

Nancy L. Black · W. Patrick Neumann ·
Ian Noy *Editors*

Proceedings of the 21st Congress of the International Ergonomics Association (IEA 2021)

Volume II: Inclusive Design



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Proceedings of the 21st Congress of the International Ergonomics Association (IEA 2021)

Volume II: Inclusive Design

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Preface

The International Ergonomics Association (IEA) is the organization that unites Human Factors and Ergonomics (HF/E) associations around the world. The mission of the IEA 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, working closely with its constituent societies and related international organizations” (IEA, 2021). The IEA hosts a world congress every three years creating the single most important opportunity to exchange knowledge and ideas in the discipline with practitioners and researchers from across the planet. Like other IEA congresses, IEA2021 included an exciting range of research and professional practice cases in the broadest range of Human Factors and Ergonomics (HF/E) applications imaginable. While the conference was not able to host an in-person meeting in Vancouver, Canada, as planned by the host Association of Canadian Ergonomists/*Association canadienne d’ergonomie*, it still featured over 875 presentations and special events with the latest research and most innovative thinkers. For this congress, authors could prepare a chapter for publication, and 60% chose to do so. The breadth and quality of the work available at IEA2021 are second to none—and the research of all authors who prepared their publication for this congress is made available through the five volumes of these proceedings.

The International Ergonomics Association defines Human Factors and Ergonomics (HF/E) synonymously as being:

the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.

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

Ergonomics helps harmonize things that interact with people in terms of people’s needs, abilities and limitations. (<https://iea.cc/definition-and-domains-of-ergonomics/>)

The breadth of issues and disciplines suggested by this definition gives one pause for thought: what aspect in our lives is not in some way affected by the design and application of HF/E? For designers and managers around the world, a similar realization is growing: every decision made in the design and application of technology has implications for the humans that will interact with that system across its lifecycle. While this can be daunting, the researchers and professionals who participated in IEA2021 understand that, by working together across our disciplines and roles, we can achieve these lofty ambitions. This is especially relevant as we continue our collective journey into an increasingly “interconnected world”—the theme for the 21st IEA Congress. With the rise of a myriad of technologies as promulgated by Industry 4.0 proponents, we need now, more than ever, the skills and knowledge of HF/E researchers and practitioners to ensure that these tools are applied in a human-centric way towards resilient and sustainable systems that provide an enduring and sustainable road to prosperity—as advocated in the new Industry 5.0 Paradigm (Breque et al. 2021). Where the trend of Industry 4.0 aims primarily at encouraging technology purchasing and application, Industry 5.0 includes goals of resiliency and sustainability for both humans and our planet. These proceedings provide examples of research and development projects that illustrate how this brighter, human-centred future can be pursued through “*Ergonomie 4.0*”, as stated in the French theme of the Congress.

While the theme of the Congress concerns human interactions within a rapidly evolving cyber-physical world, the devastating impact of the COVID-19 pandemic has given an added dimension to the Congress theme and its delivery model. As the pandemic began to engulf the world, the traditional in-person Congress became increasingly less viable and gave way to the creation of a hybrid model as a means to enhance international participation. In early 2021, it became clear that holding an in-person event would not be possible; hence, the Congress was converted to a fully virtual event. The uncertainty, mounting challenges and turbulent progression actually created new possibilities to engage the global HF/E community in ways that were never previously explored by the IEA. Indeed, one of the scientific tracks of the congress focuses explicitly on HF/E contributions to cope with COVID-19, and readers will find some submissions to other tracks similarly focus on what HF/E practitioners and researchers bring to the world during this pandemic period. This journey epitomizes broader transformative patterns now underway in society at large and accentuates the urgency for resilience, sustainability, and healthy workplaces. No doubt, the notion of globalization will be redefined in the wake of the pandemic and will have far-reaching implications for the connected world and for future society, and with new paradigms emerge a host of new human factors challenges. The breadth of topics and issues addressed in the proceedings suggests that the HF/E community is already mobilizing and rising to these emerging challenges in this, our connected world.

IEA2021 proceedings includes papers from 31 scientific tracks and includes participants from 74 countries across 5 continents. The proceedings of the 21st triennial congress of the IEA—IEA2021—exemplify the diversity of HF/E, and of the association, in terms of geography, disciplines represented, application

domains, and aspects of human life cycle and capability being considered. Our diversity mirrors the diversity of humans generally and is a strength as we learn to weave our knowledge, methods, and ideas together to create a more resilient and stronger approach to design than is achievable individually. This is the strength of the IEA congresses, in the past, in the current pandemic-affected 21st occasion, and in the future. There is no other meeting like it.

A substantial number of works were submitted for publication across the Scientific Tracks at IEA2021. This gave us the happy opportunity to group contents by common threads. Each volume presents contents in sections with papers within the track's section presented in alphabetical order by the first author's last name. These proceedings are divided into five volumes as follows:

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These volumes are the result of many hours of work, for authors, Scientific Track Managers and their reviewer teams, student volunteers, and editors. We are grateful to Springer for making it available to you in book form and are confident you will find these works informative and useful in your own efforts to create a better, more human-centred future.

References

- Breque, M., De Nul, L., Petridis, A., 2021. Industry 5.0: Towards More Sustainable, Resilient and Human-Centric Industry, in: Innovation, E.D.-G.f.R.a. (Ed.), Policy Brief. European Commission, Luxembourg, p. 48. https://ec.europa.eu/info/news/industry-50-towards-more-sustainable-resilient-and-human-centric-industry-2021-jan-07_en
- International Ergonomics Association (2021) Definitions and Domains of Ergonomics. <https://iea.cc/definition-and-domains-of-ergonomics/>; accessed March, 2021

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The Organizing Committee is also indebted to those contributors who were instrumental in developing and promoting IEA2021. Joanne Bangs, our freelance Communications Specialist, provided engaging news blogs and other promotional collateral to help get the word out about the Congress. Sadeem Qureshi (Ryerson University), Elizabeth Georgiou, Elaine Fung, and Michelle Lam (Simon Fraser University) helped to create widespread awareness of the Congress as well as the HF/E field and profession through creative use of digital and social media. We are also grateful to those who worked diligently to ensure that the Congress provided meaningful opportunities for students and early career researchers, including Daniel P. Armstrong and Christopher A.B. Moore (University of Waterloo), Owen McCulloch (Simon Fraser University), Dora Hsiao (Galvion, Inc.), Chelsea DeGuzman and Joelle Girgis (University of Toronto), and Larissa Fedorowich (Associate Ergonomist, self-employed). The ePoster presentation option, new to IEA triennial congresses in 2021, was defined with care by Anne-Kristina Arnold (Simon Fraser University). Colleen Dewis (Dalhousie University) was key to

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The organizers are especially grateful to our sponsors, whose generous contributions made the Congress possible and readily accessible to the global HF/E community. Their recognition of the Congress as a valuable opportunity to advance the field of HF/E, as well as their steadfast support throughout a very trying planning period, was critical to the success of the Congress. The IEA 2021 sponsors include:

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**Part I: Ageing and Work (Edited by Jodi
Oakman)**



Ageing Factors and Forecasting Tool for Companies

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Abstract. Improving age management in companies and administrations and increasing the employment rate of seniors is a major challenge. The methods for analyzing and acting on this topic need to be applied on a large scale, despite the fact that there is a huge amount of publications on this subject. We found poor return of practical experience about the application of tools, the possible actions, the assets, the impediments, etc. This paper summarizes a prospective analysis of aging at work. It highlights the stakes about the economic level, the health of employees, the share of knowledge in the company, as possible actions to be taken. The main aspects of the methods are exposed, as some results, and the actions steered afterwards in the company

Keywords: Ageing in companies · Forecasting methods · Costs estimation · Action plan

1 Context and Objectives

The company is of a worldwide dimension. The perimeter of the study covered 10 sites. We focused this presentation on 6 production sites. The kind of production changes considering each site, but the organization of the workshops, the tools, the management, are very similar. The social and cultural factors introduce differences among the working population.

The request was about a prospective analysis of aging at work, its impact on the company and possible actions to be taken. The results were used to develop the action plan and prioritize the actions to be implemented.

The study followed this sequence:

- Data analysis about the population on each site: ages range, years of experience, absenteeism, pathologies
- Construction of hypothesis about the absenteeism and pathologies factors, using human factors models
- Interviews with production managers and human resources managers belonging to the different sites, in order to share the interpretations, and to collect information about the age management strategy

- Integration of all the results in a steering group, including top managers, occupational medicine, human resources department, prevention department
- Creation of a mind map about the over ageing factors and the ageing management
- Creation of a set of actions, assigned to different project managers (Fig. 1)

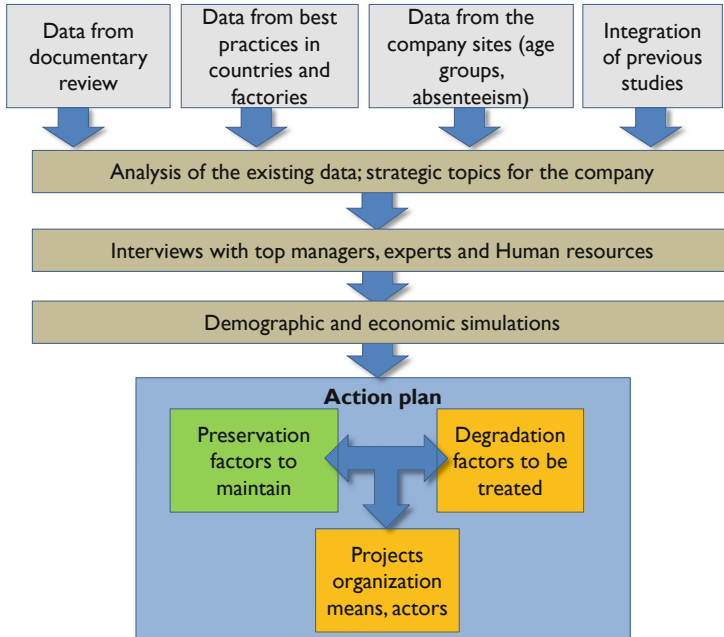


Fig. 1. Overview of the steps followed by the study

All along the study, the staff management was involved, including for the adaptation of the operational organization in the different teams.

2 Findings

The amount of findings is important; we show here some of them which appear to be relevant and useful for the actions (Fig. 2).

2.1 Differences Among the Population's Sites

The sites numbered 4, 5, 6 have a younger population than the other sites while the site numbered 2 shows a large workforce in the older age groups, with 45.6% of employees aged 50 and over.

Some sites show a more or less pronounced peak in the 45 to 59 age groups. This peak will lead to a large proportion of older employees in the years to come (sites 1, 2, 3).