Ergonomics and nudging

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1 Ergonomics, human factors and behavioral economics

Ergonomics is the science of interactions, systems' wise and design oriented. In the past three decades there has been a continuous and systematic move of researchers and professionals to affirm and clarify why human factors are the fundamental elements of every system (Dul et al, 2012; Wilson, 2014; Xie & Carayon, 2015). This has pushed the International Ergonomics Association and national societies to systematically pair these terms in the definition of the discipline, as well as in the name of national societies . For the purpose of the contributions in this book, we use the term Ergonomics and Human Factors (EHF). Nowadays, it is widely accepted that humans, with their limitations and potentials, are the crucial factors for the success of a system and that their individual factors, physical-cognitive-emotional-social, have to be addressed and seriously considered in the design and management of technologies, organizations, and institutions (Thaler & Sunstein, 2009; Vicente, 2015) . In fact, even highly automated systems require human intervention for maintenance and especially to manage the unexpected or critical incidents (Weick & Sutcliffe, 2001; Reason, 2017).

Basic sciences such as biology, psychology and neuro-psysiology have seen a dramatic improvement in the understanding of the nature of human beings and the impact of their environment on their behavior, providing also some evidence for the explanation of complex behavioral patterns in social interactions and effectively clarifying an increasing set of connections between body and mind (Rizzolati, 2005; Maturana & Varela, 2012; Cryan & Dinan, 2012; Damasio & Carvalho, 2013; Alòs-Ferrer, 2018a). Also, traditional western philosophy based on humanism and individualism has been questioned, thanks to the recognition of scientific evidence behind the different conceptions of human and individual life laid down in eastern philosophy and religions (Braidotti, 2016), as well as in the proven benefits of simple practices such as meditation (Goleman & Davison, 2017) and fasting (Brandhorst & Longo, 2019).

On the other side of the curve, leading from micro to macro systems, political, social and economic sciences are considering the new evidence from basic sciences and the extraordinary potential of computing to systematically collect and automatically elaborate data on human behaviors with the aim of designing and integrating policies or marketing strategies into physical and virtual interfaces (Carlsson & Johansson-

Stenman, 2012; Rice, 2013; Chetty, 2015; Thaler & Ganser, 2015; Thaler, 2018; Gigerenzer, 2018; Bicchieri & Dimant, 2019; Bilancini et al. 2020). In this regard, Behavioral economics (BE) has recently been extremely successful in promoting awareness regarding the role of human factors in political, economical, and social phenomena and, at the same time, in generating influential think tanks and research-based policy agencies that have demonstrated to be capable of influencing actual policy-making (Team B.I., 2010; Cassidy, 2011) in a wide spectrum of sectors (health care, environmental protection, traffic management, tax compliance, pensions, school choice, lifestyle, addictions, technological standards) and at different governance levels (hospital, municipality, utility firm, local government, ministry, central government, army).

The success of BE in this regard has been obtained in two steps: first, by providing compelling experimental evidence that many relevant economic and social phenomena could not be explained relying only on the basis of the assumption of "homo oeconomicus" (i.e., the simplification that economic agents are only interested in their own material benefits; Henrich et al. 2001; Gintis, 2005; Fher & Gintis, 2007; Bowles & Polanya-Reyes, 2012; Bowles, 2016) and the assumption of "unbounded rationality" (i.e., costless and exact computation, costless attention, infinite memory, bayesian elaboration of information; Simon, 1990; Jones, 1999; Gingerenzer & Todd, 1999; De Martino et al. 2006; Evans, 2017; Bilancini & Boncinelli, 2018), and, second, by providing alternative assumptions on human behaviour and decision-making, inspired by experimental evidence, which encompass other-regarding preferences (e.g., envy for social status, Bilancini & Boncinelli, 2014, 2019; social norms, Bicchieri, 2016; altruism, Choi & Bowles, 2007; reciprocity, Bowles & Gintis, 2004; Bilancini et al. 2022; fairness, Fehr & Gächter, 2000; inequity aversion, Fehr & Schmidt, 1999; spite, West & Gardner, 2010; in-group favoritism, Bilancini et al. 2020) and bounded rationality (e.g., limited memory, Mullainathan, 2002; reliance on heuristics, Alòs-Ferrer, 2018b; Belloc et al. 2019; inattention, Gabaix, 2019; cognitive biases, Enke et al. 2021; multiple selves, Alòs-Ferrer & Strack, 2014; costly cognition, Bilancini & Boncinelli, 2021; non-bayesian elaboration of information, Bilancini and Boncinelli, 2018). It is not necessary to go back to Kanheman and Tversky's Prospect Theory (Barberis, 2013) or, more recently, to Thaler and Sunstein's Nudge Theory (Hertwig & Grüne-Yanoff, 2017), to realise that BE has deeply impacted the study of human behaviour and its interaction with the social and technological environments. How to promote cooperation in the workplace? How to minimize the likelihood of mistakes by professionals? How is human behavior affected when the actual interaction is with an AI rather than another human decision-maker? All these questions have been answered - or are being answered – also thanks to the tools, methods and theoretical framework provided by BE.

We believe in the encounter between EHF and BE provides a threefold opportunity: (i) to improve the understanding of safe and effective interactions between humans and the other elements of a system; (ii) to extend and aggregate methods and tools for the design of usable and attractive physical and virtual artifacts; (iii) to contribute to the establishment of a new ethics for public and private institutions based on joy, happiness, satisfaction and well-being.

In this introductory chapter of the Proceedings of the SIE 2022 national congress, we briefly outline the current and potential value of the encounter between EHF and BE in the 3 above-mentioned areas, trying to connect the following chapters with existing literature as well as our individual, and diverse, scientific perspectives.

2 Safe and effective interactions in dynamic complex systems

The development of a human being throughout her lifetime is deeply rooted and dependent on the interactions with other humans and the environment. Our knowledge of the world, skills and competences unfold from basic potentials given at birth through continuous interactions with parents, families and communities permeated by one or more referent cultures (Cole, 1998; Vygotsky, 2014). Interactions occur since the very early days of life with the mediation of an uncountable number of artifacts, that are the results of adaptation and creativity of current and previous generations, facing problems, creating solutions and opportunities for interactions in the natural and human-made environment (Wenger, 1999). The pervasivity and ubiquity of technologies during the past two decades have created unprecedented scenarios, on one side through the physical implant of devices, on the other side due to the neverending connection to humans and non-humans via portable or wearable digital interfaces (Harari, 2016).

Today, and even more in the foreseeable future, EHF and BE share the opportunity to provide new visions, to inform research directions and contribute to the development of new products and services, bringing together the accumulated knowledge for an updated understanding of dynamic interactions between humans and non-humans in complex systems, blended within physical and virtual environments.

Traditional questions such as cooperation vs competition between individuals and groups, autonomy vs centralization of planning and control in organizations, substitution vs integration of workers and robots in industries and services are already under review as we can read through the chapters of this book.

From transportations to manufacturing, from health services to health protection and promotion, we can see how the combination of a bio-psycho-social model enhances comprehension and inclusion of the multiplicity of dimensions and factors that shape human condition and potentials. When the focus is on the system and the interactions of its parts, rather than on single components, then the challenge for researchers and practitioners moves from the classic distinction between three types of interactions classified in physical, cognitive and social ergonomics to an integrated and updated version of holistic ergonomics. Human beings are constantly embedded in exchange of: strength through physical interaction with the hardware surrounding their environment; information retrieval through the five senses by means of concrete and virtual interfaces; relations through emotions, rules and values. As we cannot separate body and mind for health and wellbeing, a worker from her tools in safe and effective activity, a nurse from her identity and position within a hospital or a community, we have to apply an holistic approach to face even the apparently simple

tasks, such as hand washing to prevent the spread of hospital acquired infections (Hollnagel et al, 2015).

Moreover, the focus on micro, meso or macro system levels can somehow be merged thanks to the evidence from BE, that demonstrates the connections between behaviors, management of daily lives at home or in the workplaces, with policies and values. An inaccurate understanding of individual attitudes, preferences and determinants of behaviors may contribute to the failure of entire systems, while a comprehensive approach may provide options to the individuals that are actionable and easy to understand at the micro-level, respectful and flexible to different rules and practices at the meso-level, transparent and coherent to the reference values at the macro-level (Bellandi & Albolino, 2019). This second movement of integration can create the conditions for informed decision making as well as for social engagement, as we have seen for example, with lights and shadows, during the vaccination campaign for Covid-19.

The convergence of the two movements to integrate physical-cognitive-social interactions on the one side and micro-meso-macro systems dynamics on the other side is a theoretical perspective that we suppot and that the reader may appreciate by reading the chapters of this book and playing to connect the dots which support this vision.

3 Mixed methods to study and design convergent systems

If we accept a new vision of human conditions and systems of interactions, then we need to update methods and tools to study the present and shape the future.

First of all, the traditional separation between subjective and objective data, as well as between qualitative and quantitative methods do not fit with the complexity of a holistic approach to interactions and a merge of system's levels either in the controlled laboratory situation or in real life scenarios (Poth, 2018). The definition, collection and elaboration of objective data through quantitative methods is fundamental to understand questions, generalize eventual patterns of observed relations and make some predictions for the future which can be extended to the same problems under uncertain conditions. Anyway, how people make sense of a problem in a real context and make decisions to enact a behavioral response is something that cannot be understood just by objective data (Weick, 1995) .

The meaning of a problem for an individual in the real world can be different from those observed in experiments, depending on many variables that vary according to individual's and system's conditions. Therefore, a combination of subjective and objective methods, that is typical of EHF and BE can widen the view of researchers and the toolbox of practitioners.

A good example comes from the use of wearable sensors and portable devices to track physical conditions, actions and interactions in the environment, where recognized metrics are systematically combined with subjective data to understand human efforts in physical and cognitive tasks. Devices that originated in the military industry for performance measurement and enhancement, such as exoskeletons, are today top

priorities for research in manufacturing and in healthcare. Implantable, wearable and portable devices create the condition to collect and use an enormous amount and variety of data, along with the power of calculation available at an accessible price.

Actually, the potential of wearable sensors and portable devices to routinely collect and elaborate big data is already a reality, even though the production and use of this data for research or marketing purposes represent a challenge for privacy, industrial and political relations. On the one hand, collective events such as trends and effects of a pandemics can be automatically tracked through routine collection of population data, on the other hand a rehabilitation treatment can be hyper-personalized by creating solutions on the basis of individual data.

According to our view, a strong public engagement in big data collection and analysis is the condition to provide a perspective to scientists and professionals where sensitive data can be used under the control of the individual who is the producer and should be the owner of her data.

EHF has a tradition of participatory approach and user engagement in evaluation of problems and design of solutions. It is a strong basis to be applied in the new landscape where artificial intelligence is substituting humans in decision making in work systems and daily lives. Evidence from BE may then help to understand and design decision making processes related to the purchase or the use of new technologies. The disseminated computing, taking more and more the characteristic of robots which replace, cooperate or lead interactions with humans within convergent systems, can be addressed with a combination of methods and tools from EHF and BE.

4 A new ethics for research and practice in behavioral sciences

A new vision on human systems and a multi-disciplinary methodology to investigate and shape interactions require a new ethics, capable of encompassing the challenges for humanity in the young but extreme era of anthropocene (Lewis & Maslin, 2015) .

The current official definition of ergonomics dates back to 2000 and seems out of date especially when it refers to “the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance.” The optimization of human well-being and system performance should be based on a balance between individual and population health and well-being, opportunities provided by today’s and future technologies and the limited natural resources of our planet. It is maybe the time for considering an update of the definition that encompasses the overlaps with BE and, more in general, with the science of human behavior, interaction and decision-making (Gintis, 2014).

Finally, let us stress that, on the ethics side, we also believe that any ambitious research agenda should be informed with frugality to: avoid waste, protect common resources and public goods, promote prosociality towards present and future generations, taking into account the different cultural values and welcoming pluralism. These are fundamental premises for peace (Shiva, 2005), as well as to prevent the loss of lives due to missed access to care and cure. The authors' contributions in this book

aim at embracing the challenge to improve health, wellbeing and happiness in different areas of working and daily lives.

Presentation of the book

The Congress took place on the 2nd, 3rd and 4th of May 2022 in Lucca, hosted at the IMT School for Advanced Studies Lucca, that is a public university for higher education and research with a special statute that focuses on the analysis of economic, societal, technological and cultural systems.

The editors invited authors to submit the long papers that have been peer reviewed with recommendation to publish.

The majority of selected contributions were on the track of ergonomics and nudging in health-care systems (9), followed by ergonomics and technological innovation (4), design for all (3), health and safety in industry 4.0 (2), neuroergonomics (1), ergonomics and nudging to face the pandemic (1).

The invited speaker Valerio Capraro presented a state of the art review on cooperation and pro-social behavior and some perspectives on the strategies to facilitate cooperative interactions between individuals and groups.

Augusto and colleagues reported the original research project, started in 2021, on the occasion of the World Usability Day, to innovate EHF methods by integrating user experience and strategic foresight to design scenarios for home care in 2041.

In the work of Menicagli et al and in Frangioni et al some good examples of ergonomic and nudging techniques have been used to promote vaccination among pregnant women and to improve hand hygiene in a pediatric hospital, while in the paper dedicated to “ErgoMeyer” Frangioni and its colleagues present a selection of EHF intervention in the context of an academic pediatric hospital.

In the papers of Lefosse, Del Gaudio, Dagliana and Terranova different qualitative studies and interventions are reported with the common denominator of complexity of systems and dynamic interactions in place among healthcare workers, patients, organizational procedures and technologies.

Coraci and colleagues presented an interesting analysis of risk communication strategies during Covid-19 pandemic and their potential effects on people's understanding about reliability of lab tests, by using up to date evidence from EHF and BE.

Barresi and his group illustrated the ongoing research at the Italian Institute of Technology on EHF applications to enhance surgeon performance by improving physical and cognitive interactions with tools and the patient's body.

Carnazzo and colleagues presented an innovative approach to evaluate risks of musculoskeletal disorders in manufacturing, through a combination of motion capture techniques and virtual reality with existing risk assessment tools.

Orfei reported an original research, including a new tool to evaluate occupational stress related to the intensive use of new technology among bank workers and a training intervention to mitigate stress based on behavioral techniques.

Duca and Sangermano described two different packages of a European research program to model human behaviors in air traffic control, tackle a dynamic system with updated rules and increasing volume of work and providing reliable tools to train and evaluate performance with simulations.

Frisiello and colleagues is one of the most original contributions at the congress, as they showed the potential of gamification to support decision making of commuters in busy urban centers.

Attaianese and Rossi proposed a research agenda to integrate concepts from sustainable development within human centered design, with an original classification of innovative approaches for the design of systems and artifacts.

Capodaglio and her colleagues presented a EHF perspective on domotics solutions for people with disabilities, by using a complex case study to illustrate potential and limits of current technologies and approach to provide assistive tools and an enabling home environment.

Tosi and her research team described the guidelines they prepared for the design of people centered urban parks, in order to create an urban environment that facilitates physical activity and healthy social life in a residential area.

Oberti et al also proposed an evidence-based approach to support institutions in the design of urban environments, integrating EHF and BE methods with design for all principles to sustain healthy life in the aging population.

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