, de la sécurité et de 1'ergonomie. Docis 6d., Paris, 329 p.

Vatin, F. (1999) - Le travail, science et Société, Ed. de l'Université de Bruxelles, 222 p.

MONOD, Hugues, born April 19 1929 in Paris (France), M.D., professor of physiology.

Research fellow 1954-61 at the Centre d'étude scientifique de 1'homme (CNRS - Paris); assistant professor of physiology 1961-1965 at the medical school in Amiens, full professeur 1966-1998 at the faculty of medicine in La Pitié-Salpêtrière (Paris VI University). Teaching basic physiology, ergonomics, exercise physiology and sports medicine. Emeritus professor since 1998.

Field of research activities: Muscle physiology, work capacity and fatigue, static contraction and posture, exercise physiology, anthropometry and applied physiology, ergonomics and history of medicine. More than 350 papers (J. Physiol. Paris, Le Travail Humain, JAP and Eur. JAPOP). Co-author in text books (Physiologie du Travail, Ergonomie, Physiologie du Sport, Médicine du sport).

Positions:

Chief of the laboratory of work physiology (1975-91). Chief of the hospital department of Physiologie et explorations fonctionelles du sport (1979-1990), and Explorations fonctionelles respiratoires (1990-1995).

Elected member of the National board for the scientific research, CNRS physiology section (1970-75, 1980-82). Elected member of the Universities' national council for Physiology (1975-79; 1983-86, 1987-91 as president). Officer (secretary, general secretary and president) of the French Speaking Ergonomics Society - SELF (1967-73) and of the French Speaking Association of the Physiologists (1977-93). Treasurer for the 11th IEA meeting in Paris (1991).

3 The European Productivity Agency and Ergonomics

Text based on communication in the meeting of the Association Suisse d'Ergonomie, Berne, October 5, 1999: "L'Agence Européenne de Productivité et l'ergonomie".

Denise Lecoultre (OECD 1953 - 1984)

I want to extend my thanks to Professor Paule Rey who made it possible for me to be with you today. It is an honor but also a pleasure to learn that a Swiss Ergonomic Association finally exists.

I'll attempt to outline here the successive stages of the European Productivity Agency (EPA) in your discipline. To begin with, allow me to make some general remarks about the origin of the European Productivity Agency and its place among International Organizations.

In 1948, $14 billion was provided by the Marshall Plan. This resulted in the need to found the *Organization for European Economic Co-operation* (OEEC). The goal of this organization was to help properly carry out post-war reconstruction, by restoring industries, guiding them towards improved work organization, and increasing the competence of their employers in order to improve cooperation on all levels and by everyone. The aim of all this was to increase the economic growth necessary to reestablish devastated countries (by then, the target growth was 6.5%). To help achieve these goals, OEEC established a special agency, the *European Productivity Agency*, in 1953.

At the end of his mandate in 1959, the director of the EPA, Roger Grégoire, wrote a 200-page report, the "Répertoire des Activites de l'Agence". It is regrettable that this report has not been published. In any case, I will concentrate here only on ergonomics questions.

At the time of the dissolution of the EPA, the OEEC was no longer only "European" because new members such as Australia, New Zealand, Japan and the founding member, the United States, joined the organization. When I left, the Organization consisted of 24 member countries, with Yugoslavia being, with a special status, the only country from the "Eastern Bloc". Since the organization was no longer strictly European, its name was changed to the Organization for Economic Co-operation and Development, OECD. OECD is an intergovernmental organization that is not part of the United Nations, in contrast to the specialized agencies such as the World Health Organization, Unesco, the International Labour Office, the ILO, and others. Nor is the OECD tripartite, according to the "constitutional" meaning of the term. However, it consults employers' organizations through the Business Industrial Advisory Committee of the OECD (BIAC), as well as workers' organizations through the Trade Union Advisory Committee of the OECD (TUAC).

Before ending these preliminary remarks, let me mention—for history—that in 1926, a Swiss expert Léon Walther published "La technologie du travail industriel" which included an important bibliography on studies in the fields of psychology, physiology and psychopedagogics. The oldest publication appearing in the list and dated 1883 was that of F. Galton, "Inquiries into Human Faculty and its Development".

By the way, you may be aware that volume number 6, page 404, of the Encyclopaedia Universalis contains a rather detailed article on the history of ergonomics, mainly in the United States.

The OEEC created the *European Productivity Agency* in 1953, which established a working group intended to investigate human factors and productivity. A distinguished member of the Ergonomics Research Society, Ronald G. Stansfield (who worked extensively on the establishment of the International Ergonomics Association, see footnote (1), proposed that ergonomics investigations and expert groups should be included in the EPA program. A clarification of the term was needed because most of the working group members did not know exactly what the term included. The first action of the European Productivity Agency was to send three experts, namely M. Friedberger (Austria), R.G. Stansfield

(UK) and M. Bougnet (Belgium) to the Austrian Alps in order to compile an operational definition of "ergonomics". Such a definition should be useful in drawing up proposals on multidisciplinary and international investigations. Based on the reflection of the three experts, the working group on human factors preferred to drop the term "ergonomics". In order to be better understood by the outside world, the working group adopted the term "fitting the job to the worker" ("adaptation du travail à l'homme").

The objectives of the working group's program were defined as follows:

First: To gather the acquired knowledge in the various disciplines in order to understand how to improve both physical and mental working conditions. By that time, the disciplines included time and motion studies, psychology, occupational medicine, industrial environment and hygiene, accident prevention and lighting technology.

Second: To create a true interest on the part of industries in a better adaptation of workplaces to the workers' capacities and in understanding how to apply biological sciences to the man-machine tandem for better harmonization of functions. All this had the goal of improving the workers' well-being and industrial productivity.

The launching of this program "Fitting the job to the worker" was well received by all parties, namely employers' and workers' representatives, as well as the scientific community. Approval was also obtained from the national authorities of the participating countries. An excellent expert group was then consulted during all phases of the program.

First stage: Mission to the United States

Interest in ergonomics had grown in the USA during the war, particularly concerning practical applications. For example, aircraft cockpits' increasingly complex instrument panels had been the cause of problems and accidents. In an emergency, various specialists had had to intervene to improve military planes' instrument

panels and the entire pilot working space. Therefore, in 1956 it seemed to be appropriate to start the EPA's program through a mission to the USA. It became an international mission of nine European experts (from Austria, France, Germany, Italy, Norway, the Netherlands and the United Kingdom) as well as one representative from the European trade unions. In 1958, M.K.F. Murrel wrote a report on this mission, organized and conducted by Professor Belding (USA). The group was able to collect extremely important and mostly first-hand information for the "fitting the job to the worker" program. The report deals with themes such as the design of machines and tools, anthropometrics, physical and nervous fatigue, noise, vibration, and lighting. In addition, the mission touched on questions such as work accidents, aging, radiation and deleterious psychological effects. The participants appreciated the opportunity to exchange information, which they could continue to do more or less regularly after the mission and throughout the European Productivity Agency's existence. They became very useful consultants in further developing the Agency's program.

Second stage: Technical seminar - Leyden

Experts from eleven European countries, including Switzerland, gathered at a seminar held in Leyden, the Netherlands, in 1958. Professor G.L.E. Burger chaired the seminar. The aim of the seminar was to analyze existing knowledge in the research centers of various countries to determine whether it was sufficiently concrete and relevant to be used by the employers' and workers' representatives for practical implementation in workplaces.

The answer was positive; a tripartite conference was therefore organized in 1959 in Zurich, Switzerland.

Third stage: Zurich tripartite conference

At the conference held in Zurich (March 2-6, 1959), there were 200 participants from the following countries: Austria, Belgium, France, Germany, Ireland, Italy, the Netherlands, Norway, Sweden, Switzerland, the United Kingdom, the USA and Yugoslavia. International organizations were also represented: the International Labour Office (ILO), the World Health Organization (WHO), the European Coal and Steel Community (ECSC), the European Economic Community (EEC), as

well as employers' and workers' organizations. The aim of the conference was to present to the participants, designs of machine-tools, weaving machines, and cars—in fact, examples of applications of ergonomic principles.

The conference was held at the Ecole Polytechnique Fedérale de Zurich (Eidgenössische Technische Hochschule, Zürich, ETH) and its chairman was Professor Daenzer. An exhibition was held in the auditorium of this school. Various ergonomic achievements were presented: looms, vehicles, workplaces, etc. The Swiss had every reason to be proud: the ergonomic message had crossed the threshold.

Professor B. Metz from the University of Strasbourg, France, wrote the report, which was published in 1960.

Fourth stage: seminar for Engineers - Liege.

To follow up on the recommendations of the conference in Zurich, a seminar for engineers was held in Liege, Belgium, from September 5-12, 1961. The chairman was Professor Coppee from Belgium. The Zurich recommendations stated that engineers have an extremely important role in the application of ergonomics principles to work. However, the programs of overcrowded technical universities and schools remained silent about the diverse factors in "fitting the job to the worker". Consequently, when engineers had to design machines and tools, they did not take human factors into account. There were 54 participants and 19 representatives from international organizations. The seminar program was concentrated and very professional. The aim was to attract the attention of the management and teachers of technical universities and engineering schools to the necessity of integrating ergonomic elements into the curricula. This should allow engineers to take ergonomic principles increasingly into account in designing machines and tools.

A report on "Fitting the job to the worker" (seminar for Engineers), written by an English ergonomist, S. Laner, was published in 1963.

In 1960, the European Productivity Agency, EPA, had come to the end of its six-year mandate and its director, Roger Grégoire, retired. We owe him posthumous thanks for his support in the "fitting the job to the

worker" program. The EPA had fulfilled its role in giving ergonomics an international dimension. The International Ergonomics Association was founded in 1959 and Professor Etienne Grandjean from the ETH was its first secretary general.

Conclusions

Ergonomics can look forward to a significant future in improving not only working conditions, but also the quality of life of certain population groups. Globalization will no doubt require intervention in child labour and on behalf of large groups of exploited workers excluded from the protection of labour legislation and social security, as well as the elderly who require collective amenities, handicapped persons and the disabled (wars, land mines, traffic accidents).

Engineer training was only a beginning. The training of ergonomists will involve an entirely new civilization, that of computerization which, as if putting a "spell" on people, may make them more vulnerable and in many cases will lead them to robotization. New approaches will have to be found for protecting the world of "manual and non-manual" labour, as the saying used to be.

I would like to express my best wishes for a great future to the Swiss Ergonomics Association, since Swiss specialists have actively participated in establishing an international approach towards the continuous development of "fitting the job to the worker".

References

(1) Lecoultre, D. (1985). Ergonomics and the European Productivity Agency: a historical note. In I.D. Brown, R. Goldsmith, K.Coombes and M.A. Sinclair (Eds.), Ergonomics International 85. Proceedings of the Ninth Congress of the International Ergonomics Association, 2-6 September 1985, Bournemouth, England (pp. 1009-1011). London: Taylor & Francis.

Denise Carmen Lecoultre, M.A., University of Washington - Seattle and licentiate in social and economic sciences - Geneva 1.

After having completed her basic education in Geneva, Switzerland, Denise Lecoultre entered the University of Geneva where she studied social sciences and economics. After the war period, she went to the United States in 1949 to study sociology and political science at the University of Washington, in Seattle. On her return to Geneva, she worked in 1951-1952 as a consultant for the International Labour Office, but moved in 1953 to the Organisation for European Economic Co-operation, OEEC, in the framework of the Marshall Plan. She was invited to OEEC's division, the European Productivity Agency, EPA, where she became head of Section III, Division B, Human Factors, as well as that of Economic, Human and Technical Factors. It was in that context that she organized several ergonomics-related activities, as for example, the tripartite conference in Zurich (1957), the seminar on human factors for engineers (1961), as well as various missions, consultations, etc.

In 1960 she moved to UNESCO, where she was responsible for various work-related programs. In 1963, she returned to the OECD where she became principal administrator of the Social Affairs Division. She retired from the OECD in 1984.

4 The EPA Period of the IEA

W. T. Singleton

The Economic Context

In the early 1950s all European countries were recovering from the devastation of the Second World War. There was a significant shift of the working population from agriculture to manufacturing and a consequent interest in industrial productivity. The model aimed at was American industry which, safely distant from bombing and other dislocations, had expanded very rapidly during the war as 'the arsenal of democracy'.

In 1948 the Organisation for European Economic Cooperation (OEEC) was formed when seventeen European countries signed a convention "to combine their economic individual capacities and potentialities, to increase their production, develop and modernise their industrial and agricultural equipment, expand their commerce, reduce progressively barriers to trade among themselves, promote full employment and restore or maintain the stability of their economies and general confidence in their national currencies". They also agreed to facilitate the return to freedom of trade throughout the world and to the general convertibility of currencies.

The headquarters was the Chateau de la Muette in Paris, this remains the headquarters of what is now known as OECD. The USA and Canada were not members of OEEC but they participated in its work.

In 1953 the European Productivity Agency was set up within the framework of the OEEC "to promote the widest possible application of the latest technical know-how, managerial skills and sociological methods in European industry, commerce and agriculture". There were national Productivity Agencies in many European countries, their initiatives and experiences were exchanged in the European forum. In another form of co-operation the EPA sent international teams of business men, workers, trade unionists, farmers, technicians and scientists to the USA.

Introduction

In the pursuit of greater productivity it is not surprising that the European Productivity Agency selected a project in the field of industrial psychology and physiology. EPA Project 335 was entitled "Fitting the Job to the Worker". It was envisaged that the project would consist of three consecutive stages:

1956 Stage A. A tour of American institutes, companies and other organisations thought to have relevant expertise
1957 Stage B. A technical seminar and survey of research to be held in Leyden
1959 Stage C. A tripartite international conference to which industrialists, trade unionists and scientists from all EPA member countries would be invited

The project organiser was Mlle D. Lecoultre from the EPA. A project adviser was appointed, H.S. Belding, Professor of Environmental Physiology in Pittsburgh, together with a team secretary, K.F.H. Murrell from Bristol University.

Member countries were invited to nominate participants in the mission and seven countries did so - F. Schofel, a management consultant from Vienna, Austria, B.G. Metz, Professor of Physiology from Strasbourg, France, B. Schulte, a methods engineer from Siemen-Schuckert, Germany, A. Ionnaccone, assistant Professor of Industrial Medicine, Florence, Italy, F. H. Bonjer, Chief of Occupational Medicine, Leyden, Netherlands, K.R. Karlsson, a work-study engineer from Oslo, Norway and W. T. Singleton, Head of Ergonomics at the Shoe Research Association, Kettering, England. Three were engineers, three were physiologists and one was an applied psychologist. All took part in the mission and in the following seminar at Leyden. There was also a Trade Union representative, P.F.Blau from Austria. It is interesting to note that in various later years four members of the group - Murrell, Bonjer, Metz and Singleton were invited to give the Ergonomics Society Annual lecture.

During 1955/56 the team met several times in Paris to formulate the objectives in more detail and to agree on the places to be visited in America. There was quite a lot of heated discussion about which topics were within the remit and which were outside it. Body measurement, posture, displays, controls, heat, noise, lighting and fatigue were included. Accidents, ageing, diet, toxic hazards, motivation and learning were excluded.

The American Tour

The team travelled along the East Coast states from Maryland to Massachusetts, across all the states below the Great Lakes and as far west as Minnesota.

In the physiological laboratories and institutes the main topics of interest were heat and noise. Four were in universities, one was operated by an insurance company (Liberty Mutual), one by an industry (DuPont) and one by the American Society of Heating and Ventilation Engineers. We met well known individuals such as Belding and Hatch in Pittsburgh, Keys and Brozec at Minnesota, Frederik at Hopkinson and Brouha at DuPont. There was a lot of effort going into the devising and evaluating of heat-stress indices and related activities such as indices on the permeability of clothing materials and the use of ventilated suits. There had been a recent increase in noise research because it became feasible to sue employers for hearing loss thought to be caused by noise at work.

Of the psychological laboratories and institutes seven were in universities. There were many individuals who were to become very well known in the human factors field such as Al Chapanis at Johns Hopkins, Frank Taylor at the Naval Research Laboratories in Washington, Paul Fitts at Ohio State, Ernest McCormick at Purdue, Karl Smith at Wisconsin and Ross McFarland at the Harvard School of Public Health. It is striking that so many of the research topics then being pursued still await further refinement. For example: the number of colours that can be distinguished with a small chance of error, the optimum information content per symbol for efficient communication, communication within a group, the measurement of the 'gain' of the human operator, quickening and unburdening, air traffic control problems, recognition of collision courses by pilots, and so on. Most were still using the paradigm of development of concepts potentially relevant to work by laboratory studies. The Naval Research Laboratory aimed to study man-machine systems rather than human performance.

One way or another most of this work was financed by the military. At that time Bell Telephone had three research establishments with a total staff of about ten thousand. The military human engineering group was separate from the civil user preference research group, we visited the latter. They were working on the difference in performance using alphanumeric and straight numeric telephone numbers and on selection and training techniques for telephone operators.

Nine industrial establishments were visited. There was some methods engineering on the production side but the only activity that could be classified as human engineering was concerned with the products. Human engineering was the most widely used term for matters to do with consideration of the machine user. Automation was proceeding rapidly at the time and it was still the popular view that the way to cope with the human operator in production processes was to remove him. The companies big enough to have separate general research laboratories such as IBM and General Motors were beginning to take a systematic interest in human engineering.

A number of Trade Unions were visited, the attitude to human engineering varied considerably, some had merely heard of it but others had staff who consulted the current literature. Three consulting organisations were visited but only one had extensive work of interest to us. This was the American Institute for Research which had a range of remarkable staff in this field including Flanagan, Miller, Folley, Van Cott, Altman and Swain. Unlike the universities they were developing techniques for field investigations such as systems analysis and task analysis They were particularly interested in maintenance, from both design and training aspects.

In conclusion the situation in the USA at that time seemed to be that industry was changing rapidly but driven by the engineers, not the human engineers. In contrast with Europe there was less interaction between physiologists and psychologists, the industrial hygienists were concerned with the environment including toxic hazards and engineering psychologists were quite separately working on the theory relevant to product design.

There was research on lighting, heat stress and noise but very little work physiology which could be compared with the extensive European research at that time.

The engineering psychology was essentially financed by the military, there were several hundred human engineers working in the universities and in large industrial firms supplying military needs, there was a small amount of work on product design (aircraft, cars, business machines, farm machinery and

telephone equipment) but none on production design outside the more traditional methods study.

The Cultural context

These events took place about half a century ago and much has changed over this period, not only in Europe but also in the USA. The two continents were far less in communication then than they are now, although business men and scientists were beginning to make visits across the Atlantic to find out personally how the others did things. At that time, in England, 'BTA' (been to America) was regarded as an additional qualification almost of similar status to the more recent MBA. Although I had been in the Far East during and after the war it was on this, my first visit to Washington, that whilst going for a walk in Rock Creek Park one evening I realised, from the noise of the crickets and other insects that here there was a sub-tropical climate.

The flight from Paris to Washington by Air France Boeing Stratocruiser took seventeen hours with stops for refuelling at Shannon, Newfoundland and New York. The return trip by sea from New York to Cherbourg took almost a week, incidentally in very bad weather. The most striking impression for we Europeans was in the roads and the automobiles. There were multi-level, multi-lane roads and cars with huge bonnets, boots with fins, chrome everywhere and bright colours.

I had heard that the USA was a matriarchy and we soon had experience of this. At one of our first visits, the Director of the Institute welcomed us, informally, in the large entrance hall. He began a little speech with a cigarette in his hand, his wife was standing at the back of the mixed audience of our team and the local staff, she was to be our hostess that evening. Suddenly she interrupted him in a loud clear voice - "Honey, put that cigarette out!"- he did so immediately. American hospitality was as charming and generous as it still is, but more formally then. European visitors were rare and were prized as guests. There were many dinner parties arranged for us, sometimes as a team and sometimes as individuals. After one such dinner the hostess announced, without prior warning, that she had three speakers for the assembly. The first was a senior officer who had been on General MacArthur's staff, the second had "just been released from more than twenty years in a mental hospital". The third was me and I won-

dered how I would be introduced, she simply said ,"Our third speaker is from England". At another formal gathering the hostess sat at the end of the room during the cocktail hour and each guest was called to sit next to her for five minutes for a private grilling. During the elaborate meal that followed I sat next to a man who wanted advice on how to spend four million dollars on research. I heard snatches of the conversations ..."last time Foster (Dulles -Secretary of State) came to dinner....." ...."of course I've known Adlai (Stevenson - a presidential candidate) since he was so high...." These were not the circles I moved in at home. However I gradually got used to being asked to rise after dinner to, "talk about his work and give his impressions of our country". One evening in Massachusetts our hostess for the whole group decided personally that we ought to see the Governor. We had to change our programme and go to his office next morning whether he or we liked it or not.

We had a tour manager from the State Department who was in the tradition of the great fixer. He regarded it as his job to get us the best rooms in hotels and the best seats in aircraft. We never had to stand in queues. As a matter of routine he would send for the person in charge and there would be a whispered conversation of which we heard snatches ..."guests of the State Department.....Foreign Diplomats.....American Foreign Policy...." It always worked. On his own initiative he decided that we ought to see Niagara Falls. This was well off our route and there are no factories or research institutes there but nevertheless he fixed it that we should have a mid-tour evaluation weekend there. Our secretary, Hywel Murrell was concerned that once we got back to Paris the team members would think about going home rather than concentrating on our final report so the tour manager arranged that we go back by sea rather than by air. This also worked, we arrived back in Paris with a draft report already available and were able to disperse and return to our separate countries the next day.

The Leyden meeting

Around Easter 1957 the five day conference took place at the Netherlands Institute for Preventative Medicine. It was designed to be a review of European research, and a comparison with work in the USA. Sixty scientists attended, about ten each from France, Germany and the United Kingdom, smaller numbers from the smaller countries and four from the USA.

The meeting began with a description of the findings of the American Tour by Murrell and Belding. There was emphasis on the problems of transition from military to industrial work, the need for team approaches not only for interdisciplinary understanding between scientists but also to appreciate the different priorities of engineers and managers. There was a need for methods to evaluate the chronic strains of work. It would be desirable to avoid the danger of slowing progress by making premature claims to management about what could be achieved. .

This was followed by technical sessions on heavy muscular work and heat stress, noise, information display, psychological and sociological factors, engineering psychology, work posture and machine design. Finally there were plenary sessions on communication and attitudes, training, and recommendations for the future.

Each technical session had a chairman and a rapporteur who were specialists in the particular field. There were review papers and also details of particular projects which each country had been invited to provide in preparation for the meeting. For physical work the two main methods were the measurement of oxygen consumption and of pulse rate. Oxygen consumption provides a measure of energy used and the pulse rate incorporates also working capacity and environmental stress. For heat stress the two main determinants discussed were the period of exposure and the time of recovery. Some overall limits were suggested; 4 cal/min for heavy work, a pulse rate of 125 beats/min and a core temperature rise of one degree centigrade. On noise the situation was not reducible to a simple limit because of variation in frequency distribution, individual differences in sensitivity and less clear cut effects on performance. Nevertheless there were suggestions of methods to reduce noise levels, long term hearing loss was accepted as a real problem. In terms of legislation there had been a recent change from consideration

of loss of capacity to earn a living to a wider view that such loss is a general disability.

It was accepted that European research on information display was on a smaller scale than that in the USA. There was discussion of the validity of applying the results of laboratory experiments usually with inexperienced young subjects to industrial situations. However there was still considerable scope for the application of geometrical principles such as avoiding displays oblique to the user and suiting the display size to the distance from the user. The concept of calibration of 'internal displays' against external information was developed, the idea being that the more complete the calibration the less external information was needed to maintain stability. The importance of auditory displays as warning signals and as indications of effective machinery function was emphasised. Within psychological factors related to work design mention was made of intrinsic interest, knowledge of results and the disadvantages of inflexible pacing. It was suggested that the ratio between speed of work over a day and maximum possible speed was about one to two. Motion analysis, popular at the time within methods study and 'Predetermined Motion Time Systems' was extended into variables affecting manual operations, handwriting and gait such as stress, personality, motivation and age.

Within engineering psychology, tracking studies were very popular at the time. The importance of display-control compatibility, coding as in letter sorting and the advantages of standardisation were discussed. Anthropometric data were being accumulated in four countries. Several procedures such as electromyography, flicker-fusion frequency measurement and tachography appeared to be developing nicely but are not in common use half a century later. Analyses of faults, errors and accidents suffered then, as now, from problems of classification.

In the plenary session on communication the barriers due to differences in orientation, attitudes and values between research workers, managers and unions and even between different disciplines within research had their usual airing, usual in the sense that such discussions then and now take place at every ergonomics meeting.

Evaluation of the Leyden meeting

It was an exciting occasion for many of these involved because it was the first opportunity to meet colleagues from other countries with similar objectives but often with different approaches. Also it was becoming clearer that a new discipline called ergonomics was emerging and its content and boundaries were identifiable. It was a science in the acceptance of reliable and valid standards of evidence and a technology in that it could be applied in industrial as well as military situations. The journal 'Ergonomics' started publication in this year (1957).

One of the recommendations adopted at the final plenary session about the future was that a steering committee should be designated 'to consider the desirability of organising human work scientists on an international basis'. The secretary was E. Grandjean from Zurich. The members were H.S. Belding and K.U Smith from the USA, G.C.E. Burger from the Netherlands, S. Forssman from Sweden, B. Lehman from Germany, B.G. Metz from France and R.G. Stansfield from the UK. It was asked 'to consider problems of implementation and to draft a statement of purpose, scope, structure, membership and relationship to existing organisations'. This was the origin of the International Ergonomics Association which held an inaugural meeting in Stockholm in 1961.

The Zurich meeting

This took place at the Federal Institute of Technology in March 1959. The two years since the Leyden meeting had been used to define the objectives, audience and content. The format adopted was similar to that for the Leyden meeting, there were plenary sessions at the beginning and the end with technical sessions inbetween . The rapporteurs were scientists but the chairmen were from industry. The two rapporteurs at each technical session did the presentations and the chairmen encouraged discussion from the audience, including inviting employers and trade unions speakers beforehand to make contributions. The early organisational meetings were conducted by an ad hoc group of experts but at the final preparatory meeting in September 1958 rapporteurs also attended. The presentations were to be designed to be comprehensible to non-specialists and there would be emphasis on practical examples drawn from industry.

About two hundred people attended, fairly evenly distributed between employers associations, trade unions and scientists, and with representatives from various productivity centres and international organisations. Thirteen countries were represented, mostly between ten and twenty per country with one (H.S. Belding) from the USA. French and English preprints were circulated beforehand and the rapporteurs later produced reports on the discussions.

The topics covered in the technical sessions were the same as those at Leyden, the presentations were understandable to non-specialists as evidenced by the extensive discussions. On heavy muscular work industrial experience suggested that the total energy expenditure per day was usually less that than recommended from research particularly for men aged over fifty. On handling operations the importance of training was emphasised. Accident rates depended on the nature of the operation rather than the energy expenditure. In relation to the design of work places using the optimal posture principles available from research it was pointed out that this process was facilitated if machines could be evaluated before coming into use and that for machines already in use there were problems of the cost of modification and the need for retraining. Automation never seemed to eliminate all the laborious operations. On presentation of information the concept of the man-machine system in which the operator received the right amounts of information in the appropriate form and at the right moment was accepted. The importance of structure such as regular patterns was emphasised. This was echoed in the session on controls. At the end of this session the many difficulties in the application of ergonomics were discussed, for example the conventional outlook at all levels in industry and the importance of the wider concept of wage scales, taxation, regulations and even the political framework.

The discussion on lighting centred mainly on questions of glare from situations as diverse as the chrome surrounds of dials to car headlights. It was suggested that as well as impeding vision glare is a source of fatigue. It was also suggested that the shadow of an object as well as the object itself is an aid to perception. On noise the discussion was mainly about earplugs and audiograms. There was extensive discussion of heat which was a problem in a number of industries at

that time, the best solution was the engineering one of containing more of the heat within the process which would increase the thermal efficiency as well as suiting the operator. Tolerance time and the consequent arrangement of rest pauses was a difficult question to answer generally. This led in the next and final session to consideration of rest pauses within working periods and shift work. Again there were no general solutions.

Evaluation of the Zurich meeting

The participants seemed to have found the meeting interesting, the scientists were pleased to become more acquainted with industrial problems and the people from industry were looking seriously for principles of work design which might help them. There was some frustration as both sides were made aware of the intricacies of the issues (theoretical and practical) although it was accepted that there were no simple answers because of the number of factors influencing situations, many of these factors themselves interacting in complex ways.

Evaluation of Project 335

In retrospect this project seems to have been remarkably purposeful and well organised. Much of this is to the credit of the EPA representative, Denise Lecoultre, but all the people involved in ad hoc meetings, team activities , visits and conferences appear to have been aware and enthusiastic about what they were trying to do and why. Of course there were only about three hundred people involved in total, many of the problems were old but this academic interdisciplinary way of looking at them was novel and the theory and practice were developing nicely in parallel. There seemed to be an important present and a great future and so it has proved.

References

Murrell, K.F.H. (1958). Fitting the job to the worker. Report on a mission to the USA and on the Leyden Seminar. The European Productivity Agency. OEEC, Paris.

Metz, B. (1959) Fitting the job to the worker. International Conference of Zurich. The European Productivity Agency, OEEC, Paris.

Emeritus Professor W. T. Singleton, M.A., D.Sc.

In 1950, after graduation in Natural Sciences and Moral Sciences, he stayed in the Cambridge Psychology Department as a member of the Nuffield Unit for Research into problems of ageing. He left in 1954 to set up an Ergonomics Department in the British Shoe Research Association. From 1960-65 he was Senior Lecturer in Ergonomics and Systems Design at the Cranfield College of Aeronautics. From 1965 - 1982 he was professor of Applied Psychology and Head of the Department of Applied Psychology at Aston University. Since 1982 he has worked as a consultant in ergonomics, safety, process control and information technology, in the UK and internationally.

He is an Honorary Fellow of the Ergonomics Society, and was appointed as the first Distinguished Foreign Colleague of the Human Factors Society in 1970. He received a recognition award from the International Ergonomics Association in 1988 and from the International Foundation for Ergonomics and Safety Research in 1991.

5 The EPA and Contacts with Human Factors

Frederik Bonjer

These recollections and interviews were collected and compiled by Pieter Rookmaaker and Ilkka Kuorinka.

IK: Dr. Bonjer, how did you get interested in ergonomics?

FB: Good question. I was always very interested in the relationship between men and their work, and that relationship can be further studied through physiology, and to a lesser degree, toxicology.

PR: Would you say then that technology was in your bones? That at a certain moment of choice, there was in you a dualism between men and machines?

FB: Yes, I have been inclined to change course. For example, once I had ideas about the construction of a new lifting crane. I've always been interested in technology and man's function, and in the interaction between the two. In a way it was my character that got me into all that.

In my somewhat strange career, I finished my studies during the war and escaped in November 1944 from German-occupied territory. After crossing the lines I resumed medical and surgical work in the liberated southern part of the Netherlands.

The allied forces organized the semi-military "Netherlands Red Cross Auxilliary Corps". There were 42 "feeding teams", each consisting of a medical officer and 14 nurses and assistants. Each team had an army ambulance for 8 patients and two trucks loaded with special nutrients for

parenteral administration to feed the victims of malnutrition and starvation.

In May 1945 the Germans surrendered and the medical feeding teams were sent out immediately over the central and northern Netherlands. Most teams moved into existing or former hospitals and stayed there until the end of August.

During that time, there was the day that I picked up all my diplomas in Leiden. Getting leave was difficult and I asked if I could come back the following week, which was accepted. A very strange way to obtain your medical and legal degrees!

Then I studied internal medicine for three years in Amsterdam from 1945 to 1948. From 1948 to 1951, I studied cardiology in Groningen. At that time, a number of people were called up for service. So I began my service with the air force, via the army, and stayed for a year or more in Soesterberg.

In Soesterberg I was ordered to set up an air force physiology laboratory. There was an empty building there, with only telephones—nothing more. No furniture, no instruments or appliances. That was on the Kampweg. So I had the job of installing low pressure caissons, and of setting up apparatus for measuring physical capacity. I had worked in Groningen on a physiological method, actually studying the displacement of the blood through pilots body when they were affected by directional changes and gravitational influences. The strongest G forces affect you from head to foot when banking or pulling out of a dive.

In Groningen I developed a method for measuring blood movement (displacement) within the body. And in Soestduinen, we had an air force radioradar laboratory, so we had ready-made airborne apparatus. Part of the installation was in the air and part on the ground, with telemetric communication between them. I was working intensively on aviation physiology during that time and went to England and somewhat less often to France in that connection. This is what is called

'applied physiology' or 'human physiology' in England. So I was dabbling in it for a number of years. Then my period of military service came to an end in 1952.

I was offered a civilian post in the research laboratory that I had started in Soesterberg on Kampweg 3. But at the same time, a post as future head of a department of Occupational Health was offered at the Netherlands' Institute for Preventive Medicine in Leiden. I finally chose Leiden. In 1953, I became departmental head.

PR: Was the term "ergonomics" known at that time?

FB: Not really, but my interest was there, because I was an early member of the English group, the Ergonomics Research Society. I frequently attended their annual conferences.

IK: Your career in ergonomics had roots in World War II experience. Did that war truly create something essential for ergonomics?

FB: As long as tools and machines used by man were not too complicated, relatively simple training methods met the requirements. Nevertheless, it took 3 to 6 years to learn some trades.

As tools and machines became more complex, more attention had to be paid to human capacities and limitations. More attention had to be paid to anatomical, physiological and psychological considerations. Collaboration of specialists in these fields with man–machine system designers created the new science of ergonomics in Europe and human factors engineering in the United States of America. The main transition took place with the armed forces in the second half of WW II. The steering of a submarine, the piloting of an aircraft and the operation of armored cars became so complicated that the operator became the limiting factor in the system. Similar developments occurred in industry during the postwar period.

The collaboration of disciplines continued and many national ergonomics societies were formed.

IK: And then came the EPA period. Dr. Bonjer, were you the leader of the European Productivity Agency's mission to the United States in 1956?

FB: Well—at first I had the role of observer, but naturally I played an important part in the development, since I was a member of the group—the 'team'—that was sent from Europe to America for a three-month period to see what there was to be seen and to be learned in the sphere of ergonomics.

PR: What team was that?

FB: The establishment of the team was related to the fact—which is indeed important—that the USA, after the Second World War, was endeavoring to encourage the rebuilding of a largely devastated Europe through the Marshall Plan. For its administration, an institution, the Organisation for European Economic Co-operation (OEEC) was established. That institution had a department, the European Productivity Agency, EPA, that concentrated on the rebuilding and development of industry in Europe, paying careful attention to the question of people. The OEEC also had a 'human factors' section, with an office in Paris as of 1955. This section intended to improve things by creating a team of nine experts from seven European countries. This team was sent to the USA to become familiar with modern developments in the area then called 'human factors'. I was able to be part of that team and was very much involved in it since the beginning in 1956.

PR: How long was the visit to America?

FB: It lasted three months. And, naturally, we had to report our experiences. The report was published in 1957 in a seminar, then called an EPA seminar, with the title "Fitting the job to the worker". That was actually a very good title because I believe that there is always the problem of explaining the precise aims of ergonomics; 'fitting the job to the worker' is a brief and clear definition. So the first EPA seminar was held under that title. That was in 1957 in Leiden. Not just the participants in the USA trip were present. Representatives of trade unions and employers' federations and international organizations were there, coming from Holland,

Switzerland, Germany, France, Austria, Belgium, Norway, Yugoslavia and England. I think that some 80 people attended that seminar. Among them were Prof. Belding from Pittsburgh, Prof. Burger from Eindhoven, Prof. Forssman from Stockholm, Prof. Lehmann from the Institute of Work Physiology at Dortmund, and Prof. Metz from Strasbourg, who is well known in this country. Dr. Smith from America and Mr. Stansfield from England also attended.

PR: The goal was achieved through visits and through the seminars? Those involved were spread out more widely than the specialized centers and research institutions.

FB: Indeed, I think a vision existed, which came to fruition in a good way. It was partly due to a single person. I say "person" and not "persons", because one of the very inspiring people at the EPA in Paris was Mme. Lecoultre. I know nothing of her background. But she had a definite vision, and she knew how to realize that vision by organizing visits and giving a goal to the EPA seminars. One example is the title "Fitting the job to the worker".

PR: That was her way of thinking?

FB: Possibly. That lies in the philosophy of things. I find what she did most important, and most satisfying that the IEA established itself (with its ups and downs, and initial difficulties and problems with the English), and began to function well and, in my view, still functions well.

IK: Back to the EPA mission, traveling was not always comfortable at that time?

FB: Indeed! I remember that the EPA was very cunning about our trip. They sent us out by Air France, but the return trip was by English mail boat. We were of course supposed to prepare a collective report to the EPA. The mail boat was supposed to give us a good week's time to write our final reports. But the weather was stormy and we had never been so seasick! So nothing came out of it immediately.

IK: The first discussions on an eventual international ergonomics association began after the EPA mission?

FB: Etienne Grandjean of Zurich acted as secretary when the initiative of forming a European ergonomic group was undertaken. It began with a steering committee being set up. And that, indeed, was the nucleus of the EPA, which is important. That happened in 1957 in Leiden. In 1958 the steering committee met again, this time in the headquarters of the EPA in Paris. Their aim was then to have a more precise definition, and to make a decision about establishing an international association.
The new association was not immediately called the International Ergonomics Association. That was decided in another EPA seminar in 1959 in Zurich with Grandjean as host.

The same steering group was there, together again for the third time to try out their ideas together, and with the two hundred Zurich seminar participants. That led to discussions about the future structure and about a definitive choice of name. I should say that an international group met regularly for two years. A steering group was busy on an ongoing basis with preparations for the IEA.

IK: There was also the question of relations between the Ergonomics Research Society and the eventual new association?

FB: In that same year, 1959, the Ergonomics Research Society in England organized an Annual Conference, with a large number of overseas members. That was in Oxford. At that conference, a definite opposition view was expressed: the ERS felt that they had so many international members, and that they had aligned themselves internationally to such an extent, that there was absolutely no need to form another international association. Thus differences arose between the English and the other Europeans, who had already played a definite role for a number of years.

The members of the steering group were there to meet for the fourth time. There they accepted the IEA's articles of constitution (it must have been in

1959) as they had been drawn up by Etienne Grandjean. In these articles, it was clearly stated that the IEA aimed to be "a federation of national societies in the sphere of ergonomics" (quotation F.B.), so then we tried, and finally succeeded, in persuading the English to co-operate. Eventually the ERS became a member of the Federation. So, at least in theory, the squabble, the opposition, was actually resolved. I myself played a part in this development as I had been a good client of the English organization, and consequently there was a certain mutual trust. On the other hand, I was an obvious champion of federation ideas for the founding of the IEA. The problem was solved in a friendly way. The first IEA Congress could then be held in Stockholm in 1961, the first founding assembly of the IEA. There the national ergonomic societies became members individually, as did countries where there was no national society.

PR: Also individually?

PB: Yes, that was allowed. Whether it was common, I no longer remember. This all took place in Stockholm in 1961, under the chairmanship of Sven Forssman. Sven was a medical man in the service of the Swedish Employers' Association. He was someone who could very well guide international societies and bring them together in a conciliatory way. Sven Forssman thus became the first president of the IEA, which was very convenient, and Grandjean became the first secretary-treasurer. Then there was a new development, a newsletter. The ERS had published a an international journal called 'Ergonomics'. The editorial board had, since the founding of the IEA, given sort of an impression of consisting of leading ergonomists from various countries. Etienne Grandjean sat on the editorial board—probably for Switzerland. I have also sat on the board, so it was easy later to persuade the Netherlands Ergonomics Society to make an official contribution to "Ergonomics". Other board members were Rutenfranz from Germany, Metz from France, Welford from Australia, and I believe, Hywell Murrell and Cotes from England and Belding from the USA. In the end, the editorial board was in fact a reflection of the leading members of the IEA.

PR: Your narrative has a strong European bias. It seems that America played an important part in the early days, for example in the fact-finding mission, but drifted later into the background, as did perhaps other non-European countries.

FB: Your remarks are perfectly correct. Actually, when we got moving in 1956, there were already several initiatives, think-tanks in Europe, mainly in England, I believe. They were definitely not as vigorous as the American initiatives at that time. We consulted American researchers and think-tanks dealing with this subject. I say this quite openly and frankly in order to explain the situation as clearly as possible. What happened later is another story. There were many activities in America from which we really learned a great deal, such as the work of Chapanis, clearly someone who was working in an area in which we could learn a lot. We gathered ideas from various visits, to the Bell Telephone Company, for example. They were busy at that time with what we called 'human factors'. I remember—and this is no joke—that I was strongly impressed that research was being carried out on the difference in efficiency between choosing telephone numbers by voice rather than dialing them. And I thought, "Heavens, how can they all accept this sort of thing in a good research organization?" A young woman sat there who was forbidden to speak; she was only allowed to listen. Why was Bell Telephone investigating this sort of subject? Was it better if people said what telephone number they wanted to contact rather than dialing that number?

PR: Apart from the word, what did the title 'ergonomics' imply in Europe?

FB: You could say that in Europe, technical scientists (experts) and medical experts played a relatively large part, made a contribution to ergonomics, while in America, psychology, so-called engineering psychology, played the biggest role. You saw that a little bit in England, too. There was a more or less similar difference between the British Isles and the continent. The UK was a little more in line with the USA.

IK: Quite a few medical doctors showed interest in ergonomics in Europe in the early days. What attracted them to ergonomics?

FB: The essence of ergonomics is the study of the relationship between man and his work or environment. In most cases, the interest is in the nature of the limiting factor. This may be physiological, psychological, perceptual, environmental or even emotional. The type of work, the climate and the tradition of the country and availability of skilled workers will determine which aspect is the first to get attention.

Heavy muscular work, often resulting in a high energy expenditure, was mainly studied in Scandinavia, Finland, Germany and the Netherlands. Logging, agriculture, fishing, mining and building were of interest to physiologists. Determining the required rest breaks and comparing different methods of doing the same work are examples of the contribution of work physiology.

The measurement of oxygen consumption, cardiac output, respiration and body temperature during work show the adaptation of bodily functions to physical work and their return to resting levels. These functions are reversible.

The response to work and rest can be improved through training, just as the response to unusual climates can result in acclimatization.

Medical officers in the army, navy and air force in many western countries have been interested in human and environmental physiology. Many other names in early ergonomics have also been active in their respective armed forces.

Health hazards are not the primary concern of ergonomics. Occupational health officers and medical doctors in industry have to monitor the relationship between men and work or the work environment in such a way that no irreversible changes occur, such as permanent hearing loss, emphysema, asbestosis or lead poisoning. They are responsible for the early detection of precursors, signs or symptoms of occupational diseases.

Medical doctors with training in ergonomics will have a good success rate in recognizing disabilities of the back, bones and muscles caused by inappropriate working postures or improper patterns of movements.

The interest of medical people and human physiologists in ergonomics is typical for Europe. Alphonse Chapanis reported to the 4th International Congress on Ergonomics in 1970 in Strasbourg, France, the results of his comparative study of Ergonomics and Human Factors Engineering. He stated that one third of all papers presented to the Ergonomics Research Society and one half of all papers presented to the Société d'Ergonomie de Langue Française had a physiological content. In contrast, only one in eight papers presented to the Human Factors Society had this characteristic.

IK: *Therefore, in your opinion, interest in human physiology made ergonomics interesting to medical doctors.*

FB: That interest was perhaps proportionally greater in Holland than elsewhere. Industrial medicine, or occupational health, was flourishing in Holland at that time.

PR: Was that because of certain individuals?

FB: Yes indeed, pioneers like Burger, de Groot, Vertin, Fortuin, van Wely and members of my own staff.

The start was far from easy. If I should meet someone, someone from that time, like Jan Bosman, he would say, "If you had to go through it all again, you would sink to the ground in despair."

PR: You could perhaps say: "The goal has been reached." How did awareness develop at that time about hard physical work?

FB: I don't actually know. There were naturally very important social developments. Hanging in this room are a couple of pictures, and one of them is a horse-drawn cart. That was a different age. By then, hard physical labour was normal and accepted. You see a number of barges (canal boats)

in one picture and a number of wagons. With these wagons, earth was loaded onto the barges in Friesland and then transported via the Zuider Zee to the tulip fields. That was heavy physical work, all manual. Then mechanization came, and then automation. With these developments came an emphasis on the difficulties, limits, and misery of that heavy physical work. This was gradually substituted by complicated man-machine systems requiring knowledge and the application of ergonomics.

Frederik Hendrik Bonjer

Dr. Frederik Bonjer was President of the International Ergonomics Association from 1974 to 1976, after being Secretary General from 1972 to 1974. He was one of the individuals who founded the International Ergonomics Association, being among other things, the leader of the European Productivity Agency mission to the United States in 1956.

The following lines summarize the many-sided career of Frederik Bonjer:

Born May 13, 1917 in Rotterdam, the Netherlands

1930 - 1936	Gymnasium Erasmianum in Rotterdam
1936 - 1944	Medicine Universities of Leiden and Amsterdam (MD)
1945 - 1948	Specialized as Internist at Amsterdam
1948 - 1950	Specialized as Cardiologist at Groningen
1950	Ph.D. in Physiology
1950 - 1952	Medical service, Royal Netherlands Air Force
1952 - 1953	Netherlands Institute for Preventive Medicine in Leiden
1953 - 1970	Chief of the Department of Occupational Health in the Netherlands Institute for Preventive Medicine
1967	Visiting Research Professor, State University of Kentucky Consultant, US Public Health Service, Washington DC
1970 - 1976	Editorial Board of the Int. J. Ergonomics
1970 - 1982	TNO Health Organisation, The Hague
1972 - 1974	Secretary General, IEA
1974 - 1976	President, IEA
1976	6th IEA Congress, College Park, Maryland, USA
1974 - 1986	Preventive Cardiology Section, University of Leiden

6 Recollections from the early days of the IEA

Recollections have been compiled by Ilkka Kuorinka.

Interview with Bernard Metz

This interview is based on Professor Metz's tape-recorded recollections, which have been completed with his written notes and by later discussions with him in 1999.

IK: Professor Metz, you were one of the eminent specialists who initiated ergonomics in Europe. How did you get involved in it?

BM: When the Association, the IEA, was founded in 1961, it was a product of four years of international contacts: they started in 1956 with the mission of ten European human factors experts, which was called "fitting the job to the worker". The mission was sponsored by the European Productivity Agency, the EPA. The secretary was Hywell Murrel, and another member of the British Ergonomics Research Society, Tom Singleton, was a member of the group. The mission to the USA was initiated by the Human Factors section of the EPA. The principal officer was a (then young) Swiss lady, Denise Lecoultre, who spoke fluent French, English and German. Her office was in Paris where she kept in close contact with several occupational health, physiology and psychology specialists. Among them was Dr. J.J. Gillon, chief medical officer for occupational medicine in the French Ministry of Labor. He played an important role as initiator, in particular by setting the goal of the mission to the USA as: "Fitting the job to the worker". He also had an influence on who the French delegate would be, with the rule being "one man, one country". Two names were proposed: Alain Wisner's and mine.

All potential delegates were interviewed in their home countries by the American envoy, H.S. Belding, during his tour in January-February 1956. It appeared that we had briefly met in October 1950 at the end of my one-year Rockefeller fellowship in the USA. I had tried to visit the US Army's Climatic Research Laboratory, located at that time in Lawrence, Massachusetts. In fact, the whole Center was leaving this location for Natick, where it is still in operation. H.S. Belding was about to leave this military institution for an academic appointment with Professor Hatch in Pittsburgh, Pennsylvania. He had set up the specifications for the new Climatic Research Laboratory and its Human Physiology department, whose first director was Austin Henschel. I had worked with him under Ancel Keys in the Physiological Hygiene laboratory at the University of Minnesota during the year of my Rockefeller fellowship. Many staff members had been trained in Douglas Dill's Fatigue Laboratory.

Belding's recommendation on my behalf, as well as the fact that Alain Wisner (who had recently joined the Renault Car Manufacturing Company) could not obtain the 2-month leave of absence for the mission to the USA, resulted in my appointment as the French delegate.

IK: *"Ergonomics" was a relatively unknown concept at that time?*

BM: I confess quite frankly that although in 1956 I had just started an occupational physiology laboratory at the Faculté de Médecine of Strasbourg with the financial support of the National Social Security Fund, I was then unaware of the whole field of ergonomics. I was unfamiliar with the word until I met Murrel and Singleton in the hall of the Invalides Air Terminal in Paris where the participants of the USA mission met a few hours before takeoff for Washington DC. Except for Frederik Bonjer, the Dutch delegate, who had already attended a meeting of the Ergonomics Research Society, ERS in Great Britain (the reason why he was elected chairman of the group), none of the non-British members of the group knew exactly what the word ergonomics denoted. This was the case for the Austrian delegate Schoeffel, the German delegate Schulte, the Italian delegate Ianacone, the Norwegian (whose name I have forgotten), and the delegate of the Council of Free (i.e., non-communist inspired) European Trade Unions, another Austrian named Paul Blau.

As the tour of the USA progressed, the term "ergonomics" became more understood through a truly "dialectical" process in which the ERS views, presented unreservedly by Murrel and Singleton, confronted those of successive American interlocutors. Some of them expressed, however, their personal preference for the ERS views over those prevailing in the Human Factors Society. They later became strong supporters of an international ergonomics association based on individual membership, which they joined with the deliberate purpose of breaking loose from the HFS. Later, they were quite unhappy when the IEA became a federation of national or regional societies. This meant that individual members were no longer allowed from countries where a national society existed. The result of the massive influx from the HFS into the IEA proved detrimental for the old world spirit of the early IEA.

IK: *The EPA mission to the USA was not an isolated act, but had important sequels?*

BM: After this mission to the USA, the ten European experts participated in organizing a seminar, still with Hywell Murrel and with the support of the EPA, which was held in March-April 1957 in Leyden, Holland. The aim of this seminar was the dissemination of conclusions and observations contained in the mission's report. The participants were mainly human factors and human science experts from European countries, but also from the United States, Canada, Australia and New Zealand.

Many aspects of ergonomics met the needs of industrialised countries in the recovering economies in Europe. As a consequence of this Leyden seminar, it was felt that it would generally be useful to inform social partners of this fact. This was the aim of the Zurich tripartite conference that took place in 1959 with ergonomics experts, and delegates from employers' and workers' unions.

This Zurich conference was very carefully prepared. All lecturers were invited to meet in Paris two months before the conference in order to make sure that there would be no overlapping of the lectures and that no important point would be missed. Agreement was also reached on the style of the presentation. And the papers were available a few weeks before the conference. This left time to prepare the translations in two of the three conference languages. The papers could therefore be distributed in English, French and German.

It was during this meeting that contacts were made to create an international association whose members would first of all be ergonomists or scientists contributing to ergonomics. This association was founded in a meeting in Great Britain in 1960.

Another follow-up to the mission to the USA, the Leyden seminar, and the Zurich tripartite conference, was an international awareness-raising meeting on the introduction of ergonomics into curricula of technical universities and higher engineering schools. Once again, Hywell Murrell was in charge of this action sponsored by the European Productivity Agency. He toured all western European countries to contact both the major teaching institutions involved and the governmental authorities in charge of them.

The meeting took place in Liège, Belgium (in 1961, if I remember correctly). Just as with the Zurich conference, the lectures were co-ordinated several weeks before the meeting, and manuscripts (submitted in English, French or German) were translated into the two other languages under the control of the organising committee. An excellent interpreting team was briefed one day before the meeting on the terms and concepts of ergonomics and related human sciences as well as on the systems of higher education existing in the European countries represented.

Even if no short-term effects of this meeting were reported, it seems that many delayed consequences have occurred. The documents and discussions of the meeting have inspired many ergonomics curricula introduced since 1961. Papers and resolutions from a NATO symposium on the same subject held in Berchtesgaden around 1970 had the same effect. Last but not least, this symposium set the foundations for the criteria for being registered by CREE as a European Ergonomist.

I personally took part not only in the mission to the United States, but also in the Leyden seminar, the Zurich tripartite conference in which I was the general rapporteur, the meeting in Liège and the Berchtesgaden symposium. But I did not attend the meeting where the International Ergonomics Association was founded. One of the features was that it was decided to have its headquarters in Switzerland, once the rules were registered according to the terms of Swiss statute law. This allowed membership fees to be paid in Swiss francs. The first honorary secretary general was a Swiss colleague, the late Etienne Grandjean from the Federal Polytechnic Institution.

The decision to found the International Ergonomics Association was preceded by a generous offer from the Ergonomics Research Society to become fully international and to set up national chapters in the various European and overseas countries. But this offer did not seem realistic because of the idiosyncrasies of the various countries, as for example, the way of running the meetings, especially the general meetings on administrative matters. It was considered more appropriate that every country set up a national society (or a regional society grouping neighbouring countries either on the continent or elsewhere in the world).

IK: *You were involved in several of the IEA Triannual Congresses?*

BM: The newly founded International Ergonomics Association held its first international congress in 1961 in Stockholm. Its organiser was the chief medical officer of the Swedish employers' association, Professor Sven Forssman. This meeting was an opportunity for some groups from different countries to set the basis for national associ-

ations. In particular, the French ergonomics society (Société d'Ergonomie de Langue Française, Society of French-speaking ergonomists) was initiated in Stockholm where at least the decision to found it was taken. The administrative steps took place afterwards.

The meeting in Stockholm was the first of the regular sequence of international congresses of the IEA, which were successively held in 1964 in Dortmund, 1967 in Birmingham, 1970 in Strasbourg, 1973 in Amsterdam, 1976 in College Park, Maryland, near Washington DC, 1979 in Warsaw, 1982 in Japan, 1985 in Bournemouth and so on...

I was personally involved in the preparation of three of these congresses. I organised the congress in Strasbourg, and during its preparation, I received advice from two IEA delegates who were members of the Ergonomics Research Society. One was Pat Ruffel-Smith, and the other was John Fox. Both provided us with very relevant suggestions based on the expertise they had gained in organising the congress in Birmingham three years earlier.

After the congress in Strasbourg where I was elected president of the IEA, I had to provide the same assistance as I had received from Ruffel-Smith and John Fox to the organisers of the Amsterdam congress. This allowed me to participate on three occasions in meetings of the Dutch organising committee held at Schipol Airport near Amsterdam. I therefore met in particular Frederik Bonjer, who had been a member of our group during the mission to the USA in 1956, as well as Jan de Jong and Pieter Rookmaaker. As a matter of fact, Bonjer became president the IEA after the congress in Amsterdam, and we had the opportunity to meet on several other occasions.

It was around the time of the congress in Amsterdam that it was felt that the IEA should move from the status of individual memberships to a federation of national or regional societies. But I do not remember exactly when the decision was finally taken to make this change (in 1976, IK).

IK: *IEA gradually developed relations with the Soviet Union and other Eastern Bloc countries. You were among the first ergonomists to establish contacts with Eastern Bloc countries?*

BM: It was also during the time I was president of the IEA that, with Alain Wisner who was then honorary treasurer of the IEA, I was invited by our colleagues Boris Lomov and Vladimir Munipov of the USSR to participate in the first ergonomics conference of COMECON countries held in Moscow in July 1972. This was an exceptional opportunity for disseminating the view of western ergonomics among the various member countries of COMECON. I would like to stress the eagerness of our colleagues from all countries, Poland, Czechoslovakia, Bulgaria, Romania, the Soviet Union, and East Germany. They not only wanted to assimilate the way of thinking of western ergonomics, but were also anxious to be allowed to found societies which would be run according to the rules of free associations in the west. This was the subject of the talk that I had been invited to give at one of the general meetings of this Moscow conference. I had insisted on being free to expose unambiguously the requirements that an ergonomists' association in an Eastern country would have to satisfy to be accepted as a federated society in the IEA.

It was immediately following this conference that our Polish colleagues, in particular Jan Rosner and Andrzej Oginski, took steps to be allowed to form in Poland, which was still under communist rule, an association with non-compulsory individual membership, freely-elected committees, etc. This enabled the Polish Society to be founded in due course before the IEA congress, which had been decided to be held in Warsaw in 1979.

Between 1973, when the congress in Amsterdam took place, and 1979, when the congress in Warsaw took place, I had the difficult duty of defending the holding of the IEA congress in Warsaw against several criticisms about the risk of meeting in a socialist country, and the risk of being overwhelmed by low value contributions coming from these countries. Thus, the IEA Council prescribed that I should take responsibility for

its organisation as its delegate to the Polish Ergonomics Association, in order to make sure that the congress in Warsaw would meet the standards already established by previous congresses of the IEA following the congress model of the ERS in Great Britain.

The preparation of the congress in Warsaw was a rather interesting experience because, due to the fear of "samizdat", almost no photocopying equipment was available, and also because a difficult balance had to be maintained between the members of the western and eastern countries regarding the papers that had been submitted either for poster presentations or for oral presentations. We had to refuse many papers which were much more related to occupational medicine than to ergonomics, but also papers from Eastern Germany, which were merely political propaganda.

Finally the congress in Warsaw could be held, I think, under rather good conditions.

I want to go back to make an additional point concerning the preparation of the Warsaw congress in 1959. Since we had refused, under my responsibility, three or four papers strongly politically oriented and presented by teams from the German Democratic Republic (East Germany,) I took the opportunity during a standardisation meeting that was taking place in West Berlin to pay a visit to the director and deputy director of the Zentralinstitut für Arbeitsmedizin in the DDR (the central institute for occupational medicine in the German Democratic Republic) to explain to them why I had insisted that the organising committee in Warsaw refuse several East German papers. I took this step to avoid the Polish organisers having to bear that responsibility. To my great surprise, these two gentlemen agreed strongly with our decisions and told me that they were glad that we avoided the bad image that such papers would have given of East German ergonomists.

Another event of importance has to be mentioned, namely the IEA symposium on standardisation which was held in Loughborough in April 1973 immediately after the IEA congress in Amsterdam. This symposium was the origin of the foundation of ISO Technical Committee 159/ergonomics, and subsequently, CEN (Comité Européen de Normalisation) technical committee 122 also called 'ergonomics' which was actually the fruit of the ISO activities.

I could add that I was involved in the preparation of the IEA congress in Paris in 1991. And that, for us in France, the IEA represents an essential framework for international co-operation. But as founders of the French ergonomics society, we never forget that the true source and the first impulse for its founding came from the existence of the Ergonomics Society in Great Britain.

Bernard Metz

Bernard Metz was president of the International Ergonomics Association from 1970 to 1973. In 1970, he organised the fourth IEA Conference in Strasbourg, France, and has been actively involved in most of the founding meetings of the IEA. He is also founding member of the Société d'Ergonomie de Langue Française. Bernard Metz has been the prime driving force in the standardisation arena, especially in ergonomics standardisation within the framework of the ISO and CEN, being since 1975 the chairman of the French ergonomics standardization commission.

Bernard Metz is honorary professor at the Faculté de Médecine, Université de Strasbourg. He is founder of the once world famous Centre d'études bioclimatiques in Strasbourg.

7 Moving from a society of individuals to a society of societies

Reginald Sell

Establishing the IEA

When the IEA was set up in 1959 it was set up as an organisation with only individual members. There was some justification for this in that were very few ergonomics societies in existence and it was felt that it would be unfair to those people who wished to participate from countries without ergonomics societies of their own if the basis for membership was membership of a national society. The national ergonomics societies that existed at that time did not share that view and felt that they should have more influence. The Ergonomics Research Society (as it was called then), for instance, thought that those individuals from countries without an ergonomics society of its own could always join a society in any appropriate country. The ERS as the first ergonomics society in the world had always had a large international membership and so saw no problems with this.

In fact there was a view within the ERS that there was no need for a new international organisation at all as the ERS considered itself as being very international in nature. However, at the formal meeting to establish the IEA, which was held during the ERS 1959 Annual Conference, these views were not perpetuated.

There was also concern expressed from some people that such an organisation would be unable to belong to other international organisations like the International Council of Scientific Unions (ICSU), the World Health Organisation and the International Labour Office which would only have societies of societies as members. (It is interesting to note that the IEA has never actually felt the need to belong to ICSU, even since it became such an organisation, perhaps because it sees itself more as an applied technology organisation rather than one concerned with basic science).

At the time of setting up of the IEA the General Assembly was established as the main decision making body. This was the general meeting of all members held in conjunction with the triennial congresses. This body had little time to think about the consequences of the decisions it was being asked to take and so in reality the main decisions were being taken by the Council which was elected by the General Assembly and met, usually annually, in between congresses. National ergonomics societies felt that they had little organisational influence on the Association because they were not formally represented on the Council or the General Assembly.

Moves towards being a society of societies

By the time of the 1964 congress in Dortmund there had been great pressure on the Council by the National Societies to move the IEA towards being an association of societies. At that General Assembly there was agreement to speed up the move towards the IEA becoming a Federation of National Societies but this was by no means unanimous with a vote of 25 in favour, 15 against and 9 abstentions.

What was not agreed, however, was a proposal that future General Assemblies should be arranged to have a majority of voting members from Federated Societies - 12 in favour, 21 against with 8 abstentions. At this time there were four societies which became Federated members – SELF, Netherlands, Italy, and Japan. The Ergonomics Research Society, however, who were to become the hosts for the next (1967) Congress expressed an unwillingness to become a Federated Member under the rules as adopted at the 1964 meeting.

Between the 1964 and 1967 congresses very active discussions took place between the Council of the IEA and the representatives of the various Ergonomics Societies and by the time of the 1967 Congress in Birmingham, England the Ergonomics Research Society, (UK) the Human Factors Society (USA) and the German Society had joined with the expectation that the rules would be changed again

The 1961 and 1964 Congresses were organised by international groups as sub committees of the IEA although they were largely made up of people local to the site of the meetings. The ERS created a precedent and organised the 1967 meeting itself as a Federated Society on behalf of the IEA. This established the pattern for the future and all subsequent congresses have been organised by the appropriate Federated Society.

At this Congress the General Assembly was held in two halves the first half under the old rules and the second under the new. The major decision taken here was to increase the power of the Federated societies. The General Assembly remained the decision taking body but now consisted of Federated Society delegates in proportion to the size of society and delegates of corresponding members (Individual members) elected as representatives by those corresponding members present before the meeting. It was also decided that that individual members could not stay as such if they were already members of Federated Societies even if, as was the case with some foreign members of the ERS, they were not resident in the home country of the Society.

Fees for membership of the IEA were set on the basis of two Swiss Francs for each member of a Federated Society and Twenty Swiss Francs for a corresponding member making it much cheaper to be a member through a Federated society.

Whilst in 1973 the Council, which was in practice governing the IEA, was largely made up of representatives of Federated Societies it was not formally linked to them. The General Assembly, which was formally still the governing body, was linked directly to the Federated Societies in that membership of it was related to the size of each Society. There was, however, still representation on this by individual members and there was concern that they might feel disenfranchised if the general Assembly ceased to have a governing role.

In 1976 the IEA moved to make the Council the governing body ensuring that the Federated Societies now had complete control. Voting on the Council was established according to the size of Federated Society with no votes for less than 50 people, one vote for 50-100, two votes for 100-1,00 and three for over 1,000. There were still corresponding members but with no vote. From 1979 there have been no individual members. Any applicants for individual membership from countries without Federated Societies were told to apply though whichever of the Federated Societies was most appropriate to them.

The General Assembly has remained as a general forum where any member of a Federated Society has the opportunity to hear about IEA actions and to ask questions of the IEA Executive. It is no longer a decision making body.

Other membership issues

There have been a number of issues regarding the criteria for membership, voting and subscriptions of Federated Societies. One of the main reasons for disagreement concerned those societies from Eastern Europe. Up to the late 70s organisations in Eastern Europe were organised in a different way from those in the West. They were not democratic societies or self-governing in that they were more like government related organisations such as the Polish Committee on Ergonomics and Labour Protection and the Czech Committee for Scientific Management. Even though they were not organised on Western terms it was felt desirable that they should be members of the IEA to ensure that the IEA was representative of all countries.

As they did not have individual members they were not registering high numbers for subscription purposes. This meant that they were paying very much less than western societies but were still requiring the same amount of service. As a result it was felt that each society should pay a fixed fee plus a per capita fee for each member to even things out. Some societies did become members of the IEA without official approval in their own country and never paid their subscriptions even though they remained nominal members for some years!

In 1979 the Polish Ergonomics Society was accepted as the first Eastern Europe Society organised in a traditional way and this has led to many more joining since. All Federated Societies are now self-governing in the traditional Western way.

There have also been a number of attempts to bring in Affiliated Societies. These are societies which, whilst not ergonomics societies as such, do have a major interest in the subject. In the 70s the Spanish Psychology Society was such a member and for some time now the Japanese Society of Human Ergology has been an active member in this category.

There have also been attempts to bring in large international companies as financial supporters. At one time AT&T were such members but there has not been much success with this initiative. There are also problems in that most large organisations have their main base in one country and there might be competition between the IEA and the local Federated Society for this kind of support.

The first two IEA congresses were organised by the IEA itself. Since then, all have been organised by the local Federated Society under the auspices of the IEA. However, the IEA has set up meetings in places covered by a local Federated Society without involving that society. This has created criticism and questioning that is directly linked to the organisational structure of the IEA, which is comparable to that of United Nations' bodies. It therefore creates similar problems. We can also recognize the link to the political debate on the conflicting trends between the sovereign power of "nation states" versus "internationalism". This debate is well known to Europeans and others.

The relations between the IEA and its federated societies is a moving target. An opinion that has been fiercely defended by strong national societies is that the IEA should not do things that are the prerogative of national societies. Typically national/regional societies may have been openly less stringent but not necessarily less so in reality. Some societies, however, may have seen such an extension of activities by the IEA as even desirable. A debate on the relative roles of the IEA and the federated societies is continuously on the agenda and both parties have to find a modus vivendi in this situation. However, it must be said that the Council, which represents all the federated societies, is the governing body of the IEA and has all the powers for regulating the limits of the federation. The centre of gravity of the debate is therefore within the Council. So far, most problems have been resolved without major conflict.

There is also the question of having only one society for each geographical area, versus the regional, and even global interests of some societies. In a few cases, these interests have been in conflict with IEA principles, although a lid has to a great extent been kept on the problem. "One (ergonomics) society, one geographical area" has been debated on the basis that er-

gonomics should present a unified front to governments, etc., in that area. The concept is not without discrepancies, and from a historical perspective, similar concepts have varied greatly. It seems that political realities, economic importance, and to a lesser extent scientific dominance, determine the mutual influence of an international body like the IEA and its federated societies, more than formal principles and regulations.

Reg Sell

Reg Sell was one of the first people in the UK to have a job as an ergonomist. His first work was on control room design for the steel industry and associated organisations then on power station and grid control for electricity generation. Since the early 70s his main work has been concerned with helping organisations to develop better ways of designing jobs and organising their work.

He has held many posts in The Ergonomics Society including Meetings Secretary, General Secretary Chairman and President. He took an active part in the organisation of the 1967 IEA Congress and was Chairman of the organising committee for the 1985 IEA Congress. He was also Chairman of the group set up to organise the celebrations for the Society's 50th anniversary.

He was Secretary General of the IEA from 1973-79 and has been on its Council on and off since 1966 and continually since 1991.

A lot of his recent activities have been concerned with trying to bring ergonomics to the attention of government and other organisations through membership of committees concerned with occupational health, new technology and research.

He has represented the Ergonomics Society on CREE , the IEA Council and the Parliamentary and Scientific Committee. The Parliamentary and Scientific Committee is an informal grouping of members of bot Houses of Parliament and representatives of scientific institutions. He has also served as Secretary and a Vice President of this body.

8 Emergence of ergonomics/human factors science and the International Ergonomics Association – concepts, perspectives and debate

Thomas J. Smith

Karl U. Smith
(Deceased)

Overview

This chapter is dedicated to the memory of Karl U. Smith (K.U. to all who knew him), who presented a series of recommendations to the Leyden Seminar in 1957 (European Productivity Agency (EPA), 1958; Kuorinka, this volume) calling for establishment of an International Association of Work Scientists. The Leyden Seminar, and these recommendations, set in motion a chain of events which culminated in the establishment of the International Ergonomics Association (IEA), for which K.U. served as first Treasurer. K.U. died on June 22, 1994, just days before the IEA honored him with a Founders Award at the 12th Triennial Congress in Toronto, that Thomas J. Smith (K.U.'s son) accepted on his behalf. K.U. compiled and retained an extensive collection of historical documentation pertaining to the early history of the IEA and to the emergence of ergonomics/human factors (E/HF) science, some of which he summarized in two reports published in the decade before his death (K.U. Smith, 1987, 1988). K.U.'s perspectives on the emergence of both the IEA and the E/HF field itself - which have attracted some controversy (Fox, 1988) - -represent a fascinating and provocative testimonial by a first-hand witness and contributor to the emergence of both E/HF science in the U.S. and the first international body devoted to ergonomics

Rather than simply reviewing the history of these movements, which is dealt with elsewhere in this volume and by K.U. himself (op cit.), this chapter outlines a series of conceptual issues and perspectives pertain-

ing to the origins of both the IEA and E/HF science, based largely on unpublished chapters, letters and notes that form part of K.U.'s historical archive on the IEA. The focus primarily is on areas of uncertainty and/or controversy in the viewpoints of the major originators of these concepts. As such, the chapter's purpose is threefold: (1) to underscore the point that the founding of the IEA, and more largely of E/HF science itself, was not as straightforward as sanitized historical accounts might lead one to believe; (2) to discuss the conceptual background to historical developments during the fifties; and (3) to reflect on the degree to which early visions and goals of the IEA and the field have been realized over the ensuing five decades. K.U.'s contributions, with some editing, are in plain text demarcated by quotation marks - material cited is quoted verbatim from K.U.'s writings. Commentary by T.J. Smith is in italics.

K.U. was fiercely protective of the originality and ownership of his ideas, and deeply resented any effort to misinterpret or distort them. Raised as one of nine boys in a working class household, and intimately familiar with hard, blue collar work as a teen and young adult, he became the first of his family to succeed in an academic career. This background undoubtedly contributed to his lifelong dedication to workers and to human work and to his combative professional nature, reflected in some of his commentary below.

Conceptual inspiration for formation of the IEA

There are two major conflicting viewpoints on the conceptual inspiration for formation of the IEA: those of Ronald G. Stansfield and of K.U. Smith. Stansfield maintained that the primary inspiration for the IEA was the British Ergonomics Research Society (ERS), referring to the ERS as the "direct antecedent" (1980, p. 103) and the "pioneer" (1985, p. 1006) to formation of the IEA. K.U. vigorously disputed this view, maintaining instead that the inspiration for the IEA was the body of theoretical and practical concepts associated with development of HF science in the U.S. during World War II (WWII), and that the idea of "fitting the job to the worker" (the theme of the EPA Project 335 mission to the U.S. and of the Leyden Seminar) originated with the need for "fitting military equipment to combat personnel" during WWII (K.U. Smith, 1988). Additional commentary that elaborates on K.U.'s viewpoint is provided in the following excerpts (1) Copies of published or unpublished material cited in this chapter may be obtained upon request from Thomas J. Smith

[From an unpublished Oct. 18, 1985 letter from K.U. to Arnold Small, then Historian of the Human Factors Society, prompted by Stansfield's 1985 paper, edited and with florid rhetoric omitted].

"Dear Arnold:

I am enclosing copies of Stansfield's section in the recent IEA Congress in Bournemouth...I have been trying for some time to organize my own thoughts about what Stansfield's fictions regarding the founding of the IEA really add up to, and I think I now have the ideas in some order...The gist of the historical story of IEA is that the U.S.-based human factors knowledge and emphasis that I brought to the Leyden Seminar, and my sensing and reading of the...British activity in trying to defuse the European emphasis on worker factors in the seminar, made it possible for me to write the preliminary bylaws and proposal for the international society, and to have these adopted enthusiastically by the Continental members of the seminar. That is to say, the real force of the group for organization of the IEA was the U.S. human factors influence which I represented... The evidence for this point of view is that there was a strong movement and effort prior to the Leyden Seminar among Continental members of EPA to create a human factors approach to the seminar that would be concerned with work design and worker motivation...It just so happened that my formulation of the meaning of human factors science in this regard corresponded to what many people had intended originally in the Leyden Seminar, a correlation which served as a basis for forming the IEA at the end of the seminar.

I think that Lecoultre (Lecoultre, 1985) in her piece at the recent Congress put a little light on the origins of the IEA. In this she mentions the human factors concerns of EPA prior to the Leyden Seminar, and notes that there was continental opposition to the use of the British term, ergonomics. She also notes that fact that the EPA mentions the mission of EPA members to the U.S. in 1956 as a critical factor in eventual formation of the IEA..."

[1] Copies of published or unpublished material cited in this chapter may be obtained upon request from Thomas J. Smith.

[From an unpublished chapter entitled, "Origins of the IEA - Emerging Concepts of Adapting Work to Human Needs," prepared by K.U. in the late 80's to introduce an intended book on the history of the IEA.]

"Primary Origins of the IEA

Inasmuch as the field of ergonomics has become tightly integrated with that of human factors (HF) science,...the origins and early development of ergonomics is of general interest. The view advanced here is that the organization of the IEA defined the primary origins of ergonomics as that field of science primarily concerned with adapting work design to meet human needs. This chapter's senior author, K.U. Smith, is especially qualified to discuss these origins since he developed and wrote the initial proposals and preliminary bylaws which led to the formation of the IEA at the University of Leyden in Holland in 1957.

There are two key questions pertaining to the origins of the idea of ergonomics of the IEA. The first concerns the essential meaning of the U.S. concept of ergonomics as an aspect of HF science. The second is whether British contributions to work science and to the design of military equipment and operations prior to 1957 were critical in originating the field of HF science and in leading to the formation of the IEA This chapter's senior author had personal knowledge and complete records of events leading up to the organization of the IEA, including a survey of HF research in the U.S. and Great Britain in the middle 1950's by an organizing committee of the Leyden Seminar. Based on these records and observations, the conclusion drawn regarding both of these questions is that development of HF science in the U.S., especially related to beginning efforts in scientific research on HF in work design, led to the primary proposals for and the initial organization of the IEA.

The IEA was formally organized at a meeting of the Organizing Committee of the Association in Paris in the fall of 1959. A Steering Committee was formed during the Leyden Seminar in the fall of 1957, to address specific, detailed proposals of the senior author of this chapter to set up an international organization for the scientific study of HF in design of work. The Leyden Seminar, "Fitting the Job to the Worker," had been organized by a commission of the European Productivity Agency (EPA), an operational arm of the Organization for European Economic Cooperation. This commission had the task of organizing and naming the seminar, to follow up a 1956 mission to the U.S. to explore emerging applied and theoretical studies being done on HF science and its implications for raising European industrial productivity.

At the time in late 1956 when the EPA mission came to the U.S., the EPA commission, composed of members from different European nations, identified the field of ergonomics in Europe with the field of human engineering or engineering psychology in the U.S. (EPA, 1958a, 1958b). The questionable validity of this linkage is indicated by the fact that when names for the new IEA were first proposed in 1957, a majority of the Organizing Committee of the Association opposed the British term "ergonomics" because it lacked any definite scientific meaning...

It is doubtful that the term achieved any significant HF meaning in WWII or during the ensuing decade since it was used generally to designate established fields of environmental physiology, anthropometry, motion study, work study, and industrial engineering. In the period just before the Leyden Seminar, there were no specific research programs in English universities which could be described as being specifically concerned with HF design of work or working conditions, other than conventional work study programs (Svensson, 1959).

Prior to the Leyden Seminar, an informal British Ergonomics Research Society existed. Reports differ on the degree of organization of this society. The facts suggest that it was more of an informal scientific fraternity than a formal professional scientific organization. Proposals presented at the Leyden Seminar by K.U. Smith to set up an International Association of Work Scientists were based on the belief that the British Society lack significant acceptance on the Continent or in the U.S., and that the interests of its members were principally concerned with determination of work efficiency based on work productivity measures, as contrasted to HF adaptation of work design to meet human needs. At the time of the Leyden Seminar, the only HF organization in Europe consisted of the Human Factors Section of the EPA, headed by D. Lecoultre.

The EPA Mission to the U.S.

This 1956 mission was the first phase of EPA Project 335, "Fitting the Job to the Worker." Nine members of the mission committee visited 11 physiological installations, 3 industrial hygiene laboratories, 16 psychology laboratories or departments, and 15 factory installations, and held discussions with 8 firm managements and 8 trade union leaders and groups. The bibliography of the report of the mission (EPA, 1958b) lists 6 items on anthropometry, 6 on physical work, 9 on noise in industry, 6 on heat stress, 7 on vibration, 9 on lighting and vision, 58 on engineering psychology and experimental psychology, 6 on motion study, 6 on employment of the physically handicapped, 6 on equipment design, and 16 classed as miscellaneous. Predominant topics listed in the engineering/experimental psychology section dealt with instrumental tracking, knob and dial design studies, and motion design research on work. The latter was associated mainly with the University of Wisconsin Behavioral Cybernetics Laboratory, directed by the senior author of this chapter.

Conclusions of the report of the EPA mission to the U.S. gave no hint that an international ergonomics organization was in the offing. Three needs were stated in the report to be necessary in Europe. These were: (1) increase in inter-scientific communication; (2) investigation of communication between scientific workers and industry; and (3) increase in education in the field of ergonomics. As an indication of the status of ergonomics in England at the time, the report stated that there were no university chairs or university appointments in ergonomics in any European country.

The Leyden Seminar and Proposals for an International Organization

The 1957 seminar in Leyden, Holland, with the theme "Fitting the Job to the Worker," was convened as the second phase of EPA Project 335. The sessions and topics of this seminar covered especially physiological assessment of heavy work, workplace noise, work design, information display, working postures and machine design, and machine control design. Exchange of bibliographical information, scientist-industry communication, training in ergonomics, and formation of an international organization also were discussed.

During its general meeting, K.U. Smith wrote and presented what turned out to be a major highlight of

the seminar - namely, the proposals to set up an international association of work scientists and to consider the Leyden Seminar as the initial organizing base of this association. These proposals, the original handwritten copy of which still exist (1), stated five terms of organization: (1) the Leyden Seminar constitutes the first meeting of the international body; (2) the third phase of EPA Project 335 be defined as the permanent establishment of the international body; (3) specification of five objectives for the international body: (i) scientific study of work; (ii) dissemination of results of such study; (iii) establishing bibliographies of scientific publications in this area; (iv) holding an annual Congress; and (v) holding the annual Congress under the auspices of the EPA until a formal organization is established; (4) distinctive sustaining functions - bylaws - of the international body be defined and provisionally accepted by the Leyden Seminar (these included statements calling for cooperation with industry, government, unions, health organizations, and other professional scientific organizations and groups); and (5) formation of a Steering Committee to put these proposals and preliminary bylaws in effect.

These proposals were accepted enthusiastically by all but a few members of the seminar (Stansfield, 1980, 1985), and a Steering Committee for organization of the international body was formed. Following the suggestion of the original proposal, the association was titled, "The International Organization of Human Work Scientists." Opposition to the term "ergonomics" surfaced because the term was stated by the appointed Chair of the Steering Committee to lack any clear meaning. In addition, it was agreed that an initial organizing meeting would be held in 1958 as the third phase of EPA Project 335, an international conference on the industrial aspects of fitting the job to the worker."

"It is my belief that the reference to the relations between human factors and the concept of ergonomics in the history (of the IEA) should state that the fundamental theme of the initiation of the processes of or-

(1) [From an unpublished June 29, 1989 letter from K.U. to Ilkka Kuorinka, pertaining to design of a plaque to be placed in the Institute of Preventive Health at the University of Leyden commemorating the role of the Leyden Seminar in providing the impetus for formation of the IEA. The order of the two paragraphs is reversed from that in the actual letter.]

ganization of the IEA consisted of imparting a biological formulation of the human factors principle (as contrasted to an engineering formulation of that principle) to the concept of ergonomics, which at the point of initial IEA organization meant generally the study of the laws, customs, conditions and methods of work. At the time of the Leyden Seminar, the fields of work study in Europe, the British Isles, and the U.S. all featured engineering formulations of the ergonomics concept when that term was used. The charter of the IEA, in contrast, specifically alters this existing concept of ergonomics of the 50's and imparts to it a biological-human factors meaning.

I have no objections to a reference to the Oxford meeting (Stansfield, 1980, 1985) in the history, as long as the facts of this meeting are stated in full. These facts are that unanimous agreement ordinarily is needed by the officers of an organization to approve its bylaws or any change in these laws. No such unanimity was achieved at the Oxford meeting, however, inasmuch as I, as the Treasurer of the newly-formed Association, opposed the holding of the meeting, opposed the locus of the meeting, opposed the actions taken (including the irregular actions of permitting unauthorized observers to take part in the voting proceedings), and opposed the report of the actions taken. I have no objections to a statement that part of the Organizing Committee and the officers of the newly-formed Association approved a preliminary summary of the by-laws at this meeting."

Stansfield and K.U. shared some common views. Neither initially favored using "ergonomics" in the name for the new international body. Both generally favored the idea that work should represent the central focus of E/HF science and of the IEA. For example, in reference to the Working Party on Human Factors in Productivity formed in 1953 by the Organization for European Economic Cooperation (OEEC), Stansfield (1980, p. 104) notes, "One of the well-supported views put forward in the Working Party was that high priority should be given to "increasing the interest of the worker in his work, in productivity, and in the firm"." Their views differed however regarding the central scientific emphasis of work science. Stansfield, and the ERS generally, tended to focus on study of the physical and physiological capabilities of the worker. Conversely, as delineated above, K.U. emphasized improving the human factors design of work and the work environment to benefit work performance.

It was in relation to the conceptual inspiration for forming the IEA that viewpoints diverged most widely. The foregoing synopsis profiles the positions of two strong-willed individuals whose differences appear to be grounded in both professional as well as parochial pride. Stansfield (1980, p. 106) was openly dubious of the need for an EPA Project 335 mission to the U.S. to consult with E/HF professionals there in order to advance the cause of ergonomics and "fitting the job to the worker" in the U.K. and Europe generally. Conversely, as noted above, K.U. was deeply suspicious that the underlying agenda of the British contingent was to closely tie the new international body to the ERS, which he felt lacked both scientific credibility and professional acceptance on the continent (K.U. Smith, 1988).

The preponderance of historical evidence appears to favor K.U.'s views on this matter. First, as he noted above, Lecoultre (1985) commented on HF concerns of, and the influence of the U.S. mission on, the EPA prior to the Leyden Seminar. Second, in a February 1, 1990 unpublished letter to Ilkka Kuorinka regarding the commemorative plaque at the University of Leyden, Frederik Bonjer (host for the Leyden Seminar) notes that, "The proposal of the "Awards Committee" mentions the European Productivity Agency, but not its origin: the Marshall aids program of the New World to help the Old World to overcome the losses and handicaps experienced during World War II. It was not only a bright vision to offer help, but also to help by improvement of the productivity and thirdly to improve the productivity in such a way, that not only the quantity and quality of products was increased, but also that at the same time health and well-being of the human worker were promoted." This statement suggests a U.S. influence on the EPA dating back to the immediate post-WWII period. Finally, and perhaps most significantly, it was the views of K.U. that prevailed at the Leyden Seminar regarding formation of an international body devoted to work science

Conceptual origins for the work science focus of the IEA

Many, perhaps most, E/HF professionals share the view today that the study of human work represents one of the most important concerns of E/HF science and of the IEA. At the time of formation of the IEA however, no broad consensus existed as to the meaning of the terms "work science" and "ergonomics," or as to what the conceptual focus of professional societies devoted to these

areas should properly be. K.U.'s proposals at the Leyden Seminar to establish an international body devoted to work science clearly resonated with those in attendance. This section explores the conceptual basis for these proposals.

Interest by K.U. in the study of human work substantially predated the Leyden Seminar. After joining the University of Wisconsin (UW) in 1947, he decided to wean himself from wartime research concerns with "fitting military equipment design to combat personnel" (K.U. Smith, 1987), and to dedicate his professional career to E/HF research on work behavior and performance, that is "fitting job design to the worker." At the time of the EPA Project 335 mission to the U.S., he was proud of the fact that his was the only academic E/HF research program surveyed by mission delegates not supported by military funding (Singleton, 1956; K.U. Smith, 1988). It is likely that at that time, he was one of the few E/HF researchers in the U.S. with a work science (as opposed to an engineering psychology or human engineering) focus. In the late 50's, he declined an invitation to join the UW Department of Psychology in a program grant funded by the U.S. military, an action for which he was ostracized by much of the department during the remainder of his career there.

K.U. held two fundamental convictions regarding the conceptual focus and scientific meaning of work science and the IEA. The first was that the organization should comprise a community of work scientists devoted to improving work design in order to benefit the performance of work and the health and well being of the worker. It is fair to say that this ideal largely has been realized, although actual success in "fitting the job to the worker" remains mixed (next section). The second of K.U.'s convictions was that variability in human behavior and performance is prominently influenced by design of the task, and that therefore the focus of E/HF science should be on modifying work design, rather than the behavior of the worker, in order to benefit work performance. It is fair to say that E/HF science still struggles with this concept, and that the concept has yet to be universally accepted by the E/HF community.

Work Science Focus of the IEA. Three of K.U.'s original resolutions (copies of original hand written version available1) to the Leyden Seminar emphasized establishment of an international association devoted to work science, as follows:

Resolution 1. That this Leyden Technical Seminar on Fitting the Job to the Worker (E.P.A. No. 335) be considered the first international meeting of the Science of Work Study or Ergonomics.

Resolution 2. That the third phase of E.P.A. No. 335 be defined as a permanent establishment of the International Organization for Human Work Study or Ergonomics, & that suitable working committees & officers be appointed to make such an international body a reality.

Resolution 3. That the objectives of the International Organization for Human Work Study or Ergonomics be defined. Suggested primary objectives are:

• The promotion of scientific study & dissemination of scientific information regarding research, standards & industrial practices on the design, nature, control & improvement in human work...

To expand upon these initial resolutions, in January, 1959 K.U. prepared a formal proposal to establish an international work science organization, and submitted it for consideration at a March, 1959 Conference in Zurich of the Steering Committee formed at the Leyden Seminar to oversee creation of the international body called for in Resolution 2 above. It is instructive to examine some of the content of this unpublished proposal, since it provides insight into K.U.'s conceptual approach to the science of human work

Introduction

In the two years just past the first decisive steps have been taken by a group of European and United States scientists to set up a permanent international scientific society concerned with human problems related to work. These steps constitute a noteworthy scientific advance. They signal the directing of scientific inquiry toward the human problems of modern technology. Science in modern times has created great material progress and tremendous advance in human resources, but it has also produced deep-seated problems in human work and in human relations in work. Scientific organization at all levels of society is one line of action certain to help us with these grave problems of our economic world. It is hoped and intended that the international organization of biological sciences of human work shall serve to promote progress in understanding and dealing humanely with the adaptation of work to man in the modern world.

Insight into human problems of work represents one of the central challenges for scientific research. Only in recent years have we come to know what this challenge really is. In the past, all of us, scientists included, have lived too close to our jobs to recognize how these biosocial activities mark out the main channels of human life. The fact that our understanding of human work has not kept pace with the advancing front of modern scientific technology has finally attracted the attention of men in many fields - industrial owners, union leaders, teachers and scientists. We now enter a period when work must be examined scientifically if we are to understand man in his society, or to deal rationally with the problems of the individual in modern industry. The creation of jobs, the planning of education, the organization of industry, the development of labor policy, the making of labor laws, and the planning of automation are all human problems of work which must be solved in human terms with the help of scientific research.

Work has never been investigated scientifically in terms of its true status as a biosocial activity of significance to the health and welfare of the individual. Our interest has been mainly in the measurement of work relative to the requirements and standards of the factory operator. Automation is teaching us that work measurement in terms of efficiency is of less significance

"The international organization of human work scientists.

Preliminairy statement of purpose of organization

than adaptation of machines to man and the fitting of the job to the emotional and psychological make-up of the human individual. Human work is undergoing great change in industry. Individual freedom, personal dignity and distinctness of individual personality are tied to these changes. Greater effort is needed in the work sciences to alleviate the misery, the frequent disruptions of human life, and the social injustices which often accompany the industrial upheavals produced by advancing technology.

What is the broad scientific problem of work today? It deals with a central issue in modern science - the values and traditions of science as related to the life and progress of man in society. It involves understanding the functions of work in individual behavior, in human social evolution, and in the growth of human institutions. It includes the study of the specific biochemical, physiological, behavioral, and social activities and their interactions in human workers.

The attention of scientists to fundamental human problems in work no longer can be delayed. We know too much about these problems to accept inaction in what should be a major branch of science. We believe that work is the dynamic center of human life - the central activity about which motivation, consumption, attitude, thought, and family life are articulated. The nature of the job in the adult years helps structure human personality, not only in relation to economic status but also in regard to social status, manners, morals, and attitudes. Work activities are more than the use of tools. They are persisting, motivated, systematic patterns of behavior which constitute a basic form of human cooperation and conflict. The grouping of men in work determines the critical avenues of communication in society and thereby defines how social constellations are formed in industry, in the community, and in the nation. Our efforts in work science must be directed toward all of these vital interactions between work and the human condition of individual and social life...

Objectives of Work Science

Our objectives in the international organization of work sciences are threefold: to stimulate among the leaders in society a fundamental interest in the human conditions of work; to reaffirm the basic concern of science with the rational understanding of human life and progress; and

to promote the understanding of human work activities as aspects of and determinants of the course of human evolution and growth.

Science by long tradition is dedicated to the welfare of man and to the achievement of human dignity through rational insight into natural phenomena. Science is a part of man's social evolution, an evolution which has been defined very largely by skill, creativity, and conflict in work. Scientific research must provide a positive approach to the understanding of the human conditions and biosocial consequences of work, lest the advances of science contribute unwittingly to human degradation. The science of work must extend beyond limited conceptions of efficiency in industry, because the principles of labor efficiency unmodified by human considerations may imply the scientific validation of forms of human slavery.

To establish beyond doubt the devotion of science to man's welfare in industry, we intend to develop a world-wide scientific organization based on a scientific-idealistic conception of work. By this we mean a positive theory of work behavior founded upon the long-term needs and values of human life - individual freedom in society, dignity of person, orderly progress in human affairs, and understanding among peoples and nations. For many years past the power to influence the course of human work and the attendant development of human values and human welfare has rested largely with the physical scientist. We need now an understanding of work from a dynamic biological point of view.

Work science is founded upon fundamental biological principles of biosocial evolution. Work is an unrecognized key to human evolution. Its understanding through work science is the primary avenue for insight into cultural evolution as it is taking place in our time.

When we speak of biosocial or cultural evolution defined by the activities of work, we are not just drawing analogy with the events of organic evolution. Biosocial evolution is continuous with organic evolution and interacts with it. This continuity and interaction are defined by the phenomena of human work. It is in the work place - in industry and elsewhere - that the dynamic events of cooperation, change, and natural selection in human biosocial evolution occur. Work cooperation, industrial conflict, social power, and progress through creative discovery are fundamental biosocial events derived from and related to the phenomena of organic evolution. The events of work present us with the challenge to understand the scientific principles of human progress, and to create programs of human development which nature - or chance - has failed to provide.

It is our belief that the principles of evolution in human work are essential for a true understanding of man's personality as a social being. Human relations, social status, and the specific structure of the social environment are determined by the level of cultural and technological evolution. We will begin to gain an understanding of these events, and of related social standards of intelligence and personality, when we achieve systematic insight through work science into the make-up of the social environment. The social environment is a created thing - a product of human work - the divisions of labor within which have been articulated by biosocial evolution. To control and influence this development, we need to understand its principles.

At the present time, the amount of true scientific activity in the investigation of the conditions, the behaviors, and the physiological events of work is relatively very limited. Not over a dozen scientific laboratories the world over are concerned with fundamental problems of human work. Work science has an important bearing on progress in applied fields of medicine, education, and industry. It's primary significance, however, will be in its achievements as a pure science in contributing to our understanding of human work and its role in social evolution."

After the Zurich Conference, G.C.E. Burger, Acting Chair of the Steering Committee, contacted K.U. in an April 3, 1959 unpublished letter, and informed him that the Committee had decided that: (1) the name of the international body should be the International Ergonomics Association; and (2) it would not be appropriate to publish K.U.'s proposal on behalf of the international group. However, a number of themes that K.U. addresses in the above excerpt retain currency today, such as: (1) the uncertain, unpredictable and occasionally dangerous impact of new technology on the organization and conduct of work; (2) the potentially dehumanizing influence of automation on both

work and the worker; and (3) the pervasive biological, behavioral and biosocial influences of work on workers, their societies, and on the human condition generally.

Yet it can be argued that it is the central thesis running throughout K.U.'s appeal that continues to resonate most strongly today, namely the need for more scientific attention to that process of human behavioral performance that we call work. In the academic realm, a coherent, integrated systems approach to teaching and scientific research related to human work remains lacking. When it comes to influencing political, institutional, commercial, and operational decision-making governing the organization and conduct of work, E/HF science all too often is marginalized at the periphery. Sadly, to a substantial degree, after over four decades of growth and development by the IEA and by E/HF science generally, K.U.'s idealism (which Burger explicitly noted in his letter) regarding the central role that work science should play in the design of work systems and operations remains to be transformed to practical reality.

Design Specificity in Work Behavior and Performance.

One of the key concepts advanced in the foregoing commentary, a cherished idea that K.U. felt was fundamental to full scientific understanding of work, is that in shaping the organizational, operational and technological design of work to meet their needs, humans in turn have shaped their own behavioral and biological specialization and adaptation throughout evolution. This is a cybernetic concept - it implies reciprocal feedback relationships between work design and work behavior and performance. It also can be argued (T.J. Smith, 1993, 1994, 1998) that design specificity in performance represents the central concern of E/HF science, in that the distinctive scientific focus of E/HF (unlike that of either engineering or psychology) is the interaction of design and performance.

There is extensive empirical evidence, dating back a full century, to support the view that a much of the variability observed in human behavior and performance is attributable to the influence of design factors in the performance environment (as opposed to that of innate biological or learning factors). The following excerpt, from an unpublished chapter entitled, "Human Factors Psychology: Origins and Development," prepared by K.U. in the late 80's to introduce an intended book on the history of the IEA, provides an historic context for the elaboration of this view.

"Human Factors Design as the Preeminent Determinant Of Work Performance

The overriding issue of all levels of human science is how performance is specialized. Psychology has insisted that performance is specialized by learning. The scientific facts are that it is specialized by task structure or, more specifically by human factors design of performance situations and conditions. Thorndike and Woodworth (1901) opened up the issue by finding that there is little transfer of learning between learned tasks. Perl (1934) did a first correlational study and found intercorrelations between performance scores on successive trials decreased as a function of the separation of trials. Her results were confirmed many times and give rise to the concept of superdiagonal form in learning performance (Jones, 1966, 1969). Woodrow (1938) found that the specific variance (the variance attributable to task structure) of task performance tended generally, i.e., in six out of nine tasks, to increase significantly with practice.

During World War II, research on a mechanical-optical search radar trainer showed that final perceptual scores on the trainer could not be predicted with any degree of significance from initial learning scores (K.U. Smith, 1987). Adams (1953) showed that verbal task performance tends to follow the rules of determination of specific variance of psychomotor tasks in the sense that, if two tasks are dissimilar, practice in one of them decreases the correlation between them. Fleishman and Hempel (1953) found that during practice with the complex coordination test, the specific variance increased from 6 to 38 percent. Fleishman (1954) found in an analysis of psychomotor tests, that the proportion of the variance specific to the tests averaged 49 percent. Jones (1959), in a specific study of naval training tasks, and in a general systematic analysis of the problem (Jones, 1966, 1969), reached the conclusion that the proportion of specific variance attributable to task structure in real-life or criterion tasks is much greater than that found for test performance, in that the variance for real-life tasks is always at least 50 percent and usually amounts to 75-90 percent of the total variance. K.U. Smith and Sussman (1969) and K.U. Smith and Smith (1970) attributed the behavioral origins of

the specific variance in task performance, not simply to task structure, but to human factors design of task situations and performances. K.U. Smith and Wargo (1963) observed that the relative spatial feedback displacement between multi-joint movements and visual perception could account for literally thousands of variance-specific motorsensory performances.

The general conclusion from this sustained behavioral analysis of specialization of performance in learning is that the task structure or human factors design of task situations and performances far outweighs the factors of learning, practice and the normal range of individual differences in determining behavioral performance in work. The science of work behavior is founded on human factors psychological principles."

Beyond the references cited above, both authors of this chapter have elaborated upon the theme of design specificity in performance in a number of additional publications, in relation to the influence of educational design on learning (K.U. Smith and Smith, 1966), to design specificity in handwriting performance (K.U. Smith and Smith, 1991), to sources of performance variability (T.J. Smith, Henning and Smith, 1994), to the synergism of ergonomics, safety and quality (T.J. Smith, 1999), and to the scientific and conceptual significance of such specificity for E/HF science (T.J. Smith, 1993, 1994, 1998).

The seemingly abstruse debate about the nature and sources of variability in work performance is of more than academic interest - it goes to the heart of the question of the appropriate scientific and practical focus of the E/HF field and of the IEA itself. This point is well illustrated with K.U.'s response to an unpublished letter that Etienne Grandjean wrote on June 13, 1957 to other members of the Steering Committee, asking their guidance in the form of a series of questions about terms of reference for establishing the new international body. Question 1 in the Grandjean letter is as follows: "Which sciences or fields of science should be included in the activity of the planned organization?" In an unpublished July 18, 1957 return letter to Prof. Grandjean, K.U. offered the following perspective on this question.

"The proposed organization should be limited to basic sciences, with the possible inclusion of sociological work done on an investigative basis. All fields primarily concerned with manipulation of individuals for current industrial needs, such as personnel selection, vocational psychology, clinical psychology, industrial engineering, should be permitted associate status only."

This comment implies that E/HF science should focus on the interaction of work performance and work design, rather than on the psychophysiology of the worker (with no reference to design). That is, the proper if not imperative scientific mission of E/HF is to modify work design to benefit work performance - fitting the job to the worker - as opposed to attempts to fit the worker to the job through manipulation of worker cognitive, behavioral and/or physiological capabilities

Fitting the job to the worker – from ideal to reality

In Europe as early as 1953, the OEEC Working Party on Human Factors in Productivity was considering action related to the theme of "fitting the job to the worker," based on proposals submitted from both Germany and the U.K. (Stansfield, 1980, p. 105). Subsequently, the motto was adopted as the theme for the EPA mission to the U.S. and for the Leyden Seminar, and influenced the title of a book by Grandjean (1971). In the U.S., as noted earlier, K.U. decided to focus his post-war research on work science with this same theme in mind.

Over four decades have now elapsed since the seminal period of IEA formation, decades during which the principle of "fitting the job to the worker" has critically influenced the evolution of the IEA, of the Human Factors and Ergonomics Society in the U.S., and of E/HF science generally. It seems fitting to close this chapter on conceptual perspectives by briefly considering how the ideal embodied in this principle has been transformed and translated into reality during the remarkable growth and expansion of our discipline over the last half century.

One approach to this question is to compare and contrast major topics addressed during the first (K.U. Smith, 1961) and the most recent (Seppälä et al., 1997) International Congresses of the IEA. Table 1 summarizes the analysis. The table shows that 13 of 17 (76%) of major topics addressed by presentations during the

most recent Congress also were addressed during the 1st Congress. New topics that attracted attention over the intervening 36 years - economics, complex systems, human-computer interaction, and rehabilitation - illustrate both the influence of new technology and an inexorable tendency of E/HF science to concern itself with all domains of human performance. Aging was the most popular topic during the 1st Congress, macroergonomics during the 13th Congress, underscoring an intriguing change of focus of the field. Generally, Table 1 suggests that the topical scope of "fitting the job to the worker," embodied in the concerns of E/HF science and the IEA, has experienced more of an evolutionary rather than a revolutionary transformation over the last four decades. It is evident that in terms of gains achieved in embracing and addressing the multidimensional and emerging demands of work analysis, the original ideals of the IEA have been realized to a remarkable degree.

A second consideration is the well-documented benefits that E/HF interventions have achieved in terms of hazard management, accident and injury prevention, and economic gains (Guastello, 1993; Hendrick, 1997; Konz, 1995; T.J. Smith, 2000). Here again, the early ideals of E/HF science and the IEA have inspired gratifying improvements in work design and worker safety, health and well-being.

Nevertheless, as we launch the new millennium, it can be argued that there is no cause for celebration or complacency regarding the success of our profession. Despite almost universal devotion to the concept of 'fitting the job to the worker' among the E/HF community, in many respects practical application and implementation of the concept to benefit the worker remain unrealized. One prominent example is widespread worker suffering and multi-billion dollar employer losses caused by job-related injuries, with musculoskeletal problems leading the way. A second example is worker safety training, a multi-billion dollar industry in the U.S. and elsewhere. A third is the plethora of Government safety specification standards and regulations. If most jobs indeed 'fit the worker,' we would not expect the levels of job-related injuries, employer investment in safety training, or the stringency of government regulations to be as intense and costly as they in fact are. These considerations suggest that a major challenge for the E/HF field in the coming century will be to elevate the concept of 'fitting the job to the worker' from lip service

to true customer service to the worker in a number of major respects, in order to promote full realization of the promise and potential of E/HF science and practice.

Table 1.
Major topics addressed by papers presented during the 1st and 13th International Congresses of the IEA

Major Topic Addressed During	1st Intern'l IEA Congress	13th Intern'l IEA Congress
Aging	T*	T
Complex Systems		T
Design	T	T
Economics		T
Human-Computer Interaction		T
Materials Handling	T	T
Musculoskeletal Disorders/Biomechanics	T	T
Occupational Ergonomics	T	T
Occupational Health	T	T
Occupational Safety	T	T
Organizational Design & Management (Macroergonomics/Work Organization)	T	T*
Rehabilitation		T
Stress/Fatigue	T	T
Task Analysis	T	T
Training/Learning	T	T
Work Behavior/Work Psychology	T	T
Work Physiology/Environmental Physiology	T	T

* Most popular topic, in terms of number of papers presented.

References

Adams, J.A. (1953). The Prediction of Performance at Advanced Stages of Training on a Complex Psychomotor Task (USAF Human Resources Research Center Research Bulletin No. 53-49). Dayton, OH: Wright-Patterson USAF Base.

European Productivity Agency (1958a). Fitting the Job to the Worker. A Survey of American and European Research into Working Conditions in Industry. Report on a Mission to the United States - 5 Sept. - 3 Nov. 1956 and on the Leyden Seminar - 29 March - 3 April 1957. Project No. 335. Paris: The European Productivity Agency of the Organization for European Economic Cooperation.

European Productivity Agency (1958b). Fitting the Job to the Worker. E.P.A. Project No. 335. Report on the 1st Phase of the Project - A Mission to the United States. European Productivity Agency/Organization for European Economic Cooperation.

Fleishman, E. A. (1954). Dimensional analysis of psychomotor abilities. Journal of Experimental Psychology, 48, 437-454.

Fleishman, E.A., and Hempel, W.E., Jr. (1953). Changes in Factor Structure of a Complex Psychomotor Test as a Function of Practice (USAF Human Resources Research Center Research Bulletin No. 53-68). Dayton, OH: Wright-Patterson USAF Base.

Fox, J.G. (1988). Letter to the Editor. Human Factors Society Bulletin, 31(9), 10-11.

Grandjean, E. (1971). Fitting the Task to the Man (2nd ed.). London: Taylor & Francis.

Guastello, S.J. (1993). Do we really know how well our occupational accident prevention programs work? Safety Science, 16, 445-463.

Hendrick, H.W. (1997). Good Ergonomics is Good Economics. Santa Monica, CA: Human Factors and Ergonomics Society.

Jones, M.B. (1959). Simplex theory. USN School Aviation Medical Monograph, No. 3.

Jones, M.B. (1966). Individual differences. In E.A. Bilodeau (Ed.), Motor Skills and Motor Learning (pp. 109-146). New York: Academic Press.

Jones, M.B. (1969). Differential processes in acquisition. In E.A. Bilodeau and I. Bilodeau (Eds.), Principles of Skill Acquisition (pp. 141-170). New York: Academic Press.

Konz, S. (1995). Work Design. Industrial Ergonomics (4th Ed.). Scottsdale, AR: Publishing Horizons.

Lecoultre, D. (1985). Ergonomics and the European Productivity Agency: a historical note. In I.D. Brown, R. Goldsmith, K.Coombes and M.A. Sinclair (Eds.), Ergonomics International 85. Proceedings of the Ninth Congress of the International Ergonomics Association, 2-6 September 1985, Bournemouth, England (pp. 1009-1011). London: Taylor & Francis.

Perl, R.E. (1934). An application of Thurstone's method of factor analysis to practice series. Journal of General Psychology, 11, 209-212.

Seppälä, P., Luopajärvi, T., Nygård, C-H., and Mattila, M. (Eds.)(1997). Proceedings of the 13th Triennial Congress of the International Ergonomics Association (Volumes 1-7). Helsinki: Finnish Institute of Occupational Health.

Singleton, W.T. (1956). Report on American Visit, September/October, 1956. SATRA House, Kettering, U.K.: The British Boot, Shoe & Allied Trades Research Association.

Smith, K.U. (1961). Personal collection of papers from the First International Congress of the International Ergonomics Association.

Smith, K.U. (1987). Origins of human factors science. Human Factors Society Bulletin, 30(4), 1-3.

Smith, K.U. (1988). Origins of ergonomics and the International Ergonomics Association. Human Factors Society Bulletin, 31(1), 2-5.

Smith, K.U., and Smith, M.F. (1966). Cybernetic Principles of Learning and Educational Design. New York: Holt, Rinehart and Winston.

Smith, K.U., and Smith, T.J. (1970). Feedback mechanisms of athletic skill and learning. In L. Smith, (Ed.), Motor Skill and Learning (pp. 83-195). Chicago: Athletic Institute.

Smith, K.U., and Smith, T.J. (1991). A study of handwriting and its implications for cognitive considerations in human-computer interactions. International Journal of Human-Computer Interaction, 3(1), 1-30.

Smith, K. U., and Sussman, H. (1969). Cybernetic theory and analysis of motor learning and memory. In I. Bilodeau and E.A. Bilodeau (Eds.), Acquisition of Skill (pp. 103-139). New York: Academic Press.

Smith, K.U., and Wargo, L. (1963). Specialization of space-organized sensory feedback mechanisms and learning. Perceptual and Motor Skills, 16, 749-756.

Smith, T.J. (1993). The scientific basis of human factors - a behavioral cybernetic perspective. In Proceedings of the Human Factors and Ergonomics Society 37th Annual Meeting (pp. 534-538). Santa Monica, CA: Human Factors and Ergonomics Society.

Smith, T.J. (1994). Core principles of human factors science. In Proceedings of the Human Factors and Ergonomics Society 38th Annual Meeting (pp. 536-540). Santa Monica, CA: Human Factors and Ergonomics Society.

Smith, T.J. (1998). Context specificity in performance - the defining problem for human factors/ergonomics. In Proceedings of the Human Factors/ Ergonomics Society 42nd Annual Meeting (pp. 692-696). Santa Monica, CA: Human Factors and Ergonomics Society.

Smith, T.J. (1999). Synergism of ergonomics, safety, and quality - a behavioral cybernetic analysis. International Journal of Occupational Safety and Ergonomics, 5(2), 247-278.

Smith, T.J. (2000). Macroergonomics of hazard management. In Hendrick, H.W. and Kleiner, B. (Eds.), Macroergonomics. Mahwah, NJ: Lawrence Earlbaum. Accepted for publication.

Smith, T.J., Henning, R.H., and Smith, K.U. (1994). Sources of performance variability. In G. Salvendy and W. Karwowski (Eds.), Design of Work and Development of Personnel in Advanced Manufacturing (Chap. 11, pp. 273-330). New York: Wiley.

Stansfield, R.G. (1980). The origins of the International Ergonomics Association (paper presented to the 7th Congress of the IEA). Ergonomia (Warsaw), 3, 102-112.

Stansfield, R.G. (1985). The founding of the International Ergonomics Association. In I.D. Brown, R. Goldsmith, K.Coombes and M.A. Sinclair (Eds.), Ergonomics International 85. Proceedings of the Ninth Congress of the International Ergonomics Association, 2-6 September 1985, Bournemouth, England (pp. 1006-1008). London: Taylor & Francis.

Svensson, Y. (1959). Arbetsstudier, I. England: Intryck Fran en Studieresa Juni-Juli 1959. Stockholm: ASTI.

Thorndike, E.L., and Woodworth, R.S. (1901). The influence in improvement in one mental function upon the efficiency of other functions. Psychological Review, 8, 247-261, 384-395, 553-564.

Woodrow, H. (1938). The effects of practice on groups of different initial ability. Journal of Educational Psychology, 29, 268-278.

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His research interests deal with human factors, performance, and safety issues related to transportation systems, industrial ergonomics and human interaction with complex systems. His speciality area concerns sources of variability in human performance, with particular emphasis on effects of displaced sensory feedback on individual and group performance.

He is a Certified Human Factors Professional with over 80 publications in these various interest areas. His honors include service on the IEA Student Award Committee, as a Director of the IEA K.U. Smith Student Award Fund, as Co-Editor for the HFES Monograph series, as President of the HFES Upper Midwest Chapter, and as General Chair for the 2001 HFES Annual Meeting to be convened in the Twin Cities of Minneapolis/St. Paul.

9 Introduction of Ergonomics into Developing Countries

Adnyana Manuaba

Introduction of Ergonomics

The word 'ergonomics' was introduced nationally in Indonesia for the first time by A. Manuaba in 1969, at a National Seminar on Industrial Hygiene, Occupational Health and Safety, in Jakarta. This was then followed by publication of an article in the National Journal of Industrial Hygiene, Occupational Health and Safety, entitled "Ergonomic Approach to Improve the Productivity of Enterprises and Workers". Unfortunately, the word 'ergonomics' was misspelled as 'economics', and in various discussions was still misspelled as 'agronomics' or 'argonomics' due to its unfamiliar as well as unpopular status at that time.

In Bali itself, the word 'ergonomics' had already been introduced in 1967 through several of Manuaba's articles published in the only newspaper on the island, Suluh Marhaen. Those articles had been sent from the Netherlands when Manuaba was still taking his postgraduate course in ergonomics at the University of Amsterdam. Most of his articles discussed improving the efficiency and productivity of work or activities using ergonomic approaches. The topics were related to the daily issues and problems faced by populations at large, such as how to organize and design more effective and efficient transportation, school bags, home kitchens, traffic signs, terminals, post offices, airports and markets.

Since 1968, various ergonomics research has been done by Manuaba and the results have been published as newspaper articles and as scientific papers presented at various regional and national conferences. In 1969, Manuaba's initiative, with the support of the Department of Manpower of the Republic of Indonesia, led to the founding of the Regional Institute of Industrial Hygiene, Occupational Health and Safety, in

Bali, and its authority also covered the provinces of West and East Nusatenggara. Due to the collaboration of this establishment with the Physiology Department, Medical School, University of Udayana, and especially the academic staff, ergonomics activities increased in intensity and became more institutionalized, and programs in various sectors were conducted with special attention to agriculture, tourism and small scale cottage industries, Bali's three economic potential sectors. Most of the results have been disseminated by means such as international and national events, and because of these activities, Manuaba and the Physiology Department received a letter of honour from the Consortium of Medical Sciences in 1972. Also as a result of these positive steps, Bali and its ergonomics activities began to attract the attention and collaboration of foreign and international institutions and agencies. ILO and WHO started to consider Bali more than just a tourist island, but a place where ergonomics has been actively carried out. For example, in 1969, a paper was presented at the ICOH Congress in Japan, and for the first time, networking was established by Manuaba with Japanese colleagues, particularly with the young scientists under Dr. Kogi's leadership. In 1971, at the Colloquium on Heart Rate Assessment in Bad Kreuznach, Germany, Manuaba further developed the networking with colleagues from Europe that had been established during his studies in the Netherlands in 1966-1967. At that time, he had the opportunity to visit and gather ideas from advanced ergonomics and occupational health institutions in Europe headed by E. Granjean, Forssman, Noro, Wisner, Singleton, etc. More ideas were also gathered from famous institutions on ergonomics in the UK during the 1971 study visit sponsored by the British Council. During that time, it was still very difficult to bring together colleagues working in ergonomics in Indonesia, although some universities and institutes of industrial hygiene and occupational health and safety in other provinces have carried out ergonomically sound activities.

A similar introduction of ergonomics also occurred in other developing countries. Usually it began with someone who had the opportunity to study ergonomics abroad; then he/she started something back home. Sen in India, and Lin Tan in Malaysia are among them. Sometimes the idea is started by a foreign expert working in a multinational company or other enterprise. They do so because of the demands of their job which are related mostly to worker health and safety.

In fact, at various international or regional meetings, such as ACOH (Asian Conference on Occupational Health), ICOH (International Commission on Occupational Health), and IEA (International Ergonomics Association) congresses, very few from ASEAN countries presented ergonomics papers. Similarly in Birmingham (1967), Tokyo (1969), and in Bad Kreuznach (1971), etc., practically no ASEAN colleagues presented ergonomics papers, mostly due to financial problems. It is very difficult for colleagues from developing countries to spend money from their own limited resources for just a meeting. If there were some, they were mostly expatriates who had been working in various industries or higher education institutions, since they had the expertise and the money to support their activity. Therefore, many so-called ergonomists in the Asia Pacific regions came from oil industries or famous higher educational institutions operating in Hong Kong, Malaysia and Singapore who received British support. The papers usually had a more solid basis in occupational health and safety as the authors were mostly working as occupational/medical officers. They could also have been local citizen scholars who had the opportunity to study abroad, as happened in Singapore and Hong Kong. There were also similar cases with Koreans, Taiwanese, etc., who mostly studied in the United States. Such a mechanism might also have happened in Africa and South America, where Belgian, French and British influences talked extensively about the introduction of ergonomics. SELF was recently activated on the french-speaking ergonomists' side.

In South Asia, Sen in Calcutta with his institute introduced and initiated ergonomics activities in India.

The first colleague in Singapore working in ergonomics was Prof. Phoon Wai-On; the number grew as a result of the ACOH conference in Singapore in 1982. Someone who was very active was Dr. Ong Choon Nam, who became the secretary general of SEAES during my second term as president from 1988-1991. When we started SEAES in 1984, it was still very difficult to find people from Malaysia, and the only name I could list afterwards was Dr. Lin Tan. She was very active, and although we talk frequently by telephone, we met each other for the first time at the SEAES meeting in 1991 in Bangkok.

Even though we obtained some names from Malaysia, such as Dr. Mahathevan and others, during the International Symposium on Ergonomics in Developing Countries in Jakarta (1985), there was unfortunately no communication at all after the meeting.

In the Philippines, we do have some people at the Institute of Public Health, such as Prof. Somera, and others at the Ministry of Labour. Ergonomics was in fact introduced by these two institutions in the Philippines. There was also Dr. Reverente, a medical officer in an international company, who introduced and applied ergonomics in his enterprise. There was also someone from the forestry department who studied ergonomics in Wageningen and then introduced ergonomics into forestry. There were others who worked at IRRI, conducting many studies on ergonomics in agriculture. A woman by the name of C. Rubio, a former doctoral student of Prof. Wisner, was very active in the social aspect of ergonomics.

In Thailand, ergonomics was of course introduced by ILO and the National Institute for the Improvement of Working Conditions and Environment, Ministry of Labour and Social Welfare, through their activities. The pioneer was the director, Dr. C. Chavalitnitikul. We also have Dr. Wongpanich at the university, who was very active in occupational health, including ergonomics. Then there was Dr. Kitty Intaranont of the University of Chulalongkorn, and more recently Ms. Yoopat of Ransik University, who was very active in ergonomics studies. In this regard, CERGO led by Dr. Kamiel Vanwonterghem must be mentioned. It is important to highlight what has been done by Prof. Shahnavaz and Prof. Abeysekera in Lulea, Sweden, with their Ergonomics for Developing Countries Institute. At their school, many mainland Chinese and Arabs from the Middle East have been exposed to ergonomics. Their contribution to the introduction and development of ergonomics in those countries must be mentioned. Dr. Kuorinka's policy and work is also appreciated and noted, especially when he became IEA president and paid a lot of attention to developing countries. Not only did he pay attention, but he also did much to assist developing countries to develop ergonomics through the association.

It is also important to note the work of Japanese ergonomists like Itani in the Philippines for small scale industry, Horino in Thailand for the textile industry, and Kawakami in Vietnam for agriculture, for introducing and developing as well as for solving their daily work problems.

Of course, in other developing countries in Africa and South America, I believe similar mechanisms have also been established with the leadership of higher educational institutions in France (like CNAM under Prof. Wisner), and other institutions in Sweden, Belgium, etc. Their graduates recently became the pioneers of ergonomic activities in their respective developing countries.

Development of Ergonomics

In 1976, a meeting on PIACT (the French acronym for Improvement of Working Conditions and Environment) was organized in Bangkok, and several 'ergonomists' and 'occupational health' practitioners from the region were invited. At that time 'experts' in occupational health and ergonomics from the region met for the first time under the sponsorship of ILO, to discuss the implementation of PIACT in the region. We had Kogi from Japan, Wisner (ILO consultant) from France, Pinnagoda from Sri Lanka, Sen from India, and Manuaba from Indonesia, in addition to the several ILO officers also present.

On that occasion, the idea of founding the South East Asia Ergonomic Society was discussed for the first time, and various steps were planned, namely that it was Manuaba's duty to become the founders' secretary and begin to list other names in the region to became founding members. As a result, when ACOH was organized in 1976 and 1979, and a study visit to several ASEAN countries for Indonesian Community Medicine Representatives was organized in 1979, there was active communication and negotiation with so-called ergonomists in each country. A similar effort was made when ACOH was organized in Singapore in 1982. With all these activities, SEAES was finally founded in 1984, and Manuaba was chosen as the founders' secretary. In 1985, the first SEAES Conference was organized in Bali, in conjunction with the International Symposium on Ergonomics in Developing Countries in Jakarta, in which the ILO, WHO and the Indonesian government acted as sponsors. The conference in Bali announced the existence of SEAES, and Manuaba was chosen as the first

president for the 1985-1988 term. Around 100 participants attended the conference presenting 16 countries in addition to the ASEAN countries. At that function, networking was established for further activities. During the conference, study visits to various success story sites were also conducted, which created many good memories for the participants, particularly since Bali and Indonesia had already started to do something in ergonomics. Bali was an example of ergonomics in the small-scale/cottage industry, in tourism (especially in the hotel business) and in agriculture (with special reference to the tools used by farmers), and this was demonstrated in a meaningful way. A visit to the regional tourist office at the civic centre, where ergonomics had been implemented during the design phase, showed the participants how ergonomics could be done as expected. Most of the participants did not ask questions but made only one comment, "How could such a mechanism be carried out, and what are the approaches?" In Bali, such examples were done on purpose, and covered various sectors, as people needed good examples within their own surroundings to encourage them to do the same. Therefore, the entire 'blacksmith' village of Batu Sangyang now has ergonomic workstations, as they saw and experienced themselves the benefit of the first example given to one of the families.

This showed us that improving poor working conditions and a poor environment, simply as an academic exercise, was not the end of the journey, but must be followed up with the example of encouraging the population at large to do the same. Thanks should be given to TV Denpasar which helped Manuaba significantly in conducting this program.

The Role of Japanese Associations

One of the most beneficial outcomes of the relationship with our Japanese colleagues, especially those under Dr. Kogi's leadership, was the establishment of the joint publication of the Human Ergology Journal by SEAES and the Japan Human Ergology Association. The most critical issue in this joint effort was the financial expense, which was almost completely assumed by our Japanese colleagues, while SEAES members only paid a very small member's fee to have this journal.

Help was also provided when SEAES published a communication leaflet during Manuaba's term as president.

The invitation of Manuaba and other ASEAN ergonomists to Japan to attend various ergonomics meetings also helped develop ergonomics in ASEAN countries. Through these meetings, networking was established with various ergonomics or related institutions and with individuals, which was very significant in improving the capability and work of the ASEAN ergonomists. These links were emphasized through Kogi's efforts in ILO, both in Bangkok and Geneva. Some names must be mentioned in relation to all these mechanisms, such as Tanaka, Horino, Kumashiro, Ohashi, Aoyama, to name only a few.

We should thank our Japanese colleagues for this encouragement and collegial step. Although Japan has had to deal with economic crisis, this assistance continues.

The Role of ACOH, ICOH, ILO and WHO

ACOH was really the starting place for ergonomists in the region's developing countries, and to make and maintain contacts with other ergonomists, as well as to benchmark their activities. In fact, in the early stages, very few ergonomists came from these regions, perhaps due to financial obstacles.

ICOH was also considered as a place for meeting other ergonomists from developing countries, especially Africa and South America. From what was observed, it seems that we had similar problems and obstacles in how to tackle the problems, which are related to limited resources and references. However, previous colonies were fortunate in that some developed countries gave more priority to them in implementing ergonomics. Many developing countries in Africa and South America have been supported by several developed countries in Europe with similar languages.

ILO focused its attention on ergonomics mostly through the PIACT program, especially in the South East Asia region. After the preliminary meeting in Bangkok in 1976, Manuaba had the opportunity to work at ILO for one month in 1977, studying and writing a

report about ergonomics in rural areas, related to technological transfer. Before that, CNAM, through Wisner, also invited Manuaba to work at CNAM for one month on ergonomics in agriculture, which was really a very useful experience. After that, Manuaba attended various meetings organized by ILO related to the PIACT program in locations such as Manila and Jakarta. Thanks must be expressed to Mr. Spyropoulos, Ms. Dy and to other officers in the Working Conditions and Environment Department, ILO Geneva, for their attention to developing countries and encouragement in promoting ergonomics.

WHO's role in introducing ergonomics into developing countries, especially Indonesia, went back to late 1969 and 1970, when Dr. El Batawi in his position in Bangkok, paid a lot of attention to the development of occupational health, safety and ergonomics in Indonesia, and then in Bangkok for Thailand. There was a further contribution by WHO when Manuaba was invited to Geneva in 1984 to help WHO set up their ergonomics program. One of the historical contributions was WHO's sponsorship of the International Symposium on Ergonomics for Developing Countries in Jakarta in 1985.

The Role of SEAES Conferences

Since its creation in 1984, SEAES has had five conferences: Bali (1985, 1988), Bangkok (1991, 1994), and Kuala Lumpur (1997). The next one will be in Singapore in 2000. These conferences (especially in Kuala Lumpur under the leadership of Dr. Halimahtun and the hard work of Dr. Lin Tan, and supported by Prof. Martin Helander/IEA) have in fact become the meeting place for ergonomists, not only from ASEAN countries, but also from developed countries. It is also a barometer of the quality of the scientific papers being presented, especially by regional ergonomists. It is true, as one analyst has said, that this quality could not be compared to that of the papers presented by those from developed countries. This can be understood as far as the methodology and equipment are concerned. However, as far as the results are concerned, they were practically able to solve the local problems and this in fact was done within only limited means; they must therefore be accepted and appreciated, since this is the purpose of science. Of course, shortages would be

slowly corrected and quality would improve. It takes time and great effort, and the recent and upcoming SEAES conferences have and will contribute greatly to supporting this effort.

The Role of IEA Conferences

Those people from developing countries who have had the opportunity to attend IEA Congresses, especially the last three (Paris (1991), Toronto (1994), and Tampere (1997)), have felt that those congresses have given them a lot of inspiration for their future work back home. They learned a lot, and have developed creativity and innovation. Benchmarking could also be initiated through various conferences supported by IEA, such as the International Symposium on Ergonomics in Developing Countries in Jakarta in 1985. It was really a place where, for the first time, many ergonomists from developing countries sponsored by IEA, ILO and WHO could get together. A meeting of minds and an understanding of others' problems were really developed at this meeting. The important speech of the vice president of the Republic of Indonesia in particular, gave these deliberations a truly significant meaning.

The Role of Individuals and HFES

SEAES would not have been founded without the encouragement of Japanese colleagues led by K. Kogi and others from the Japan Human Ergology Association, and that of Prof. Wisner from CNAM who always pushed us forward. When we started to think about the organization, and especially the complex problems we would have to face, Dr. Kogi and Prof. Wisner came as volunteers and brothers to support us. I still remember how these two 'brothers' pre-financed us when we organized the 1st SEAES Conference in Denpasar under the auspices of IEA. Before that, Professor Wisner had fought hard, with the support of our Japanese colleagues (Prof. M. Akita et al), for SEAES to be accepted as a member of IEA. Of course, other members have also contributed significantly, especially those who clearly understood what developing countries are really like.

IEA presidents and officials also paid attention and helped, providing financial assistance to the develop-

ing countries' young ergonomists to attend IEA congresses. In fact, without this policy, IEA congresses would not have been attended by ergonomists from developing countries due to economic obstacles. In this mechanism, the names of Ilkka Kuorinka, Pieter Rookmaker, Hal Hendrick, Ian Noy, Alain Wisner and Kazutaka Kogi must be mentioned, to name only a few.

Other means were also provided, in setting up commissions in developing countries and in organizing joint roving seminars with the ILO. This was done in Indonesia, the Philippines, and Thailand. In this regard, credit must be given to Dr. Kamiel Vanwonterghem of Belgium, Pinnagoda of the ILO, and Kogi of Japan. I believe that similar steps have also been taken in Africa and South America.

Help in terms of books and journals was initiated first by IEA under several presidencies. This was carried out continuously until recently, but not as intensely, and the most recent help came from Jim Hitt in his capacity as president of the student members of the Human Factors and Ergonomic Society. For this, it is important to thank the presidents of the IEA and other council members who contributed greatly to these donation efforts. Similar thanks also go to the HFES members who donated many books to developing countries. Before this activity, the regular publication of the HFES bulletin was also very helpful in broadening horizons to what is really happening in one ergonomically-advanced developed country, namely the USA.

Trends in Ergonomic Development

In developing countries, various work systems exist, from the simple to the complex, and ergonomics must be developed to fill the need, to bridge the gap, and to solve problems. In this context, micro- and macro-ergonomics must be used according to need and demand. The development of ergonomics must adjust itself to meet development trends; otherwise, it will not be used or will be too expensive. This is not an easy task, as everything is so limited. In addition, since the problems in developing countries are so complex, the solution must be approached comprehensively, if the funds and forces are to be used effectively and if the outcome is to be sustained. Ergonomics as a technology must be implemented comprehensively with other disciplines within technological transfer processes.

Wisner's concept of anthropotechnology must be used as one of the guides. Manuaba's concept should also be applied, namely that technological choice and technology transfer must be technically, economically, ergonomically and socioculturally sound, must save energy, and must preserve the environment. While solving the complex problem, Manuaba's 'SHIP' approach, which covers four aspects, namely systemic, holistic, interdisciplinary and participatory aspects, is implemented comprehensively with the aim of making the results more sustainable at the end. This policy becomes even more important since in the developing countries in general, and in Indonesia in particular, especially with the recent monetary crisis, development steps must be carried out effectively and efficiently, due to limited funds and forces. In this context, the 'SHIP' approach is truly essential in overcoming the existence of complex inter-related problems, which very often occur in developing countries. One of the ASEAN conferences in Manila in 1999 related to human resource development had already adopted this approach. In doing this, there is the hope that no problem will remain or emerge once the improvement/development step has been carried out, as has happened very often in the past.

It is not an easy job, especially changing thinking from a monodisciplinary to an interdisciplinary approach. Working together in a team is not the same as simply dividing tasks between individuals. It is a totally different approach and must be applied right from the educational and training phase. Systemic, holistic, interdisciplinary and participatory thinking must be developed and established step-by-step and gradually, while at the same time slowly eliminating individual thinking and perception. Thinking must come first, followed by doing. Ergonomics curricula of educational institutions in developing countries must be adjusted in this direction. It is time not to be always a follower, but to become an initiator for the sake of the demand and needs of developing countries. To carry out this idea, first we have to produce ergonomics graduates who are able to solve their own environmental problems by developing appropriate competency, and then start benchmarking in order to be ready to face the coming new technology and global competition.

This approach has already been implemented in Udayana's postgraduate ergonomics program, having

a distinctive character and a different look. We cannot evaluate the result now, but what the alumni do in the near future will determine its viability, acceptability and validity. This is highly dependent on how successfully we meet the challenge of broadening the students' horizons, of developing their expertise and additional values, and of training them in how to manage the future in order to be able to meet real needs and demands.

To obtain more experience, attendance at national and international ergonomics conferences with papers has been encouraged, as well as visiting exclusive industries in the country, such as the aircraft, petrochemical, wood and sugar cane industries.

Experience has also been exchanged with universities in Australia, the USA and Europe/United Kingdom through joint seminars, research and teaching.

Future Development

The future development of ergonomics in each developing country will be based mainly on each country's economic situation, the government's concern and commitment, the awareness of industry, and the readiness of human resources, especially the willingness, capability and courage of ergonomists to face the challenges. In supporting and developing this atmosphere, international agencies, professional associations and foreign investors with their investment will strongly determine the outcome. They are also expected to solve the problem in advance by not importing the problem into developing countries, by developing and enhancing the expertise of local ergonomists, and by providing the facilities needed to tackle the problem.

Government concern and commitment is unquestionable, particularly in Indonesia, as has already been demonstrated by the attention given to matters related to health and safety conditions in industry. Besides Workers' Act No. 1/1970 as the ultimate base for improving working conditions and the environment in the workplace, various significant activities have also been carried out. The Health and Safety Council has been created to give advice on manpower policy to the minister of Manpower. One of its recent activities was the Convention on Health and Safety 2000 which was organized last January with so many policy papers from nearly all the technical departments, in addition to the

scientific papers presented by experts in fields including occupational health, safety, ergonomics and psychology. This was a very promising step that had never happened before. One of its prominent outcomes was the idea of founding the National Health and Safety Council, which is an independent body, just as in other developed countries. I believe that in other ASEAN developing countries such as Malaysia, Thailand and the Philippines, such an activity was carried out earlier and was better organized, as it was in Singapore, too. In South Asian countries such as India, Pakistan and Bangladesh, which had been under the British Empire and are now members of the Commonwealth, such a policy must have already been implemented.

Although concern and commitment had already been demonstrated, in daily activity the reality was in fact not as expected. Many obstacles and constraints must still be addressed in carrying out the policy. For years now and in the years to come, developing countries have been and must continue to be assisted in their development efforts by developed countries through loans, very often in the form of goods and machines. In fact, most of them are not ergonomically sound and become sources of occupational hazards for the local consumers or operators. In this case, an appeal has already been made, especially to the Japan Human Ergology and Ergonomic Association as well as to the International Ergonomics Association, to do something about it. How nice it would be if only ergonomically sound goods and machines were exported from developed countries to developing countries! I think this will be the ultimate task of our ergonomics associations, not only to be proud of organizing conferences and the publication of excellent scientific papers, but also to do something real for the populations who really need our ergonomics competency. To support this, information-shaping of ergonomics data should be one of the priorities of our ergonomics associations. Let's be fair; How much of our good research has been implemented in real situations? I think ASEAN member countries must also take this opportunity as one of their development programs, and for this, each member country must be convinced by professional ergonomics associations. This step must be one of the programs of IEA, SEAES and other local professional ergonomics or related associations.

For example, a strategic step has been carried out in Indonesia, as the word 'ergonomics' has been unanimously accepted for inclusion in the 1999-2004 State Development Guideline by the People's Consultative Council of the Republic of Indonesia. The problem that must now be faced is to make everyone aware of what ergonomics is, and then to provide experts who will use the relevant skills and know-how to implement and attain the goal. Of course, the opportunity in terms of policy already exists, and we have to utilize that policy appropriately and properly.

Recently, Indonesia has been busy improving economic conditions, as have other developing ASEAN countries such as Thailand, the Philippines and Malaysia, among others, by inviting investors to invest their money. It would be good if in doing so, ergonomics could be carried out simultaneously, 'built-in' within the development process. In this context, relevant international agencies, professional associations, industrial owners, and managers must go hand-in-hand in carrying out this idea, by recruiting and developing the expertise needed, and by conducting an appropriate ergonomic assessment of technology transfer and of the exported goods from developed countries to developing countries, and between developing countries as well. Since most of the development fund will come from loans, an effective management and efficient organization must be encouraged and become compulsory in order to sustain the development outcome. Mistakes that require more funding and more resources just to eliminate hazardous side effects should be avoided. We have to learn from other countries' mistakes. ASEAN-OHSNET, created in November 1999 with its four main programs, must be used effectively for this purpose. Indonesia, which has been chosen to lead and coordinate the research activities, must be judicious in issues and problems that are common and strategic for ASEAN countries. Other ASEAN countries must do the same with their tasks.

In the case of ergonomics, whose implementation during the planning phases has become very important, and with the recent situation where many investors were invited to invest their money in these regions, and especially in Indonesia, the above approach must be carried out wisely. Ergonomists must do the best for their countries, since this opportunity will never come again. Actually, from a legal as well as an economic standpoint, ergonomics is already having the opportunity of being utilized optimally and maximally. This is especially true when there is a policy that optimization of the existing industry must the base of economic rehabilitation. Finally, it will depend on ergonomists how to use this opportunity wisely and appropriately. In doing so, micro- and macro-ergonomics must be carried out simultaneously in accordance with existing needs and demands. It would be greatly appreciated if this action were carried out under the umbrella of, or within the 'SHIP' approach.

Adnyana Manuaba

Born on May 8, 1936, in Yogyakarta, Indonesia, he studied medical education at the University of Indonesia, Jakarta, where he graduated in 1961 as a physiologist. In 1962 he moved to Bali, to be actively involved in starting a medical school/university, mainly establishing and developing the physiology department.

In 1969, he was accredited as fellow by the Indonesian Physiological Society (FIPS), and in 1996, as Hon.FErg S by the Ergonomics Society.

He started his ergonomics research in 1967 with the main objective of solving ergonomics problems in three main potential economic aspects for the development of the island of Bali, namely agriculture, tourism and small scale and cottage industries. Finally, they covered the ten strategic industries in Indonesia, including aircraft industries, ship-building, and machine production. In 1972, he received the distinction from the Consortium of Medical Sciences.

He was also one of the founders of the South East Asia Ergonomic Society, was elected founders' secretary in 1984, first president of SEAES (1985-1988). He also started the Regional Institute of Industrial Hygiene, Occupational Health and Safety, in Bali under the Ministry of Manpower in 1969, and a consultant for ILO, WHO, and UNESCO (tourism).

In his career, he was the first person in Bali to be awarded a gold medal in 1984 for his dedication and productive work as a civil servant.

Recently, he has been busy encouraging his ergonomics group to work interdisciplinarily and holistically with other disciplines to solve development problems in Bali through the Bali-Human-Ecology Study Group, which was founded in 1986. Teaching and encouraging people to think and act holistically has become his ultimate goal.

10 Human Factors and Ergonomics Converge – A Long March

Hal W. Hendrick

Introduction

Although ergonomics and human factors had separate (but overlapping) beginnings, what those who identify themselves as human factors professionals, specialists or engineers do today is the same as what is done by those who identify themselves as ergonomists (Chapanis, 1991). This also is reflected in the current IEA definition of the discipline, included elsewhere in this book. The IEA formally recognized this convergence in the early 1980's, and declared the terms "ergonomics" and "human factors" as synonymous. In part, the IEA's recognition resulted from Council representatives from the various IEA Federated Societies informally sharing knowledge about the activities of their respective members with one another during the IEA Council annual meetings. In addition, several studies of ergonomics and human factors had identified this convergence (e.g., see Hendrick, 1981). Later studies consistently have reconfirmed this convergence. For example, a special meeting of ten Federated ergonomics and human factors societies representing over 25 countries was held during the 1988 IEA Triennial Congress in Sidney, Australia. Among other things, a major purpose of the meeting was for the representatives to share knowledge about the nature of their respective society members' activities. Two general conclusions emerged from that meeting (Hendrick, 1989). First, that the one common theme of ergonomics and human factors internationally is the focus on the design of the interfaces between the human component of systems and the other system components (i.e., hardware, software, jobs, internal and external environments, and work system structures and processes), including analysis and test and evaluation. Second, that the unique technology ergonomists and human factors professionals alike develop through scientific investigation, and apply as practitioners, is what the Human

Factors and Ergonomics Society (HFES) later labeled as human-system interface technology (see HFES, 1999, p. 389). As used here, a system can be as simple as a human using a hand implement or as complex as a multinational organization

Other confirming studies include the IEA Special Survey of Federated Societies (Brown, Hendrick, Noy, and Robertson,1996), Harmonizing European Training Programs for the Ergonomics Profession (Rookmaaker, Hurts, Corlett, Queinnec, and Schweir, 1992), A study by the US National Research Council on human factors education and utilization (Van Cott and Huey, 1992), and a review of the literature by the Board of Certification in Professional Ergonomics (BCPE) in the US which led to the development of the BCPE's international professional certification program in Ergonomics/Human Factors in 1992. The BCPE offers professional certification either as a "Professional Ergonomist" or "Human Factors Professional" based on meeting identical criteria (BCPE, 1999).

The remainder of this Chapter briefly reviews the developmental history of both ergonomics and human factors and some of the factors that led to the convergence of the two into a distinct, unified discipline.

Origin of the name "ergonomics"

The term "ergonomics" is derived from the Greek words, "ergon", meaning work, and "nomos", meaning principle or law. The early Greek word, "ergonomos", referred to a Greek law that protected workers in the workplace, similar in intent to our occupational health and safety laws today.

The first person to actually coin the word "ergonomics" and define it in a publication was the Polish scholar, philosopher and naturalist, Wojceich Jastrzebowski. In 1857 he wrote a treatise titled An Outline of Ergonomics, or the Science of Work. In his treatise, Jastrzebowski noted that ergonomics deals with "useful work", which brings improvement or is commendable, and involves making good use of Man's forces and faculties. He contrasted this with "harmful work" that brings deterioration.

Some Precursors of Human Factors and Ergonomics

Scientific Management

A major precursor to both ergonomics and human factors was the introduction and implementation of "scientific management" near the end of the 19th century, and the follow-on work dealing with the systematic time and motion analysis of work movements to reduce human effort and improve work efficiency.

The end of the 19th Century was characterized by the accumulation of resources and a rapidly developing technology in American and European industry. During this period, labor became highly specialized and industrial engineers were called upon to help design work systems and optimize efficiency. One of these, Fredrick W. Taylor, developed the concept of scientific management that came to have a major impact on the shaping of organizational theory and the design of work. The essence of Taylor's concepts of work organization is implicit in his four basic principles of managing (Szilagyi and Wallace, 1990).

First, Develop a science for each element of man's work that replaces the old rule-of thumb method.

Second, scientifically select and train, teach, and develop the workman.

Third, hardily cooperate with the men in order to ensure all of the work is being done in accordance with the principles of science that has been developed.

Fourth, provide equal division of work and responsibility between the management and the workmen.

Taylor advocated scientific analysis, rather than "common sense" and intuition as the basis for job and work system design. He believed that, though systematic observation and analysis, work could be designed to require less effort and result in increased productivity. By scientifically determining "the one best way" of performing a task, the organization would benefit financially from greater productivity and the workers from having to exert less effort and receiving higher wages because of their increased efficiency. While these objectives are consistent with contemporary human factors/ergonomics, Taylor's notion of "one best way" is

not, as we now know that there can be various effective ways, depending on the individuals involved and a variety of sociotechnical factors.

Today, Taylor often is thought of as being exploitive because of the ways his concepts have sometimes been used by management to exploit workers. In fact, he actually sought to humanize work while, at the same time, enhancing productivity. It was his insistence on work design by scientific analysis and reducing human effort while enhancing efficiency that served as his legacy for the development of ergonomics and human factors.

Taylor's concepts were further extended by Frank and Lillian Gilbreth. This husband and wife team refined the analysis of work movements and developed the basic methodology of time and motion study – precursors to modern ergonomic work analysis.

Industrial Psychology

A second discipline whose development during the first 30 years of the 1900's served as a major precursor to human factors is industrial psychology. Perhaps the most notable "father" of industrial psychology, and one of particular relevance to human factors, was Hugo Munsterberg. Munsterberg combined knowledge from experimental psychology, industrial engineering, and differential psychology (the study of individual differences) into a new area which, at the time, he labeled economic psychology. Economic psychology was concerned with the identification of human differences, as well as similarities, and taking them into account in designing machines, work stations, and work routines, and evaluating the relative efficiency of various worker-machine-process combinations. (Landy, 1985).

Related to the study of human performance differences and similarities was the development and validation of various instruments to measure human abilities and skills. During World War I, the Army Alpha and Beta intelligence tests were developed by psychologists for the purpose of selecting persons to be officers in the US Army. This selection process proved so effective that it led to the development, internationally, of a wide variety of tests to measure human abilities

and skills for the purpose of matching the capabilities of individuals with the demands of jobs. Edward Lee Thorndike was perhaps the best known of these early 1900 psychologists. Thorndike is particularly well known to human factors/ergonomics professionals for his development of the classic "law of effect". Namely, that behavior followed by positive consequences tends to be repeated in that situation. The "law of effect" provided the basis on which B.F. Skinner developed operant conditioning as a learning method for skill acquisition and performance enhancement. (Skinner, 1969).

Collectively, these and other activities, such as the human relations movement resulting from the classic Hawthorne studies, eventually became known as the discipline of industrial psychology (Landy, 1985). Although the central focus of industrial psychology was fitting persons to the job, the methods and procedures later proved equally useful for designing jobs to fit people – a domain of human factors and ergonomics.

Like human factors/ergonomics, industrial psychology eventually expanded to include organizational factors and, today, is formally known as Industrial and Organizational Psychology.

Other US Psychology Precursors

Two other psychologists deserve mention for their role as precursors to the human factors discipline, Ross McFarland and John Flanagan. McFarland was a psychologist with a very practical orientation. He conducted extensive research on aviator performance, oxygen deprivation, visibility, signage, and car and truck control and display design starting in 1927. In the 1930's, he consulted extensively with airlines on issues of crew fatigue and hypoxia. Late in life, in 1970, he became the 14th President of the Human Factors Society

John Flanagan directed the U.S. Army Air Force Aviation Psychology Program just prior to and during World War II. He initially was tasked with improving selection. Flanagan, and more than 100 other psychologists inducted into the armed forces after the war started, were asked to address true human factors issues. This group, which included the likes of Paul Fitts and Alphonse Chapanis, formed the core

and critical mass necessary for the subsequent development of the human factors discipline in the United States.

Industrial Fatigue Research Board (UK) Studies

Perhaps the root of environmental ergonomics was the work of the British Industrial Fatigue Research Board, which began in the early 1900s and carried into the 1930's. Over thirty excellent studies were conducted and reported on various aspects of environmental stress and human performance. . This work provided the foundation for the environmental ergonomics work that blossomed in the 1960's at such places as Aston, Loughborough, Wales and Birmingham universities in the UK, and various Department of Defense, NASA, and university (e.g., Cornell) units in the US. During this same period, parallel research to develop and apply human-environment interface technology was ongoing in other Western European countries, Japan, The USSR, Australia, and elsewhere.

The Beginning of a Formally Recognized Discipline of Human Factors

Although, as noted above, some of the underlying research can be traced directly back to the late 19th and early 20th centuries, human factors, as an identifiable area of research and practice, began in the 1940s during World War II. In the United States, England, and Germany, human factors research and application was conducted to enhance human performance in military weapons systems. For example, all three countries were concerned with how to improve the design of gun sights in order to enable the human to use them more accurately, given human perceptual and psychomotor capabilities and limitations.

In the United States, engineering psychologists were called upon to investigate military aircraft accidents to try and better understand why so many of them were being attributed to "pilot error", and to gain a better understanding of what "pilot error" really meant from a causation standpoint. The basic finding was that what was being called "pilot error" really was engineering design error. Put simply, the controls, displays and workspace arrangements were being designed in ways that were not compatible with human capabilities and limitations. Consequently, these designs were causing pilots to make errors. For example, a pilot would learn to fly in one aircraft, with the altimeter and other critical flight instruments having a particular arrangement on the instrument panel, and then transition into another aircraft with an entirely different arrangement, thus inducing negative transfer of training errors – particularly under stressful flight conditions. During the first two years the US was involved in World War II, over 2000 major multi-engine aircraft accidents were caused by the landing gear and flap leavers being identical in shape, size, and method of operation, and located too close together to permit identification through kinesthetic feedback. Consequently, when landing the aircraft while peering out the window, the pilot, relying on touch and kinesthetic feedback rather than visual inspection, often would mistake one control for the other. In the US, these findings led to research to better understand the human factors involved in designing human-machine interfaces and, hence, to the development of human factors as an identifiable area of research and application. Initially, the central focus was on human perception, reaction, and learning factors and the use of laboratory studies as a means of developing what then was called man-machine interface technology. For example, a classic laboratory study was done by the US Air Force human factors researchers to determine the best combination of control shapes to use in aircraft crew stations for the various flight functions to facilitate identification of a given control and discriminating it from the others. The results of this study, which made use of control shapes associated with the function where possible, led to the standardization of aircraft controls that is used throughout the world today. Similar laboratory research in the late 1940s and 1950s led to the identification of the instruments most critical to flight and an optimal standardized arrangement of them that remains in use today. These efforts have resulted in a huge reduction in design induced pilot errors and concomitant improvements in aviation safety. (American Psychological Association, undated)

The success of human factors research and application in the aviation industry led to the discipline's expansion to motor vehicle transportation systems during the 1960's. During the 1970's we saw the human factors discipline further broaden to many other types of consumer products – a trend that continues today.

In summary, the first several decades of human factors as an identifiable discipline were characterized by laboratory studies to identify the human factors relevant to design; and using the results of that research to develop a human-machine interface technology that could be applied to the design of controls, displays, and workspace arrangements. Although both anthropometric and biomechanical research was a significant part of this technology development, the central focus was on human perceptual, learning, workload, and psychomotor capabilities. The major application of this human-machine interface technology was to the design of aircraft and motor vehicle ground transportation systems.

The Beginning of a Formally Recognized Discipline of Ergonomics

As previously noted, ergonomics had it roots in other disciplines, including industrial engineering and scientific management and the work of the UK Industrial Fatigue Research Board. As a clearly identifiable discipline, ergonomics really began after the Second World War. Following World War II, Europe and Japan were faced with the task of rebuilding their factories. As a result, a concern developed over how to systematically study the nature of human work, or ergonomics, and then apply that knowledge to the design of workplaces. Although cognitive factors also were of concern, the central focus was on the physiological, anthropometric, and biomechanics characteristics of humans, and the use of systematic field observation studies to develop an ergonomics technology related to the physical and environmental aspects of work.

The Convergence of Ergonomics and Human Factors

At least through most of the 1960's, the central focus of human factors and ergonomics could be contrasted as follows.

1. Human Factors relied primarily on laboratory studies while ergonomics relied primarily on field studies.

2. Human Factors primarily was concerned with the perceptual, learning, and psychomotor aspects of human performance, whereas ergonomics primarily was concerned with the physiological, anthropometric, and biomechanical aspects of human performance.

3. Human Factors technology primarily was applied to the design of transportation systems, whereas ergonomics primarily was applied to the design of industrial workplaces.

4. Human factors professionals primarily had an educational background in psychology, whereas ergonomists typically had an educational background in physiology, engineering, medicine, or the rehabilitation disciplines.

At the same time, there also was significant overlap of the two disciplines during their early years. For example, human factors researchers also did study human physical, biomechanical and anthropometric characteristics, and apply the resulting technology to design. Ergonomists also did study human perceptual, learning, and psychomotor characteristics, and apply the resulting technology to design. Some human factors professionals were trained in engineering or medicine and some ergonomists were trained in psychology. Thus, as Chapanis noted in 1971, the differences between human factors and ergonomics primarily were ones of emphasis.

While many factors have contributed to the convergence of human factors and ergonomics, five stand out as particularly important: Growing world competition, value changes in the work forces of the industrialized world, increased awareness and concern about occupational safety and health, the development of the microchip and the computer/automation/communications revolution that ensued, and, most recently, the development by the IEA of international guidelines for the human factors/ergonomics (HF/E) discipline .

Growing World Competition

Following World War II, while Europe an Japan were in the process of rebuilding their industries, the US did not have to worry much about world competition. Consequently, US industry could tolerate considerable inefficiency without serious consequence. Once European and Japanese industries had rebuilt, and progressively enhanced the reliability and quality of

their products, the US was faced with having to improve the efficiency of their industrial operations to remain competitive. This need led to a focus of human factors on industrial ergonomics and improving the environmental and physical aspects of work, as well as work processes and procedures to enhance efficiency and productivity. It also led to human factors professionals placing a greater emphasis on field research to develop and apply its technology. Still another impact was the development of human factors or ergonomics specialties within university departments of industrial engineering in the US. At present, the number of HF/E professionals graduating with engineering degrees in the US equals the number with psychology degrees. In addition, there are a progressively increasing number of persons with professional backgrounds in medicine and the rehabilitation professions entering the human factors/ergonomics field.

In Europe and Japan, the need to produce consumer products that would be competitive on a world market led to the expansion of ergonomics into this area, including a greater emphasis on perceptual, learning and other psychological factors as they affect product usability, attractiveness, and safety.

Value Changes in the Work Force

Beginning in the mid 1960s and progressing into the 1970s, a fundamental shift occurred in the value systems of work forces in the United States and Western Europe. These value system changes and their implications for work design were noted by a number of prominent organizational behavior researchers, and were summarized by Argyris (1971). In particular, Argyris noted that workers now both valued and expected to have greater control over the planning and pacing of their work, greater decision-making responsibility, and more broadly defined jobs that enable a greater sense of both responsibility and accomplishment. Argyis further noted that, to the extent organizations and work system designs do not accommodate to these values, organizational efficiency and quality of performance will deteriorate. These value changes were further validated in the 1970s by Yankelovich (1979), based on extensive longitudinal studies of workforce attitudes and values in the United

States and Europe. Yankelovich found these changes to be particularly dramatic and strong among those workers born after the Second World War. Of particular note from his findings was the insistence that jobs become less depersonalized and more meaningful.

A major impact of these changes on both US human factors and European ergonomics was the recognition that motivational and related psychological aspects of job design needed to be addressed in our research and application. In the 1980s, this recognition also led to the realization that, in addition to addressing these factors at the job or micro-ergonomic level, they also needed to be addressed in designing the total work system, or at the macro-ergonomic level. A second impact has been the increasing use of employee participation in the HF/E analysis, design, and test and evaluation process, including development of the methodology of participatory ergonomics. (Hendrick, 1997)

Increasing Concern about Occupational Safety and Health

Occupational safety and health has been an important concern of both human factors and ergonomics since their inception. Over the past two decades, public awareness and related government regulation to address occupational safety and health via HF/E has progressively increased in many countries. In the US, this has led to a major increase in emphasis on the physical ergonomics aspects of workplaces. As a result, considerable research funding has gone into ergonomics research related to reducing work-related musculoskeletal disorders. Interestingly, in the US, Europe and elsewhere, it also has led to an increased ergonomics emphasis on addressing the psychosocial aspects of occupational health and safety.

Development of the Microchip and the Computer/Automation/Communications Revolution

Perhaps the single most important influence in integrating human factors and ergonomics began with the development of the silicon chip and the revolution that has happened in the world of work since.

Beginning in the middle 1970s, and rapidly expanding in both numbers and capability ever since, has been the development and use of the personal computer. This development, while involving human-machine interface design, shifted the major concern to how people think and process information, and converting that information into the development of a human-software interface technology, or cognitive ergonomics. In a number of countries, it also resulted in approximately a 25% increase in HF/E positions during the 1980's and early 1990's. This increase is reflected in the concomitant increase in membership experienced by a number of IEA Federated Societies over this same period. Today, there remains a shortage of ergonomists having specialized knowledge in software design.

Related to the software design of screen displays and operating systems has been the application of cognitive ergonomics to the development of artificial intelligence, computer-based information, decision support, and expert systems, and computer simulation and modeling. These cognitive ergonomics application areas should see very extensive growth and development over the next several decades.

One other outcome of this revolution is the ability to automate many functions formally performed manually. How to effectively utilize human operators with this automation technology also has created a demand for cognitive ergonomics, including application of classical psychological knowledge in such areas as vigilance, motivation, sensory depravation, attention, and perception.

Another impact of this new electronics technology is not only to change the nature of work, but the organizational structure and processes of the work systems in which individual jobs are embedded. As a result, human factors specialists and ergonomists alike have had to expand into the areas of organizational theory and design, and integrate this knowledge with traditional HF/E at the over-all work system or macroergonomics level. The effect has been a further integrating of human factors and ergonomics. (Hendrick, 1997)

Development of International Guidelines for the Discipline by the IEA

The most recent major factor contributing to a fully integrated HF/E discipline on an international scale has been the development of a series of guidelines by the IEA. These include a core competencies document, criteria for professional certification agencies and programs and, under development, guidelines for developing HF/E professional education accreditation programs. The IEA also has developed a set of guidelines for use by IEA Federated Societies in developing a code of professional practice for their members.

Core competencies guidelines.

During the last half of the 1990s, the IEA has devoted considerable effort to researching and developing a set of core competencies for the HF/E profession. Included in this development process have been an iterative series of meetings with representatives from the various IEA Federated Societies. The purpose of this effort was to provide a comprehensive guideline that can be used internationally for a variety of purposes, including development of professional education curricula and academic accreditation and professional certification/registration programs.

Criteria for IEA endorsement of certification/registration agencies and programs. The IEA recently completed developing a set of criteria for eventual use in evaluating and endorsing professional certification/registration programs in HF/E (as used herein, the terms "registration" and "certification" have the same meaning). Certification/registration agencies and programs that can meet these criteria will be able to apply for official endorsement by the IEA. In addition, these criteria can serve as useful guidelines for developing national and regional professional certification/registration programs.

Guidelines for Academic Accreditation Programs.

Currently, the IEA is in the process of developing a set of guidelines for use by national and regional HF/E societies in developing HFE professional education accreditation programs. These guidelines also can be used by academic institutions in developing HF/E professional education programs.

The Future

It seems clear that, with the passage of time, the lingering image of human factors primarily being concerned with human cognitive capabilities and limitations and ergonomics with physical capabilities and limitations will dissipate. The simple fact that persons calling themselves human factors professionals do the same things as those identifying as ergonomists makes this dissipation inevitable. During the 1990s, those IEA Federated Societies that previously were labeled as "human factors" or "human engineering" societies either changed their name to "ergonomics" or incorporated "ergonomics" into their title. The fact that there no longer is a single IEA Federated Society that does not use the word "ergonomics" in its title should help. Based on this trend, it appears likely that "ergonomics" eventually will become the single label for the discipline.

References

American Psychological Association (undated). Of Men and Machines, Engineering Psychology (APA Focus on Behavior film series). Washington, D.C.: American Psychological Association.

BCPE (1999). Candidate handbook: Policies, Practices & Procedures. Bellingham, WA: Board of Certification in Professional Ergonomics.

Brown, Ogden, Jr., Hendrick, H. W., Noy, Y. I., and Robertson, M. M. (1996). Special Survey of IEA Federated Societies, Final Report. Zurich: International Ergonomics Association.

Chapanis, A. (1971). The search for relevance in applied research. In Singleton, W.T.I, Fox, J. G., and Whitfield, I. (eds.), Measurement of Man at Work. London: Taylor & Francis, pp. 1-14.

Chapanis, A. (1988). To communicate the human factors message you have to know what the message is and how to communicate it. Keynote address to the HFAC/ACE Conference, Edmonton, Alberta, Canada [reprinted in the Human Factors Society Bulletin, 1991, 34 (11), 1-4, part 1; 1992, 35(1), 3-6, part 2].

Hendrick, H. W. (1997). Organizational design and macroergonomics, in G. Salvendy (ed), Handbook of Human Factors and Ergonomics, second edition. New York: Wiley,

Hendrick, H. W. (1989). Human Factors/Ergonomics Societies around the world: Characteristics and issues. Human Factors and Ergonomics Society Bulletin, 32 , 9-10.

Hendrick, H. W. (1981) Engineering education's response to the need of human factors engineers. Unpublished paper, presented during the 89th ASEE Annual Conference, Los Angeles, CA, 24 June.

HFES (1999). Human Factors and Ergonomics Society strategic plan, Human Factors and Ergonomics Society Directory and Yearbook 1999-2000. Santa Monica, CA: Human Factors and Ergonomics Society, p. 389.

IEA (1997). IEA Facts and Background. Zurich: International Ergonomics Association.

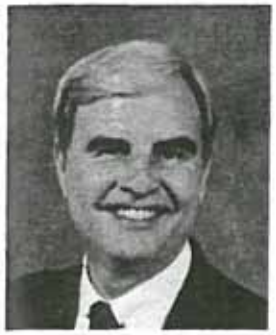
Jastrzebowski, W. (1857). An Outline of Ergonomics or the Science of Work (reprinted in 1997, Warsaw: Institute for Labor Protection).

Landy, F. J. (1985). Psychology of Work Behavior, third edition. Homewood, IL: Dorsey Press.

Rookmaaker, D. P., Hurts, C. M. M., Corlett, E. N., Queinnec, Y., and Schweir, W. (1992). Towards a European Registration Model for Ergonomists, Final report of the working group "Harmonizing European Training Programs for the Ergonomics Profession" (HETPEP), Leiden, NL, June.

Skinner, B. F. (1969). Contingencies of Reinforcement. New York: Appleton-Century-Crofts.

Van Cott, H.P., and Huey, B. M. (Eds). (1992). Human Factors Specialists' Education and Utilization, Results of a Survey. Washington, D.C.: National Academy Press.



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Hal has received USC's highest award for teaching excellence, the HFES Jack A. Kraft Innovator Award for conceptualizing and initiating the sub-discipline of macroergonomics, the HFES Alexander C. Williams, Jr. award for system design, the IEA Distinguished Service Award, and the International Society for Occupational Ergonomics and Safety Certificate of Recognition of Prominence. Most recently, he received the award of IEA Fellow. His numerous biographical listings include Who's Who in America and 5000 Personalities of the World.

Hal has edited eight books. He is a contributing author to Work Related Musculoskeletal Disorders: A Manual for Prevention (1995, Taylor & Francis) and author of the chapter on Organizational Design and Macroergonomics in the Handbook of Human Factors and Ergonomics (Wiley, 1987, 1997). He is the author of a textbook on Behavioral Research and Analysis (Kendall-Hunt, 1981) and co-author of two subsequent editions. He has authored over 150 professional publications.

11 Arbeitswissenschaft meets ergonomics

Kurt Landau

Abstract

The following contribution reviews the history of Arbeitswissenschaft (the science dealing with the design and organization of human work which is designated in this article as "work science"), of the Gesellschaft für Arbeitswissenschaft (Society for Work Science) and of the Zeitschrift für Arbeitswissenschaft (Journal of Work Science) during the period from 1950 to 1975. It examines the role of Arbeitswissenschaft in the reconstruction of German industry after the Second World War and of the Society for Work Science in the broader European context. Comments are made on the research into qualifications and certification of work scientists and on the importance of industrial practitioners of work science.

Introduction

The history of the Arbeitswissenschaft or work science practiced in the German-speaking and Scandinavian countries differs from that of ergonomics in other countries. Work science, which can be defined briefly as the science dealing with the design and organization of human work, extends beyond the purely ergonomic sphere. In addition to actual ergonomics, it embraces areas of industrial medicine, work psychology, industrial engineering, vocational training, work sociology and labor law. This is why some researchers, especially those in eastern Germany, refer to Arbeitswissenschaft in the plural, i.e. work sciences rather work science. However, most work scientists regard their discipline as integrative, rather than additive. In each case, work science as practiced in Germany embraces both micro- and macro-ergonomics.

The term "ergonomics" made its début in Germany in 1969 and its use became more frequent as from 1976 (Tolksdorf, 1984).

Work processes can be analyzed at seven different levels (Luczak et al., 1989):

1. Autonomous physical functions and work environment
2. Operations and movements with tools and machines
3. Work activities and workplaces
4. Workers' actions and work forms
5. Forms of cooperation within teams
6. Corporate working relationships and organization
7. Work and society

This means that work science creates a link between the worlds of the engineer and the natural scientist and the various fields of social sciences.

A job is defined as humane if it does not constitute a health risk for the worker and does not – or at least only temporarily – have any adverse effect on his or her wellbeing. The job should conform with the worker's needs and qualifications and enable the worker to exert either an individual or a collective influence on the work performed. Finally, an effort should be made to design the job so that it encourages development of the worker's personality by enabling him or her to develop latent potentials and perfect skills (Zink, 1998).

History of work science and the Society for Work Science between 1950 and 1975

Two factors have exerted a strong influence on the evolution of work science. Firstly, a highly active, medico-biological-oriented form of work science has existed for over 100 years. Well-known researchers like Kraepelin, Rubner, Atzler, Graf, Lehmann, Mueller working first in Berlin and later in Dortmund founded their own school of thought on the physiological aspects of work. Work science as we know it today would have been unthinkable without their contribution. Secondly, the REFA Work Study Association founded in 1924 also had a major impact on work science. This association took a practical approach to the investigation and analysis of situations arising in industrial engineering and to the application of their findings in manufacturing industry. It was against this background that the Gesellschaft für Arbeitswissenschaftliche Forschung (Society for Work Science Research) was founded in 1953. Its name was subsequently changed to Gesellschaft für Arbeitwissenschaft (Society for Work Science) or GfA. Its aim is to promote the development of work science as a discipline by publishing a journal, organizing congresses and approving scientific memoranda. It is also involved in the approval of norms (DIN, CEN, ISO etc.) relating to job design and performance. Its members include ergonomists, work psychologists, industrial engineers work sociologists and others.

The following are some of the salient points in the postwar evolution of work science as a discipline and of the Society for Work Science.

It was Hans Kellner (1896-1965) who in 1953 took the initiative of calling a meeting of prominent scientists and work science practitioners in Nuremberg at which the Society for Work Science (GfA) was founded. There were 18 founder members (Stirn, 1983). Kellner had at that time been the editor of the Zentralblatt für Arbeitswissenschaft for 6 years. This publication was later renamed Zeitschrift für Arbeitswissenschaft (Journal of Work Science) and is still the organ of the GfA. One of the problems facing Kellner during the immediate postwar period was the lack of qualitatively acceptable articles and he hoped that the newly founded society would help to breathe new life into his publication. One remarkable and unusual feature of Kellner's approach was his insistence on the need to integrate all scientific disciplines devoted to the examination of human work activities, including subjects like industrial sociology which use methods differing radically from those of the other disciplines devoted mainly to natural sciences and technical aspects. Even today, it is still possible at GfA congresses and in the articles appearing in the Journal of Work Science to detect a whiff of mistrust reigning between the camps of the engineers, natural scientists and social scientists and the methods they use.

Another of the GfA's objectives from the very start was to encourage cooperation between science and industry - an obvious advantage in the present day and age, but much less so in the 1950's. Every attempt is made to have at least one member with experience of working in industry on the GfA's governing board and also to avoid any imbalance in favor of the employers' associations or the unions. To ensure coverage of the main German-speaking countries there is normally one Swiss and one Austrian representative on the board.

Fig. 1 shows the society's membership structure.

On several occasions in the past the GfA has published policy declarations in the form of memoranda, often in conjunction with other organizations involved in labor matters. The society has also played a significant role in the compilation of lists of definitions (e.g.. KAT, 1967). More recently, a quadrilingual glossary was published which, although not an official GfA publication, was compiled by prominent GfA members (Hammer, 1997).

Personalities influencing the society's work and shaping work science research in the German-speaking region during the 1950's and 1960's include Lehmann (1952), E. A. Müller (1961) Graf (1960) and Böhrs (1965), followed in the 1970's and 1980's by names like Rohmert (1960, 1962, 1972), Rutenfranz (1975), Schmidtke (1965), Hettinger (1970), Hilf (1957) and Grandjean (1967). Works of reference on the evolution of work science, its theories and discussion of the models used include Hackstein (1977) and Rohmert and Luczak (1974).

One significant feature of the work performed by work scientists between 1950 and 1975 was the controversy over research objects and strategies and the role to be played by the various disciplines. This led to the publication of the following memoranda:

- Memorandum on the Promotion of Study of Work Science at German Universities (1963)
- Memorandum on Work Science in Legislation (1973)
- Memorandum on the Status of Industrial Medicine and Ergonomics (1980)

A symposium on the prospects of organizing work science on an interdisciplinary basis held at Bonn University in 1974 focused its attention on the demarcation of research fields and discussed the pros and cons of the monodisciplinary versus the interdisciplinary approach (Fürstenberg, 1975). The 1980 memorandum listed above demonstrates the widely differing and controversial opinions held by work scientists on what work science actually is, who work scientists are, what research strategies are appropriate, what should be the relationship between research and practice and how research can best be supported.

Analysis of the scientific articles published in the relevant journals shows that roughly 53% of these deal with engineering or natural science subjects and 35% with social science subjects. It is impossible to classify the remainder. Whereas most of the articles dating back to the 1950's were monodisciplinary, there is subsequently a trend stretching through to the 1970's towards interdisciplinary methods. Analysis of the theoretical approaches used in 190 journal articles shows that roughly 25% could be classified in the Taylor/Gilbreth or the German time study category. 8% were classified as system approaches, 8% as interdisciplinary approaches and 5% as action-oriented approaches (Tolksdorf, 1984).

The start of the transition from a predominantly monodisciplinary approach (e.g. work science based solely on work physiology) to interdisciplinary or multidisciplinary approaches is marked by an important milestone, namely the closure of the Max Planck Institute for Work Physiology in Dortmund in 1967. This seems to have initiated a process of shifting work science research from a few centers without university status to the universities. Tolksdorf (1984) speaks of two phases in the dissemination of work science thinking, the first in the mid-1960's emanating from the technical universities, the second from the beginning to the middle of the 1970's with the foundation of new universities and extensions to existing ones. This "expansion theory" is supported by an analysis of the contents of the main German work science journals.

The Max Planck Institute for Work Physiology in Dortmund can be described as the cradle of work science, in that the great majority of university lecturers teaching this discipline at German technical universities during the 1960's and 1970's had passed through this institute's school at critical stages in their careers This meant that all technical universities offering course of study in mechanical, production and commercial engineering possessed the staff and the organization to include work science in the curricula (Luczak, Rohmert, 1984).

Even the Society for Work Science itself was still unable at the end of the period under review to produce a generally accepted definition of work science. This is illustrated by the fact that Hackstein (1977) was able to compile a list of around 50 different definitions of the term. Nor was there at this time any uniform methodological structure for work science research. Human

work was a research object and investigations were based on specific types of work activity and specific human patterns. A more or less uniform and systematic structure was established as from the end of the 1970's. The thematic contents, e.g. the basic principles of work science, practical methods for measurement and evaluation of various forms of work and environmental influences and study design, of the relevant textbooks have been standardized (Luczak, Rohmert, 1984).

Work science and German industrial reconstruction after the Second World War

The economic problems and the need for industrial reconstruction following the Second World War are reflected in the activities of the Society for Work Science and the articles in the Journal of Work Science during that period. The main themes were the nutritional requirements for work performance (not surprising in view of the malnutrition prevailing in Germany at the time) and the standardization and scientific penetration of work study. Time schedules and the establishment of the principle of payment by results played a key role in the reconstruction of the German economy. Looking back from the present-day vantage point, one can be of two minds on these questions but the immediate problem was to reconstruct bombed factories and get them back into production and maximization of work output was the clarion call. A further problem was the lack of skilled technical and manual labor caused by the war, which meant that the only promising recipe for success was the provision of jobs with small, repetitive content true to the Taylorist doctrine. The human being was universally regarded as a work machine and this attitude was reflected in work science research which focused its attention on determinations of energy turnover and pulse rate analyses (Cf. Spitzer, Hettinger 1969). The aforementioned publication on energy turnover measurements in various jobs and occupations was one of the most frequently quoted work science sources in Germany.

Agriculture was for obvious reasons still of major importance in Germany at that time and was accordingly a favorite field of research. Preuschen (1973) made valuable contributions to work science in agriculture and Hilf (1977) did the same in forestry.

The Geneva Scheme of Work Evaluation defined at the International Labor Organization's 1950 conference in Geneva produced a strong response. It seems highly probable that German industry was the most avid user of this analytical method of work evaluation. Until well into the 1970's (and in some cases still today) the basic categories of ability, physical stress, skill, mental stress and physico-chemical work environment were used to evaluate industrial work, each category generally being broken down into between 8 and 16 items. It was only in the late 1970's that a new, so-called "Summarik" was evolved from the agreements on working conditions negotiated between Volkswagen and the unions, which were subsequently incorporated in the general union agreements for the engineering and electrical industries. Important publications on this subject include: Euler, Stevens (1965), Hagner, Weng, (1952); Birkwald, Pornschlegel (1973).

In addition to these - scientifically treated - subjects, the issues of the Journal of Work Science appearing during this phase of industrial reconstruction contain brief contributions and tips on practical matters like the currency reform, workers' vacation rights, purchasing power in the different occupation zones and many other such subjects.

The pragmatic approach adopted by the employers' and employees' representatives is a special feature of German work science (e.g.. IfaA, 1974 und WSI, 1974). It can certainly be claimed that the REFA Association for Work Study and Industrial Organization has made a unique contribution to the ongoing development, systematization and standardization of pragmatic work science (Cf. REFA 1951, 1952).

The Curatorium for Rationalization of the German Economy (RKW) also played a key postwar role in the field of business-oriented work science. Its main areas of activity were in the regulation of human relationships in industry with special emphasis on the human relations ideology of the 1950's (Luczak, Rohmert, 1984).

Research on humanization of industry in Germany

Work science in Germany during the 1970's and 1980's was strongly influenced by phenomena that can be summarized under the heading "Research on humanization". Both the federal and the individual state governments gave their strong support to a research pro-

gram on "Humanization of Working Life (HDA)". The institutions sponsoring the HDA program provided financial support totaling DM1.1 billion to 1432 individual or joint research projects which ran until well into the 1980's. The main areas investigated by these projects were:

- Reduction of injurious environmental influences (work materials, noise, vibrations etc.)
- Job design in the mining industry
- Design of workplace and work equipment
- Safety techniques
- Work for disabled persons
- Industrial medical research
- Technical aids and ongoing development of production techniques
- Implementation of knowledge acquired from work science research
- Non-sector-specific, application-oriented knowledge

During the later years moves to focus research work on specific points helped to tighten up the structure of the HDA program and make it more transparent. This was an attempt to silence criticism of the program which had spawned innumerable project reports, many of which were not easily available to potentially interested parties.

Academic training in work science

Training in work science is offered by universities, application-oriented research institutes and in specialised, on-site courses in industry. Lectures, practical training periods and seminars on various aspects of work science are included in the university degree syllabus for

- engineering (especially mechanical, industrial, safety and production engineering)
- medicine (industrial medicine, toxicology)
- industrial psychology
- industrial sociology
- economics and human resources studies
- industrial and social law

Technicians and foremen can receive training in the practical aspects of work science at either technical colleges or industrial seminars. Selected representatives of the unions and the employers' associations are another key group receiving training in applied work science.

Ergonomics courses per se like those available at Loughborough University in England are seldom to be found in Germany where work science is nearly always part of a broader study course. However, some German universities do offer postgraduate courses.

Legal background

During the period under review there was no single German "Work Statute Book" containing all the legal standards applying to gainful employment. Labor law was (and in some cases still is) scattered across a large number of legal sources. German labor law makes distinctions between the following categories:

1. Individual labor law (laws relating to personal employment contracts)

2. Employee protection law (regulations promulgated in the public interest for the protection of employees).

3. Collective labor law (mainly employer/union agreements on wages and working conditions, the Works Council Constitution Act and the Staff Representation Act).

4. Law on labor court proceedings

The Works Council Constitution Act (Betr VG) and the Industrial Safety Act which made their appearance in the German statute book in 1972 and 1973 respectively had a galvanizing effect on the evolution of work science in Germany. By creating a broad spectrum of ergonomic and work-safety responsibilities for industrial safety and medical officers, they stimulated demand for well-qualified personnel. They also brought fundamental changes in industrial work processes.

Clauses 90 and 91 of the Works Council Constitution Act were of exceptional significance for work science as a discipline (see fig. 2). Clause 90 requires the employer to notify the Works Council in good time of plans to erect new buildings and technical installations and to convert or extend existing ones, to introduce new work processes and procedures and to create new jobs and to discuss these plans with the council. If it appears that the proposed changes will involve specific types of stress for the relevant em-

ployees, Clause 91 stipulates that the Works Council can require the employer to take appropriate action to compensate this stress. This is a legally enforceable right of codetermination conferred on the Works Council. This was the first statutory act in which the term "validated work science findings" was used. Employers, unions, labor courts and work science itself spent much of the 1970's in the search for an interpretation of this term.

Other laws and regulations have also exerted a strong influence on work science and its implementation in industry. Examples of these are the Machine Safety Act and the Regulation on Workplaces and Work Materials. The 1970's were a prolific period for the publication of new German (DIN) standards containing work science components, for example, workers' physical dimensions, body profile templates, internal illumination, climate, ventilation etc. There can be no doubt that German work science pioneered the subsequent spate of European standards and it is impossible to exclude the possibility that hyperactivity in the field of standardization may have hampered creative approaches to ergonomic job design.

Group	Members from	No. of members abs.	%
1	Commerce and industry	195	29.1
2	Industry associations, trade unions, BG's*, ministries, other official bodies	78	11.6
3	Institutes	142	21.2
4	Universities, colleges, academies	91	13.6
5	Retired (not classified in other groups)	138	20.6
6	Technical colleges	26	3.9
	Total	670	100.0

* Employers' liability insurance associations

Fig. 1: Membership structure of Society for Work Science

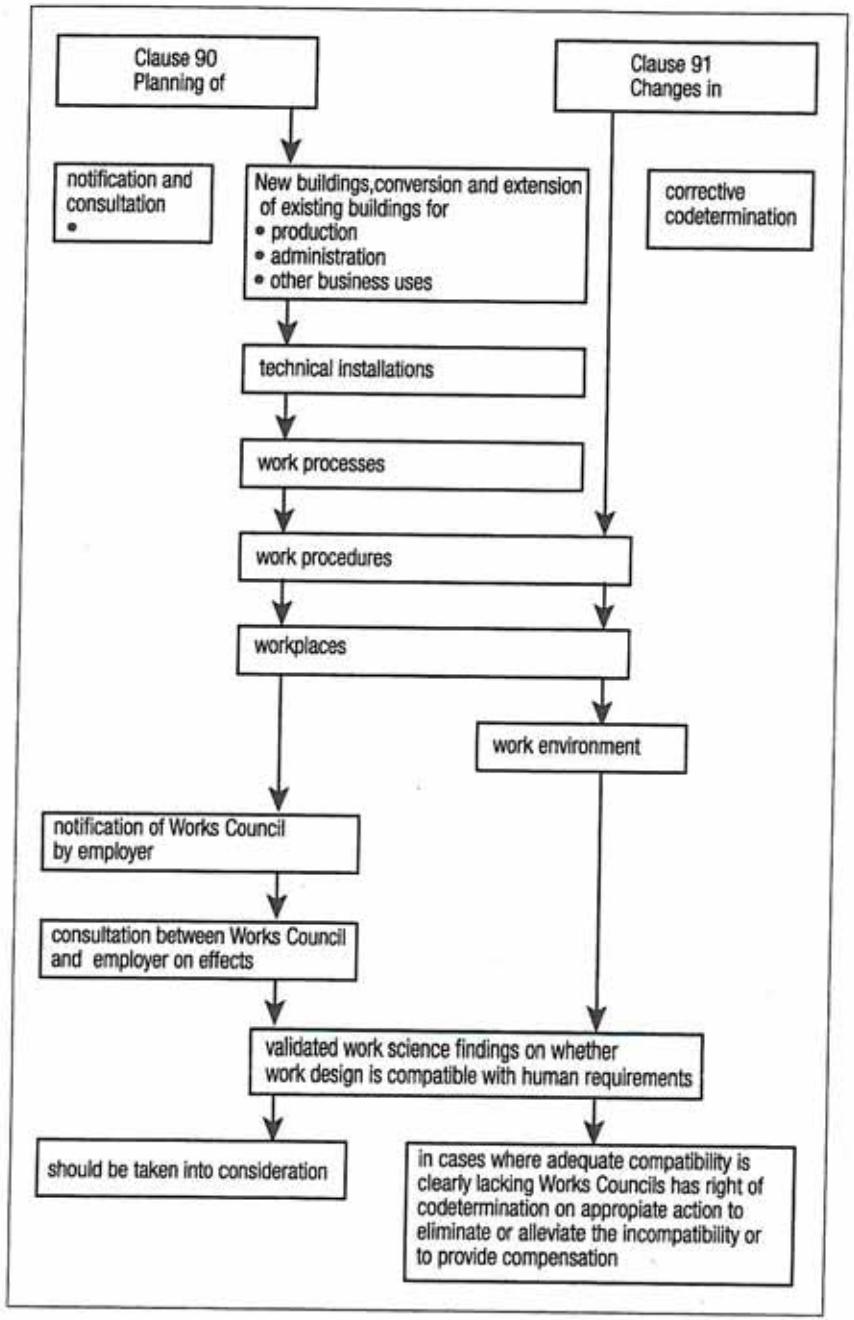


Fig. 2 Summary of provisions of Clauses 90 and 91 of the Works Council Constitution Act (from Birkwald/Pornschlegel)

Bibliography:

Birkwald, R., Pornschlegel, H. (Hrsg.): Mitbestimmen im Betrieb. Köln, 1973

Böhrs, H.: Arbeitswissenschaft. Handwörterbuch des öffentlichen Dienstes – Das Personalwesen. Berlin, 1976, Spalte 284 bis 291

Böhrs, H.: Untersuchungen zur Ermittlung der Vorgabezeit beim Heben von Lasten unter Berücksichtigung des menschlichen Energieaufwands. München, 1965.

Bramesfeld, E.; Graf, O.: Praktisch-psychologischer und arbeitsphysiologischer Leitfaden für das Arbeitsstudium. München, 1949

Denkschrift Arbeitswissenschaft in der Gesetzgebung, der Gesellschaft für Arbeitswissenschaft e.V. (GfA), edited by Rationalisierungskuratorium der Deutschen Wirtschaft e.V. (RKW).Frankfurt, 1973

Denkschrift Ausbau der Arbeitswissenschaft an Deutschen Hochschulen, edited by der Gesellschaft für Arbeitswissenschaft (GfA) Frankfurt, 1963

Denkschrift zur Lage der Arbeitsmedizin und der Ergonomie, edited by der Deutschen Forschungsgemeinschaft (DFG). Boppard, 1980

Euler, H., Stevens, H.: Die analytische Arbeitsbewertung. Düsseldorf, 1965

Fürstenberg, F.: Konzeption einer interdisziplinär geführten Arbeitswissenschaft, Göttingen, 1975

Graf, O.: Arbeitsphysiologie, Wiesbaden, 1960

Grandjean, E.: Physiologische Arbeitsgestaltung – Leitfaden der Ergonomie. Thun, 1967

Hackstein, R.: Arbeitswissenschaft im Umriss. Essen, 1977

Hagner, G. W., Weng, H.: Arbeitsschwierigkeit und Lohn. Köln, 1952

Hammer, W.: Wörterbuch der Arbeitswissenschaft, München, 1997

Hettinger, Th.: Angewandte Ergonomie – Arbeitsphysiologische und Arbeitsmedizinische Probleme der Betriebspraxis. Frechen, 1970

Hilf, H. H.: Arbeitswissenschaft. München, 1957.

IfaA: Institut für angewandte Arbeitswissenschaft, Ermittlung von Erholungszeiten. Köln, 1974

KAT, Kommission für Arbeitswissenschaftliche Terminologie der Gesellschaft für Arbeitswissenschaft, (Ed.): Arbeitswissenschaftliche Begriffe. Mainz: 1967
Lehmann, G.: Praktische Arbeitsphysiologie. Stuttgart, 1952

Luczak, H., Rohmert, W.: Stand der Arbeitswissenschaft, in: Zeitschrift für Betriebswirtschaft, Ergänzungsheft 1/84. Wiesbaden, 1984

Müller, E. A.: Die physische Ermüdung. In: Baaden, E. W. (Hrsg): Handbuch der gesamten Arbeitsmedizin Bd I, München 1961, p. 405-444

Preuschen, G.: Die Arbeit in der Landwirtschaft. Stuttgart, 1973

REFA: Das REFA-Buch, Band 1. Arbeitsgestaltung. München, 1951

REFA: Das REFA-Buch, Band 2. Zeitvorgabe. München, 1952

Rohmert, W.: Statische Haltearbeit des Menschen. Berlin, 1960

Rohmert, W.: Untersuchungen über Muskelermüdung und Arbeitsgestaltung, Aachen. 1962

Rohmert, W.: Aufgaben und Inhalt der Arbeitswissenschaft, in:
Die berufsbildende Schule, 24, 1972, 1, p 3-14.

Rohmert, W., Luczak, H.: Entwicklung und Dokumentation der Arbeitswissenschaft in Deutschland

Rohmert, W. (Hrsg.): Entwicklung und Erkenntnisse der Arbeitswissenschaft, Berlin, 1974

Rutenfranz, J.; Werner, E.: Schichtarbeit bei kontinuierlicher Produktion – Arbeitssoziologische, sozialpsychologische und arbeitsmedizinische Aspekte. Bremerhaven, 1975.

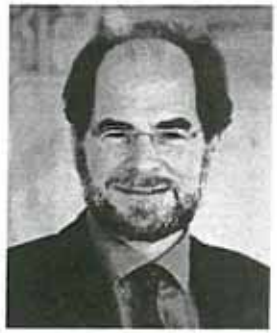
Schmidtke, H: Die Ermüdung, Bern, 1965

Spitzer, H; Hettinger, Th.: Tafel für den Energieumsatz bei körperlicher Arbeit. Berlin, 1969

Tolksdorf, G.: Zur Entwicklung der Arbeitsforschung in der BR Deutschland von 1947 bis 1983. Bielefeld: Kleine Verlag, 1984

WSI: Grundelemente einer arbeitsorientierten Einzelwirtschaftslehre. Ein Beitrag zur politischen Ökonomie der Unternehmen. WSI-Schrift Nr. 23. Köln, 1974

Kurt Landau, Prof. Dr.-Ing. Dipl. Wirt. Ing.



Director of Ergonomics Institute of Darmstadt Technical University, Germany.
Born 1947.

Studied Industrial Engineering in Darmstadt where he graduated as Doctor. Worked as systems analyst in Grenoble and in Geneva

Head of Foreign and Ergonomics Divisions at REFA Association in Darmstadt. Professor of Ergonomics at Hohenheim University.

Member of numerous scientific associations in Germany and elsewhere. Chairman of REFA Association's Basic and Further Training Committee.

Member of editorial boards of several scientific journals

250 publications.

12 Ergonomics International

Stephan Konz

Start of EI

In 1981, Jan Rosner and Harry Davis decided there was a need for the International Ergonomics Society to have a newsletter. Jan Rosner gave the newsletter the title "Ergonomics International". Stephan Konz was the first editor and the first issue was published in Nov. 1981. It was decided to have 3 issues/year.

At first, Konz not only typed the copy, but duplicated it on a Xerox machine, assembled it, stuffed it into envelopes and put a stamp and address on the envelope. At least the Post Office then delivered it!

In 1981, the IEA had an address list of about 100 people of "key people in ergonomics" in various countries. EI was sent to each of the addresses on this list. The concept was that the key people would reproduce items from EI in their own country. The IEA had a distribution cost of about $1 US for each address (about half duplication and half postage); Konz was free. In 1987, the distribution was taken over by Taylor and Francis who has paid the duplication and postage costs ever since.

Over the years the names on the address list have been updated with people added and deleted; by 1998 the number was about 350. In the early 1990s, the postal address was supplemented with fax and phone numbers (when available). Around 1995, email addresses were added as they became available. The list has always been available free to anyone requesting it. Typically there were about 10 requests/year.

The first issue of Ergonomics International was in Nov. 1981. Copies of all the EIs have been filed in the IEA Historian's files--except the July 1982 issue which has been lost.

Publication in Ergonomics

In 1986/1987 there was an important change; EI began being published in the journal Ergonomics. (The November 1986 editorial material was printed in July 1987 in Ergonomics.) This change did introduce a delay in publication of the editorial material of 4-7 months but there were many advantages to the change. The first advantage was that EI was published in a journal and thus went to a wider audience and, perhaps even more important, now became a matter of record since copies now were available in many libraries all over the world. Taylor and Francis also sent offprints of EI to the people on the IEA address list at no expense to the IEA. A more subtle advantage was printing (instead of photoduplication) permitted the addition of better graphics and photographs.

Thus, EI was now distributed through offprints and through Ergonomics.

The Jan. 1990 issue of EI was the first to list the fax number of the editor.

In 1992, Taylor and Francis requested EI go to 4 issues/year instead of 3; the request was accepted. This not only reduced the publication delay but also resulted in more pages/year.

A humorous event concerning Taylor and Francis was their identification of the 1992 issues with seasons (Spring, Summer, etc.) instead of months. After some acid comments from the southern hemisphere, they resumed using months in 1993.

Use of email

However there was still some publication delay. In the early 1990s, a new technology, email, became available to some people, including Konz. (The first listing of the editor's email address in EI was the Late Spring 1992 issue.) At first, this was just used to communicate with Taylor and Francis, supplementing use of the post and faxes. But then email was used to send EI to one key person in each national society. The concept was that the person then could forward it to the editor of the national newsletter (if there was one), cutting 3-4 months off the printing delay time. At first, there was some difficulty in obtaining email addresses for someone in each national societies.

Thus EI now was distributed through offprints, Ergonomics, and email to key people.

Use of the Web

The April 1996 issue of EI announced the IEA web page, based on an address at the Univ. of Louisville. Although it may seem amazing to people today, in 1996 most people did not even know what the World Wide Web was. (There were some initial problems in getting a web address as the initials IEA were also used by various other organizations.)

Thus now EI is available four ways: through offprints, Ergonomics, email to key people, and through the Web. The Web made EI available to "everyone", not just "key people."

New editor

In September 1988, Andy Marshall took over as the editor of EI. The August 1998 editorial material was published in Ergonomics in December, 1998.

IEA logo

Some changes in the IEA can be observed through EI. The initial logo (see Figure 1) had stylized letters and had a globe divided into two. (The two divisions symbolized "Old World" (Europe) and "New World" (North America); the total was "One World.") By 1994, there was a desire for a new logo--especially from those who felt the world included more than Europe and North America. Prof. Karwowski had a graphic designer come up with a number of alternatives. After considerable discussion at a number of Council meetings, a new logo was agreed upon. The new logo (see Figure 2) first appeared in EI in November 1996.

Figure 1. Original IEA logo.

Figure 2. Present IEA logo.

Membership in IEA

At the start of 1989, I began a survey of the IEA member organizations concerning their membership. Table 1 shows the results. This was continued every year until 1998. Table 2 shows the results of the 1998 survey.

What are some changes in the 10 years? First would be the increase in total membership of IEA societies from 11,689 to 16,516 along with an increase in Federated Societies. New countries were China, Croatia, Czech Republic, Greece, Inter-regional ergonomic society (replacing Russia), Ireland, Portugal, Slovak Rep., Spain, Taiwan, Turkey, and Ukraine. As of March 2000, Columbia has been added since Jan. 1988.

Membership in IEA Federated Societies in proportion to a population of 1,000,000 is given in both tables. In 1988, Australia had 42 members/1,000,000; countries over 20/1,000,000 were Hungary, Netherlands, and New Zealand. (I did not have data for the four individual Nordic countries in 1988.) In 1998, Denmark led with 199 (the Danish society has many physiotherapists as members). Countries over 20/1,000,000 were Australia, Canada, Denmark, Finland, Sweden, Netherlands, New Zealand, Singapore, UK, and USA.

Table 1. Ergonomic societies and their membership. If multiple ergonomic societies are in a country, only the IEA-affiliated society membership is listed (Ergonomics Int., August 1989).

Country/region	Founding date	Recent membership: Date	Recent membership: Number	Population in (millions)	Members per million
Australia	1967	1988	665	158.0	42
Austria	1976	1986	40	7.5	5
Belgium	1986	1988	92	9.9	9
Brazil	1983	1988	244	143.3	2
Canada	1968	1988	295	25.6	12
Columbia	1987			30.7	
France	1963	1987	531	55.2	10
Germany (FR)	1958	1987	550	60.7	9
Hungary	1987	1988	90	4.6	20
India	1987	1988	35	768.0	—
Indonesia	1988	1988	120	176.8	0.7
Israel					4.3
Italy	1965	1986	170	57.2	3
Japan	1964	1989	558	121.4	13
Korea (South)	1982	1988	250	43.9	6
New Zealand	1986	1988	86	3.3	26
Netherlands	1963	1986	576	14.5	40
Nordic (Denmark, Finland, Norway, Sweden)		1986	550	22.6	24
Poland	1977	1988	416	37.5	11
Singapore	1988	1989	30	2.6	12
South Africa	1984	1988	107	34.3	3
South East Asia	1985				
United Kingdom	1949	1986	644	56.5	11
USA	1957	1988	4710	242.2	19
Yugoslavia	1973	1988	50	23.2	2
Total			11 689		

Country/region	Founding date	Recent members Date	Number	Population in (millions)	Members per million
Federated societies					
Association Espanola de Ergonomia	88	97	32	39.3	3
Belgium Ergonomics Society	86	97	159	10.2	16
Brazilian Ergonomics Society	83	95	133	160.5	1
Chinese Ergonomics Society	89	94	450	1217.6	0.4
Croatian Ergonomics Society	74	93	70	4.4	16
Czech Ergonomic Society	93	94	160	10.3	16
Ergonomic Society	64	98	1262	58.8	21
Ergonomic Soc. of Australia	64	98	541	18.3	30
Erg. Soc. F. Rep. Yugoslavia	73	89	50	10.2	2
Erg. Society South Africa	84	98	123	44.5	2
Erg. Society Taiwan	93	97	210	21.4	10
Gesellshaft f.Arbeitswissenschaft	58	96	670	81.7	8
Hellenic Ergonomic Society	88	98	36	10.5	3
Human Factors & Ergonomic Society	57	97	5011	265.2	20
Hum. Factors Assoc. Canada/ACE	68	98	662	30.0	22
Hungarian Ergonomic Society	87	97	70	10.2	7
Indian Society of Ergonomics	87	98	70	949.6	0.1
Inter-regional Erg. Assoc.	95	98	220	147.7	1
Irish Ergonomic Society	95	97	33	3.6	9
Israeli Ergonomics Society	82	98	34	5.8	6
Japan Ergonomics Society	64	97	2102	125.8	17
Nederlanders Vereniging v. Erg.	62	98	500	15.5	32
New Zealand Ergonomic Society	86	95	130	3.6	36
Nordic Ergonomic Society					
Danish Ergonomic Society	72	97	1033	5.2	199
Finnish Ergonomic Society	85	97	148	5.1	29
Norwegian Ergonomic Society	85	97	155	4.4	35
Swedish Ergonomic Society	88	96	256	8.8	29
Oesterreichische A. f. Ergonomie	76	96	44	8.1	5
Polish Ergonomic Society	77	97	458	38.6	12
Portugese Assoc. of Ergonomics	92	96	70	9.9	7
Singapore Ergonomics Society	88	98	126	3.0	42
Slovak Ergonomics Association	93	97	47	5.4	9
Societa Italiana di Ergonomia	61	96	147	57.3	3
Soc. d'Erg. de Langue Francais	63	98	750	58.4	13
South East Asia Ergonomics Soc.	84	97	59	250	2
Turkish Ergonomic Society	xx	98	xx	63.9	xx
All-Urkraine Association	92	98	81	51.1	2
Affiliated societies					
European Soc. Dental Ergonomics	88	97	80		
Human Ergology Society	70	95	234		
Total			16,516		

Table 2. IEA affiliated ergonomic societies and their membership (EI, Aug. 1998).

Sustaining members:

Bureau of Hungarian Council of Ind. Design and Ergonomics

HQL

Stephan Konz

After joining Kansas State University in August 1964, Stephan Konz retired from the University in May 1996. His text, Work Design: Industrial Ergonomics, had its 5th edition in 2000. His text, Facility Design: Manufacturing Engineering, had its 2nd edition in 1994. He has about 225 other publications.

He was the founding editor of Ergonomics International in 1981 and passed the baton to Andy Marshall in September 1998.

13 Cooperation of the IEA and UN Organizations

Kazutaka Kogi

Introduction

The development of ergonomics had important impacts on the activities of the UN organizations in the 1960s and 1970s. Many ergonomists and active national ergonomics societies played prominent roles in promoting the international cooperation with the support of UN organizations. In collaboration with the ILO, these activities led to the publications about ergonomics application in machine design, control of physical environmental factors, ergonomics in industry, agriculture and forestry, hand tools design as well as safety and health related to work organization and psychosocial factors. Ergonomics has evolved to be incorporated in ILO standards and WHO guidelines. Throughout these activities, particular attention was paid to technical cooperation for developing countries. This led to the organization in 1985 of the International Symposium on Ergonomics in Developing Countries in collaboration with the ILO, WHO and IEA. Serial international efforts by the ILO, WHO and IEA helped develop education and training policies in occupational safety and health and ergonomics. This resulted later in the IEA/ILO Ergonomic Checkpoints and related activities for developing countries and small enterprises. Awareness has thus grown steadily of the need for intensified inter-organization cooperation for promoting ergonomics principles in the international sphere.

Active support of UN organizations for international ergonomics

The cooperation between the UN organizations and the IEA evolved in the early period of the IEA activities in the 1960s and 1970s. The International Labour Office (ILO) and the World Health Organization (WHO) organized serial meetings on the development and application of ergonomics with the support of national governments and ergonomics societies. This contributed to the incorporation of ergonomics aspects in national policies and programmes on working condi-

tions and occupational safety and health in many countries. Awareness thus grew in the IEA and its federated societies about the need to link research results with applications and promote education and training.

This early cooperation led to a number of publications that had international impacts. Examples included ILO Occupational Safety and Health Series 14 "Ergonomics in Machine Design" (1969) from the ILO/Czechoslovak Medical Society international symposium held in Prague in 1967 as well as OSH Series 21 "Ergonomics and Physical Environmental Factors" (1970) from the ILO/Ente Nazionale Prevenzione Infortuni symposium held in Rome in 1968. Similarly, OSH Series 35 "Ergonomics in Industry, Agriculture and Forestry" (1977) compiled papers from the ILO/Ministry of Labour of Romania international symposium held in Bucharest in 1974. OSH Series 43 "Optimisation of the Working Environment – New Trends" (1979) compiled papers from the ILO/Ministry of Labour of Turkey international symposium held in Istanbul in 1979 and included papers on ergonomic methods in plants and on the working environment in developing countries. These publications, together with the proceedings of the triennial IEA congresses, demonstrated that many ergonomists and active national ergonomics societies played prominent roles in promoting international ergonomics with the support of UN organizations.

The IEA is recognized as one of non-governmental organizations that have official relations with the WHO. The WHO Executive Board established these official relations with the IEA in 1972. A similar relationship with the ILO as a non-governmental organization is being sought. The IEA is officially associated with the International Social Science Council under UNESCO. The IEA keeps a collaborative relation with the International Commission on Occupational Health (ICOH) which has also official relations with the WHO and the ILO.

Ergonomics in international standards

The development of ergonomics up to the late 1970s had important impacts on the activities of the UN organizations, prompting the integration of ergonomics measures in international standards and guidelines. In 1976, the ILO launched the International Programme for the Improvement of Working Conditions and Environment (known as PIACT according to its French acronym) that paid special attention to ergonomics as a major element in improving working conditions and environment in both industrialized and developing countries. The programme was based on the ILO report to the 1975 International Labour Conference on "Making Work More Human". It emphasized the adaptation of work to people and ergonomics training while recognizing the importance of multiple risks and long-term health effects. Since the Alma-Ata Declaration in 1978, the WHO set the important social target of "Health for All by the Year 2000" and advocated the role of ergonomics in its many activities. These international policies took account of the increasingly important roles of ergonomics as reflected in the IEA congresses and international journals. The impacts of IEA-supported conferences and the official IEA/Ergonomics Society journal "Ergonomics" were significant.

As a result, the ILO Convention on Occupational Safety and Health (No. 151, 1981) and the Convention on Occupational Health Services (No. 161, 1985) incorporated ergonomics as essential aspects of improving occupational safety and health. Both the Conventions represented new international trends stressing the employer responsibilities for addressing multiple risks and taking comprehensive enterprise-level measures on voluntary basis. Ergonomics was embodied within the necessary action for adapting work to people and preventing multiple risks. It was apparent that the international exchange of ergonomics-related activities and their achievements had played an essential role in supporting these ergonomics standards.

Provisions on ergonomics measures were further incorporated in a number of more specific international standards and guidelines. Serial ILO Conventions and Recommendations that evolved in the 1980s and 1990s in line with Conventions No. 155 and 161 similarly emphasized ergonomics measures. Likewise, many ILO codes of practice on occupational safety and health in different industries and in technology transfer incorporated ergonomics measures addressing multiple workplace risks. A prominent example was the ILO Code of Practice on Safety, Health and Working Conditions in the Transfer of Technology to Developing Countries (1988). WHO guidelines often incorporated ergonomics as an essential part of preventive programmes. The new trends of developing international ergonomics standards within International Standards

Organization (ISO) standards started since the 1970s. The IEA federated societies are more or less involved in the recent move for developing ergonomics design standards within the ISO Technical Committee 159 dealing with ergonomics issues.

Cooperation with research and training institutions

An important development relating to these standards was the increasing emphasis placed by the WHO and the ILO on the prevention of work-related diseases. WHO Technical Report Series No. 714 "Identification and Control of Work-related Diseases" (1985) drew attention to the comprehensive preventive measures against various work-related diseases. Ergonomics measures were put forward by many subsequent WHO documents and by ILO standards and guidelines as essential in preventing work-related musculoskeletal disorders such as low back pains and neck and upper limb disorders. The IEA triennial and other conferences and the activities of the IEA Technical Committees greatly contributed to promoting relevant ergonomics measures.

The awareness of the global need to promote ergonomics further helped advance the cooperation with research and training institutions with the support of UN organizations. The support from the WHO, the ILO and the UN Educational, Scientific and Cultural Organization (UNESCO) was particularly notable. The ILO's International Occupational Safety and Health Information Centre (CIS) helped disseminate, through its national centres, the results from IEA supported conferences and journals. The IEA representatives attended from time to time the Network Meetings of the WHO Collaborating Centres in Occupational Health. The last network Meeting took place in Espoo in 1999 in which the IEA was represented. The promotion of ergonomics among the collaborating centres was one of the most important agenda items in these meetings.

Another important aspect of IEA/UN cooperation was the growing awareness of occupational stress and anti-stress measures. Here, the IEA conferences and the activities of the IEA Technical Committees on various aspects of risk assessment and work design contributed to encouraging the ILO/WHO activities in preventing adverse effects of work-related stress. IEA-related activities were well reflected in the joint effort in dealing with psychosocial factors. Thus, the Joint ILO/WHO Committee on Occupational Health discussed psychosocial factors. The results of this Committee meeting was published as OSH Series 56 "Psychosocial Factors at Work: Recognition and Control" (1986). This led to the wide recognition of a range of ergonomics measures in improving psychosocial aspects of working conditions and environment.

The ergonomics related standards and the cooperation through WHO and ILO sponsored meetings greatly helped strengthen education and training programmes in ergonomics. Particularly important was the international symposium jointly organized in Sandefjord in 1981 by the ILO, WHO and the Directorate of Labour Inspection of Norway. The symposium results were published as OSH Series 47 "Education and Training Policies in Occupational Safety and Health and Ergonomics – International Symposium" (1982). The discussion centred on the action at national, enterprise and teaching establishment levels and the action through mass media. This meeting drew attention to the spreading need for training various actors including managers, workers, inspectors, designers, engineers and occupational safety and health personnel about practical ergonomic measures. The Joint ILO/WHO Committee on Occupational Health also made special efforts for promoting the international cooperation among research and training institutions. As a result, the Committee report on "Education and Training in Occupational Health and Safety and Ergonomics" was published in 1982. The IEA member societies also promoted the exchange of positive experiences in developing training programmes and materials on ergonomics improvements through these meetings and IEA supported meetings. The directory of ergonomics educational institutions and the exchange of ergonomics manuals through the IEA and its member were also useful.

Jakarta Symposium for developing countries

Throughout these activities, particular attention was paid to technical cooperation for developing countries. The IEA collaborated with the ILO and WHO in co-organizing the International Symposium on Ergonomics in Developing Countries in Jakarta from 18-21 November 1985. The Ministry of Manpower of the Republic of Indonesia and the South-East Asian Ergonomics Soci-

ety also co-sponsored the symposium. It took several years in preparing this meeting at the joint initiative of the IEA and the ILO. This was the first large project jointly implemented by the IEA and UN organizations for promoting ergonomics research and application in developing countries. The IEA officers and the core members of the SEAES as well as many ergonomists active in the international cooperation for ergonomics in developing countries played important roles in making this symposium successful. The symposium results were compiled in OSH Series 58 "Ergonomics in Developing Countries: An International Symposium" (1987). The four main themes were (1) the role of ergonomics in development, (2) ergonomics in industry, (3) ergonomics in the rural sector and (4) education and training in ergonomics. H. Shahnavaz and I. Kuorinka acted as reporters for the IEA in themes 1 and 4, respectively. Over 230 participants from 35 countries attended. The symposium was held within the ILO's PIACT programme, and a clear emphasis was placed on the role of ergonomics in policies and activities for improving working conditions and the working environment.

This symposium was important for both the IEA and the UN organizations. For the IEA, the ergonomics needs and the approaches discussed with the active involvement of the UN agencies gave an important momentum for strengthening its activities for industrially developing countries. For the ILO and WHO, the results indicated the need to integrate ergonomics in international standards and technical cooperation projects with more emphasis on practical improvements and training. The positive impact of ergonomics on development was confirmed together with the awareness of the need for reinforcing the IEA-UN collaboration. As summarized by R.S. Baloyi and I. Kuorinka in their report on theme 4 presented to the closing of the symposium, action-oriented education and training responding to local needs were identified as clear priorities at both national and enterprise levels. Not only education and training at educational institutions and post-graduate levels but also at enterprise-levels involving managers and workers were confirmed as essential. The need was stressed to build on local practice and to direct action at production-related problems by participatory approaches.

Interestingly, the action-oriented training approaches discussed at the Jakarta symposium further spread to various international projects. Two important developments were the international development of action training programmes for small enterprises in developing countries making full use of participatory methods discussed at the symposium and the organization of "roving seminars" in a number of countries. The serial pilot training activities in which some main actors of the Jakarta symposium took part led to the development of the Work Improvement in Small Enterprises (WISE) methodology applied by the ILO through the late 1980s and the 1990s in the developing regions of Asia, Latin America and Africa. The methodology stressed participatory methods using group work of local people and led to many low-cost improvements in occupational safety and health and ergonomics in small and medium-sized enterprises.

IEA/ILO Ergonomic Checkpoints

Following the spread of the WISE methodology, the IEA and the ILO cooperated in a joint project for developing ergonomic checkpoints to find practical solutions for improving working conditions from ergonomic points of view. In 1991, a group of experts chaired by N. Meshkati was established by the IEA Technology Transfer Committee to create an outline of the checkpoints using the fund provided by the ILO. The group was piloted by K. Kogi from the ILO and I. Kuorinka from the IEA. The core group further included M. Helander, A, Imada, S. Konz, T. Kuorinka, W. Laurig and H. Shahnavaz. They prepared 128 checkpoints focusing on low-cost improvements covering main ergonomic issues of materials storage and handling, workstation design, machine safety, control of hazardous agents, welfare facilities and work organization. These checkpoints were presented as the next step of the WISE manual published in 1988 (Higher Productivity and a Better Place to Work, ILO) and formed an integral part of the ILO PIACT programme.

In the course of the preparation of the manual, a series of "roving seminars" to test the draft manual were organized jointly by the IEA and the ILO in several developing countries. IEA experts and some other ergonomists served as facilitators for these seminars. For example, roving seminars using the extracts from the draft manual and an action checklist were held in

Thailand and Indonesia in 1993. Some other roving seminars were later held in some other countries. This experience stimulated the participating national institutions in these countries and the Industrially Developing Countries Committee of the IEA to organize similar training seminars on practical ergonomics improvements.

The new manual was published in 1996 as an ILO publication entitled "Ergonomic Checkpoints: Practical and Easy-to-implement Solutions for Improving Safety, Health and Working Conditions". The publication has been widely distributed and used in many countries. Thus the book was translated into several languages including Chinese, Japanese, Korean, Farsi, Vietnamese and Polish, with further arrangements for translations in French, Spanish, Arabic and Thai and English reprint in the Philippines. The Checkpoints book became a keystone for the IEA/ILO collaboration and gave much impetus for training activities in both industrialized and developing countries.

As the next stage of the IEA/ILO cooperation, the development of ergonomic checkpoints for agriculture is underway. The IEA is entrusted to develop the manuscript for the new manual with the agreement that it will be published as an ILO publication with the IEA and ILO logos. The structure of the manual will be similar to that of the 1996 Ergonomic Checkpoints, with a clear emphasis on practical ergonomic solutions.

Areas for future cooperation

The IEA's cooperation with UN organizations has pointed to the need for intensified inter-organization cooperation for promoting ergonomics principles in the international sphere. The role of the IEA will continue to be important in orienting this cooperation toward the wider application of ergonomic principles in improving working conditions and the working and community life. The international debate involving both the IEA and UN and other international organizations can support this IEA role. A fruitful area for this cooperation has been and will be the development of international standards and guidelines covering ergonomic issues. Another important area is no doubt the promotion of ergonomic research projects by mobilizing the limited resources toward practical solutions. Therefore, collaboration in developing and spreading action-oriented education and training at various levels, especially in industrially developing countries, will continue to be important for the IEA and the UN organizations. The IEA support for certification of professional ergonomists and for accreditation procedures of ergonomics education programmes will be crucial in securing ergonomics expertise in future activities. The IEA-supported conferences and journals will play a major role in all these areas. In particular as an active NGO associated with the ILO and the WHO, the IEA is expected to play a meaningful role in expanding ergonomics activities for enhancing the quality of life of people in different countries.

Kazutaka Kogi, M.D., D.M.Sc., born on 26 February 1933

1957 Graduated from the University of Tokyo Faculty of Medicine 1958 Institute for Science of Labour, Tokyo

1965 Senior Researcher, Railway Labour Science Research Institute, Tokyo

1978 Senior Researcher, Institute for Science of Labour, Kawasaki

1983 ILO Asian-Pacific Regional Adviser on Conditions of Work, stationed in Bangkok

1988 Chief, ILO Occupational Safety and Health Branch, Geneva

1991 Director, ILO Working Conditions and Environment Department, Geneva

1993 Director, Institute for Science of Labour, Kawasaki

1999 Executive Board Member, Institute for Science of Labour, Kawasaki

Dr. Kogi has conducted applied research and consultancy on occupational health and ergonomics at the Institute for Science of Labour.

At the ILO, he contributed to developing international labour standards and practical work improvement methods. He chaired the International Commission on Occupational Health Sceintific Committee on Shiftwork from 1989-1996. He is particularly interested in international cooperation for promoting occupational health and participatory ergonomics for small enterprises and in developing countries.

Annex

The following annex shows in chronological order the officers of the IEA and the locations of the triennial meetings.

President

1961 - 1964	Sven Forssman
1964 - 1967	Günther Lehmann
1967 - 1970	Hugh P. Ruffel-Smith
1970 - 1973	Bernard Metz
1973 - 1976	Frederik Bonjer
1976 - 1979	Alphonse Chapanis
1979 - 1982	Jan Rosner
1982 - 1985	Sadao Sugiyama
1985 - 1988	Harry L. Davis
1988 - 1991	Ilkka Kuorinka
1991 - 1994	Hal W. Henrick
1994 - 1997	Martin Helander
1997 -	Ian Noy
1982 - 1985	Tarald Kvalset, Vice-President

Secretary General

1961 - 1970	Etienne Grandjean
1970 - 1973	Frederik Bonjer
1973 - 1979	Reginald G. Sell
1979 - 1985	Harry L. Davis
1985 - 1988	Ilkka Kuorinka
1988 - 1991	Hal W. Hendrick
1991 - 1997	Pieter Rookmaaker
1997 -	Waldemar Karwowski

Treasurer

1970 - 1976	John de Jong
1976 - 1982	Herbert Scholz
1982 - 1985	Joseph Rutenfranz/ Brian Shackel
1985 - 1991	Brian Shackel
1991 - 1997	Ian Noy
1997 -	Kazutaka Kogi

IEA Triennial Congress

Date	Location	Number of participants
1961	Stockholm, Sweden	120
1964	Dortmund, Germany	500
1967	Birmingham, UK	350
1970	Strasbourg, France	400
1973	Amsterdam, Holland	450
1976	Maryland, USA	500
1979	Warsaw, Poland	500
1982	Tokyo, Japan	600
1985	Bournemouth, UK	650
1988	Sydney, Australia	600
1991	Paris, France	1500
1994	Toronto, Canada	1300
1997	Tampere, Finland	1800
2000	San Diego, USA	

IEA

International Ergonomics Association

ABOUT THE DISCIPLINE OF ERGONOMICS

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 theoretical principles, data and methods to design in order to optimize human well-being and overall system performance.

Practitioners of ergonomics, ergonomists, contribute to the planning, design and evaluation of tasks, jobs, products, organizations, environments and systems in order to make them compatible with the needs, abilities, and limitations of people.

Ergonomics is a systems-oriented discipline which now applies to all aspects of human activity. Practicing ergonomists must have a broad understanding of the full scope of the discipline, taking into account the physical, cognitive, social, organizational, environmental and other relevant factors. Ergonomists often work in particular economic sectors or application domains. These application domains are not mutually exclusive and they evolve constantly. New ones are created; old ones take on new perspectives.

Within the discipline, domains of specialization represent deeper competencies in specific human attributes or characteristics of human interaction:

IEA'S MISSION

The International Ergonomics Association is the federation of ergonomics and human factors societies around the world. Working closely with its constituent societies and related international organizations, its mission is to elaborate and advance ergonomics science and practice, and to expand its scope of application and contribution to society to improve the quality of life.