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ARTICLE COMMENTARY

Human factors and ergonomics: a vital profession for today and the future

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Given the widespread use of technology in virtually every sector of the economy and personal life, the ergonomics and human factors (EHF) profession has never been more needed. Accounting for technology users' needs and expectations in design and implementation is arguably one of the most significant contributors to success or failure of any technology. A cross industry study by McKinsey & Company found that companies with a strong user-centered design approach to their products out-performed their industry competitors by as much as 2 to 1 (Sheppard et al. 2018). Other studies have demonstrated that companies that use EHF to build production lines and internal programs that are compatible with human capabilities similarly see a return on investment that ranges from 10% to 500% (Hendrick 1996), with significant payback in terms of productivity and lowered accident and injury costs (Chartered Institute of Ergonomics 2022). Industry 5.0 which represents the next phase of industrial technology evolution also heavily emphasises the importance of EHF and human-centricity (Leng et al. 2022). Conversely, when companies ignore EHF, the costs due to loss of life and business can be staggering as illustrated in many high-profile industrial accidents (e.g., Chernobyl and Bhopal). In contrast, de Winter and Eisma (2024) use cherry picking and painting with a broad brush to create a very different picture of the demise of the profession. In this response, we critically evaluate several arguments made by them and provide an alternative account of the state of the profession.

Validity of EHF constructs and theories

While some aspects of the human experience are easily measured, none is without its limitations. EHF researchers often have to develop clever techniques to fully understand complex cognitive processes, for example. Nonetheless, EHF researchers have persevered, devoting considerable effort to developing effective methods and metrics for research that illuminates the human experience (Gawron 2000; Hancock and Meshkati 1988; Salas et al. 2017). Cherry picking evidence, de Winter and Eisma (2024) claim that EHF uses invalid constructs and theories by pointing to a critique of situation awareness (SA) by Dekker and Hollnagel (2004), even though that critique was thoroughly debunked by Parasuraman, Wickens, and Sheridan (2008). They also cite claims by Bakdash et al. (2022, 2020) that SA metrics are not well correlated with performance, although that study failed to take into account the logical ways in which different aspects of SA link to different aspects of performance and SA theory. Yet de Winter and Eisma (2024) completely ignore a detailed meta-analysis of 243 studies employing SA metrics that found 89% of studies using objective measures of SA showed they were predictive of performance with a mean Pearson's $r = .46$ (Endsley 2021). Similarly, their claims that workload measures such as NASA-TLX are invalid ignores the extensive work that has investigated differences in workload measurement approaches and the ways in which such measures tap into different aspects of how people perceive and respond to workload (Hancock and Matthews 2019; Matthews et al. 2015; Wickens and Yeh 1983).

The gap from research to practice

It is easy to be frustrated when there is a gap between the development of knowledge in research settings and its real-world applications. Such challenges exist across industries and technology development and are commonly referred to as the Valley of Death (Frank et al. 1996). EHF often faces a particular burden in that many organisations, engineers and managers are unfamiliar with EHF and its benefits. Frequently, cost and

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schedule pressures incentivise organisations to ignore EHF as well, believing it will be cheaper or faster (however misguided). Therefore, the use of EHF science and practice in industry is uneven.

It is easy to point to spectacular failures where EHF was not utilised in system designs contributing to accidents and loss of life (Endsley 2019; Meshkati 1991; Roberts, Flin, and Cleland 2015). Often these failures have more to do with the lack of good regulatory processes in the United States than they have to do with EHF failures however (Claybrook and Kildare 2018), a problem that is largely political in nature and extends far beyond the EHF profession. For example, de Winter and Eisma (2024) point to Tesla as a prime example of an organisation that has ignored the extensive research base regarding the negative effects of automation on people (Mouloua and Hancock 2020), supposedly "with no indication of a significant increase in fatal accidents". This claim ignores recalls by the National Highway Traffic Safety Administration (NHTSA) and the many documented accidents and fatalities associated with the Tesla (Banker 2023; Barry 2023; Siddiqui and Merrill 2023). However, since the U.S. does not have laws requiring that automobiles (including automation features) pass regulatory testing prior to use on the roads, or that automobile companies provide detailed data on accidents and incidents, there is little to stop Tesla from fielding poorly implemented automation. Hence there is a lack of data that accurately compares accident rates with Tesla autopilot against manual driving in similar conditions (Quality Control Systems Corporation 2019). Conversely, other companies, such as Waymo, provide a counter-example, skipping over the problems of partial automation and concentrating on developing full automation due to the many EHF challenges that exist.

There is ample evidence of attention to EHF in other domains including FAA, FDA, NASA, and nuclear power (Ahlstrom and Longo 2003; Federal Drug Administration 2016; National Aeronautics and Space Administration 2022; O'Hara and Fleger 2020). In each of these fields detailed design guidance for EHF has been created and regulatory processes are in place to ensure that system developers test products appropriately prior to being approved for use. The automobile industry is sadly trailing in following this model. While such gaps are frustrating, rather than claiming it is a failure of the field of EHF, it only demonstrates the need to spread EHF practice to new areas.

EHF being subsumed by other disciplines

de Winter and Eisma (2024) posit that innovative EHF-related articles are emerging from adjacent disciplines and in countries like China without supporting their argument or qualifying what they mean by "innovative." The argument on EHF's expansion and growing connection with other disciplines such as robotics and computer science is indeed showcasing a success for EHF and contradicts the central argument that EHF is being subsumed by these disciplines! The notion that EHF is being subsumed by fields like AI or Big Tech also oversimplifies the relationship between disciplines and ignores the fact that EHF is inherently interdisciplinary. In our opinion, EHF is not fading but evolving, intersecting with domains like AI, robotics, and data science. These intersections create opportunities for EHF science to influence how emerging technologies are designed and deployed, ensuring that human factors are considered alongside technological advancement.

de Winter and Eisma (2024)'s argument about the missed opportunity for EHF to take part in the evolution of AI is also misinformed. For example, the National Institute of Standards and Technology (NIST) in the U.S. is currently collaborating with the EHF community to develop its AI standards (HFES 2024). Human-centered AI is also a rapidly growing field which is aligned with and grounded in EHF and uses its principles. Nevertheless, we agree that EHF needs to be more firmly integrated into the evolution of AI.

Academic research of EHF

de Winter and Eisma (2024) paint a rather bleak picture of the academic research process used in university labs. Sadly, this could describe basic research conducted in any field of science and is not unique to EHF. While they may conduct research using such a cynical approach, painting all university research with such a broad brush does a major disservice to a large and growing community of applied EHF researchers and their extensive body of impactful work which has yielded wholistic understandings of relevant problems in real world settings. As a whole, EHF research is often much better connected to the real-world challenges and experiences of workers in operational settings than many fields, emphasising analyses of user needs and characteristics and studies in real-world contexts and ecologically valid simulations, as well as field research in naturalistic settings (Endsley et al. 2007; Vicente 1999; Zsambok and Klein 1997). Further, EHF is also heavily involved in actual practice across many domains, even though this work is often not represented in research journals as there is generally little incentive to do so.

The future of EHF

Although we strongly disagree with de Winter and Eisma (2024) characterisation of the EHF profession, we agree with many of their recommendations. However, like the problem statements, the solutions are not unique to EHF and apply to most disciplines. In addition, we offer a few suggestions of our own.

Strengthened peer review

Peer review is at the heart of any research profession. Yet a proliferation of journals, including many low quality pay-to-publish options, has led to reviewer fatigue, journal shopping, and the ability of even sub-standard research to find an outlet. Papers that make sweeping claims based on limited data, provide faulty logic, and demonstrate little understanding of established theory and research findings should not merit publication and may do significant damage when they are. For example, after a medical journal published an article claiming that vaccines lead to autism, fears of vaccinations spread even though the Lancet journal retracted it (Eggertson 2010) and the article's claims were subsequently thoroughly rejected by multiple studies (Taylor, Swerdfeger, and Eslick 2014). Today over one-quarter of the population believes vaccines are harmful (Duffy 2018), and the rate of vaccinations in public schools has declined precipitously (Annenberg Public Policy Center 2024). Although this is not just an EHF problem, EHF editors may need to be mindful of these potential problems and insist on high standards for publication and documented evidence that is commensurate with claims. It is up to each of us to help support this process.

Cohesive academic training and identification of the profession

One of the biggest challenges for the profession is its limited name recognition among the public, funding agencies, managers and engineers. One reason for this is that EHF is generally still practiced as a sub-discipline within different academic departments (psychology, industrial and systems engineering, and others), and thus students get little exposure to it during their education and do not recognise the field later in their professional careers. Even when our research is cited in the press, it is often not identified as EHF but as something else.

Further, we are a multi-disciplinary field—a feature that is an attribute for meeting the broad demands of our profession (Howell 2001), but also contributes to both its lack of identity and a lack of consistency in the academic training, approach and knowledge base of its members (Endsley 2012). Professional certification programs provide at least a partial solution to this problem. Endsley (2012) provides a vision for the development of cohesive Human Factors Engineering programs in universities that would provide both a strong background to the science of EHF as well as its application to systems design and development.

Improved integration of basic research and real-world practice

Despite the increasing trend in applied EHF research, many academic researchers, facing the pressures of limited resources and strong pressures to publish, continue to focus on laboratory-based research using undergraduate subjects. While responsive to those pressures, such research may often fail to address the real challenges of users who may be very different from students and may face very different sets of domain challenges and constraints that are not included in such studies. Not all EHF research can be done in labs. Good EHF research needs to be well connected to real-world problems, realistic domain conditions, and representative users. Accomplishing this objective necessitates a closer tie between funding organisations, problem holders, and researchers, as well as a willingness of researchers to leave the comfort of their laboratories. There is also a need for more effective dissemination of research results to practice as academic papers may not be readily available to practitioners.

Improved integration of EHF into requirements and standards

Closing the gap between EHF research and practice necessitates a renewed focus on attention to EHF requirements in systems development. This is often both a political and educational challenge. Efforts such as the HFES/ANSI 400 standard establishing Human Readiness Levels (HRL) provide a mechanism for driving organisations to pay attention to EHF earlier in the system development process (ANSI/HFES 2021). Increased attention to the process of encoding EHF research findings into standards provides a useful mechanism for getting EHF included in the development of systems in many domains. This is an ongoing process that needs to be attended to as technologies change and evolve. However, more work is warranted to improve the adoption and utilisation of EHF standards in research, application and teaching.

Conclusions

The EHF discipline is not fading or becoming irrelevant. On the contrary, available data show real benefits to the use of EHF principles and practices indicating that the field of EHF should continue evolving to fill the gap between people and technology. The best solution to existing challenges is to avoid throwing the baby out with the bathwater. There is a clear path forward for growing the EHF profession and increasing its involvement as a recognised part of system design and development. This outcome is much needed, not for those of us who love the profession, but for the millions of people in so many different fields who count on what we do.

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References

Ahlstrom, V., and K. Longo. 2003. *Human Factors Design Standard (HF-STD-001)*. Atlantic City International Airport, NJ: Federal Aviation Administration William J. Hughes Technical Center.

Annenberg Public Policy Center. 2024. *False Belief in MMR Vaccine-Autism Link Endures as Measles Threat Persists*. Accessed from American Association for the Advancement of Science website: https://www.eurekalert.org/news-releases/1046924

ANSI/HFES. 2021. *Standard 400 - Human Readiness Level Scale in the System Development Process*. https://www.hfes.org/Publications/Technical-Standards

Bakdash, J. Z., L. R. Marusich, J. B. Kenworthy, E. Twedt, and E. G. Zaroukian. 2020. "Statistical significance filtering overestimates effects and impedes falsification: a Critique of." *Frontiers in psychology* 11: 609647. doi:10.3389/fpsyg.2020.609647.

Bakdash, J. Z., L. R. Marusich, K. R. Cox, M. N. Geuss, E. G. Zaroukian, and K. M. Morris. 2022. "The validity of situation awareness for performance: a meta-analysis." *Theoretical Issues in Ergonomics Science* 23 (2): 221–244. doi:10.1080/1463922X.2021.1921310.

Banker, S. 2023. "Tesla has the Highest Accident Rate of any Auto Brand." Forbes. https://www.forbes.com/sites/stevebanker/2023/12/18/tesla-has-the- highest-accident-rate-of-any-auto-brand/?sh=524f7c252894

Barry, K. 2023. *Tesla Recalls Over 2 Million Cars Due to Autopilot Concerns*. Consumer Reports. https://www.consumerreports.org/cars/car-recalls-defects/tesla-recalls-cars-due-to-autopilot-concerns-a6186663858/

Chartered Institute of Ergonomics. 2022. *Giving Your Business the Human Factors Edge*. https://ergonomics.org.uk/resource/giving-your-business-the-human- factors-edge.html

Claybrook, J., and S. Kildare. 2018. "Autonomous Vehicles: No Driver…No Regulation?" *Science (New York, N.Y.)* 361 (6397): 36–37. doi:10.1126/science.aau2715.

de Winter, J. C. F., and Y. B. Eisma. 2024. "Ergonomics & Human Factors: Fade of a Discipline." *Ergonomics*: 1–9. doi:10.1080/00140139.2024.2416553.

Dekker, S., and E. Hollnagel. 2004. "Human factors and folk models." *Cognition, Technology and Work* 6 (2): 79–86. doi:10.1007/s10111-003-0136-9.

Duffy, B. 2018. *Autism and Vaccines: More than Half of People in Britain, France, Italy Still Think There May Bea Link*. The Conversation. https://theconversation.com/autism-and-vaccines-more-than-half-of-people-in-britain-france-italy-still-think-there-may-be-a-link-101930

Eggertson, L. 2010. "Lancet Retracts 12-Year-Old Article Linking Autism to MMR Vaccines." *CMAJ: Canadian Medical Association journal = journal de l'Association medicale canadienne* 182 (4): E199–E200. doi:10.1503/cmaj.109-3179.

Endsley, M. R. 2012. "Building Bridges to the Future of the Human Factors & Ergonomics Society." Presidential Address to the 56th Annual Meeting of the Human Factors and Ergonomics Society. Human Factors and Ergonomics Society. Boston, MA.

Endsley, M. R. 2019. Human Factors & Aviation Safety: Testimony to the United States House of Representatives Hearing on Boeing 737-Max8 Crashes. Washington, DC: U.S. Congress. https://transportation.house.gov/imo/media/doc/Endsley%20Testimony.pdf

Endsley, M. R. 2021. "A Systematic Review and Meta-Analysis of Direct Objective Measures of Situation Awareness: A Comparison of SAGAT and SPAM." *Human Factors* 63 (1): 124–150. doi:10.1177/0018720819875376.

Endsley, M. R., R. Hoffman, D. Kaber, and E. Roth. 2007. "Cognitive Engineering and Decision Making: An Overview and Future Course." *Journal of Cognitive Engineering and Decision Making* 1 (1): 1–21. doi:10.1177/155534340700100101.

Federal Drug Administration. 2016. *Applying Human Factors and Usability Engineering to Medical Devices(FDA-2011-D-0469)*. Washington, DC: Author. https://www.fda.gov/regulatory-information/search-fda-guidance-documents/applying- human-factors-and-usability-engineering-medical-devices

Frank, C., C. Sink, L. Mynatt, R. Rogers, and A. Rappazzo. 1996. "Surviving the "Valley of Death": A Comparative Analysis." *The Journal of Technology Transfer* 21 (1–2): 61–69. doi:10.1007/BF02220308.

Gawron, V. J. 2000. *Human Performance Measures Handbook*. Mahwah, NJ: Lawrence Erlbaum Associates Publishers.

Hancock, P. A., and N. Meshkati. (Eds.). 1988. *Human Mental Workload*. Amsterdam: North- Holland.

Hancock, P. A., and G. Matthews. 2019. "Workload and Performance: Associations, Insensitivities, and Dissociations." *Human Factors* 61 (3): 374–392. doi:10.1177/0018720818809590.

Hendrick, H. W. 1996. "The Ergonomics of Economics is the Economics of Ergonomics." *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* 40 (1):

1–10. Presidential Address to the 40th Annual Meeting of the Human Factors and Ergonomics Society. Human Factors and Ergonomics Society. Philadelphia, PA. https://www.hfes.org/Web/PubPages/Hendrick.pdf doi:10.1177/154193129604000101.

HFES. 2024. *HFES Joins Forces with NIST to Advance Artificial Intelligence Safety Measures*. https://www.hfes.org/Portals/0/HFES%20Accepted%20to%20NIST%20Press%20Release_2-8-24.pdf?ver=hCnhCco0P6vgzUJQQYPUBg%3d%3d

Howell, W. C. 2001. The Human Factors/Ergonomics Parade: A Tale of Two Models. Presidential address tothe 45th Annual Meeting of the Human Factors and Ergonomics Society. Human Factors and Ergonomics Society. Minneapolis, MN. https://www.hfes.org/Web/PubPages/Howell.pdf

Leng, J., W. Sha, B. Wang, P. Zheng, C. Zhuang, Q. Liu, T. Wuest, D. Mourtzis, and L. Wang. 2022. "Industry 5.0: Prospect and Retrospect." *Journal of Manufacturing Systems* 65: 279–295. doi:10.1016/j.jmsy.2022.09.017.

Matthews, G., L. E. Reinerman-Jones, D. J. Barber, and J. AbichIV. 2015. "The Psychometrics of Mental Workload: Multiple Measures Are Sensitive But Divergent." *Human Factors* 57 (1): 125–143. doi:10.1177/0018720814539505.

Meshkati, N. 1991. "Human Factors in Large-Scale Technological Systems' Accidents: Three Mile Island, Bhopal, Chernobyl." *Industrial Crisis Quarterly* 5 (2): 133–154. doi:10.1177/108602669100500203.

Mouloua, M., and P. Hancock. (Eds.). 2020. *Automation and Human Performance: Theory and Applications*. Boca Raton, FL: CRC Press.

National Aeronautics and Space Administration. 2022. *NASA Space Flight Human System Standard (NASA-STD-3001)*. Washington, DC: NASA.

O'Hara, J. M., and S. Fleger. 2020. *Human-System Interface Design Review Guidelines (NUREG-0700)*. 3rd ed. Washington, DC: Nuclear Regulatory Commission.

Parasuraman, R., C. D. Wickens, and T. B. Sheridan. 2008. "Situation Awareness, Mental Workload and Trust Inautomation: Viable Empirically Supported Cognitive Engineering Constructs." *Journal of Cognitive Engineering and Decision Making* 2 (2): 140–160. doi:10.1518/155534308X284417.

Quality Control Systems Corporation. 2019. *NHTSA's Implausible Safety Claim for Tesla's Autosteer Driver Assistance System*. https://www.safetyresearch.net/Library/NHTSA_Autosteer_Safety_Claim.pdf

Roberts, R., R. Flin, and J. Cleland. 2015. "Everything was fine"*: An analysis of the drill crew's situation awareness on Deepwater Horizon." *Journal of Loss Prevention in the Process Industries* 38: 87–100. doi:10.1016/j.jlp.2015.08.008.

Salas, E., M. A. Rosen, J. D. Held, and J. J. Weissmuller. 2017. "Performance Measurement in Simulation-Based Training: A Review and Best Practices." *Simulation in Aviation Training* 40 (3): 393–441.

Sheppard, B., G. Kouyoumjian, H. Sarrazin, and F. Dore. 2018. The Business Value of Design. *McKinsey and Company*. https://www.mckinsey.com/capabilities/mckinsey-design/our-insights/the-business- value-of-design

Siddiqui, F., and J. B. Merrill. 2023. 17 Fatalities, 736 Crashes: The Shocking Toll of Tesla's Autopilot. *The Washington Post*. https://www.washingtonpost.com/technology/2023/06/10/tesla-autopilot-crashes-elon- musk/#

Taylor, L. E., A. L. Swerdfeger, and G. D. Eslick. 2014. "Vaccines Are Not Associated with Autism: An Evidence-Based Meta-Analysis of Case-Control and Cohort Studies." *Vaccine* 32 (29): 3623–3629. doi:10.1016/j.vaccine.2014.04.085.

Vicente, K. 1999. *Cognitive Work Analysis: Towards Safe, Productive and Healthy Computer- Based Work*. Mahwah, NJ: Lawrence Erlbaum.

Wickens, C. D., and Y. Yeh. 1983. "The Dissociation between Subjective Workload and Performance: A Multiple Resource Approach." *Proceedings of the Human Factors Society Annual Meeting*, 244–248. Santa Monica, CA: Human Factors Society.

Zsambok, C. E., and G. Klein. (Eds.). 1997. *Naturalistic Decision Making*. Mahwah, NJ: Lawrence Erlbaum.