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ARTICLE COMMENTARY

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Ergonomics and human factors: still fading—and why we need to embrace the AI revolution

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ABSTRACT
Many of the commentators use the opportunity to highlight the value of Ergonomics and Human Factors (EHF) and challenge the notion that the discipline is fading. In response, we argue that EHF science is lagging behind the rapid developments in AI, remains entrenched in past-century achievements, and is in decline. Indices such as membership counts, conference attendance numbers, and new regulations reflect activity, but not necessarily impact. Important questions about human-AI collaboration are being addressed by other disciplines, often without the involvement of EHF. Rather than advocating for systemic frameworks, we advocate for new skill development and the adoption of data-driven AI methods. To illustrate the potential of AI within EHF, we demonstrate how a vision-language model can replicate findings from a classic knobs-and-dials study. In conclusion, we acknowledge EHF's knowledge base but foresee existential risks unless the field undergoes major reforms to remain relevant in an AI-dominated future.

KEYWORDS
Future of ergonomics; technological innovation; Human-AI interaction; data-driven methods; research-practice gap

To keep the current response readable, we use the following abbreviations:

- B: Baber (2025)
- ES: Endsley and Sasangohar (2025)
- HH: Hancock and Hancock (2025)
- P: Peachey (2025)
- S: Salmon (2025)
- SC: Shorrock and Cebola (2025)
- TT: Todd and Thatcher (2025)
- W: Waterson (2025)
- WG: Walker and Greening (2025)
- Y: Young (2025)

We thank the editors for facilitating this exchange and the commentators for their responses to our target article. This debate is special because it represents a rare occasion where the EHF community publicly confronts existential concerns about its future in the face of the rise of AI.

The fade is underway

The commentators generally disagree with our assertion that EHF is experiencing an existential "fade". They argue that the field is thriving and more needed than ever (ES, P, S, TT, W, Y). While certain identity-related challenges (P, Y) and stagnation in the Northern Hemisphere (TT) are acknowledged, the commentators do not perceive a fade as De Winter and Eisma (2024) have pointed out, pointing instead to the growth of EHF organisations and conferences in China, Latin America, and Africa (P, TT).

A number of the commentators share some of our existential concerns, however. Walker and Greening (2025) find our critique and recommendations not bold enough (!). They warn that EHF, due to outdated methods, risks becoming overtaken by other fields. At the same time, they argue that the need for EHF expertise is increasing, not fading.

The commentary of Hancock and Hancock (2025) takes the fade hypothesis seriously enough to devote considerable attention to various existential threats. Their view is that EHF has a valuable knowledge base and *can* survive; but only if it heeds warnings about its weak theoretical basis, improves its impact, clarifies its reason for being, and fends off the looming risk of being overshadowed by faster-moving research fields.

Shorrock and Cebola (2025) also side with our argument to a large extent. They discuss the role of EHF within air traffic control and related sectors, and identify a shortage of EHF specialists due to a decrease in accredited programmes. They recognise dilution regarding the definition and scope of EHF, and point out that

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developments in EHF research are largely ignored in practice. The works they reference, such as the chapter "*Safety research and safety practice: Islands in a common sea*" (Shorrock 2020), we also found insightful.

Our thesis, in line with our target article, is that EHF science fails to keep up with technological developments and real-world requirements. The processing speed of computers continues to double every few years (Kurzweil 2024), while the capabilities of AI models are progressing even faster (e.g., Epoch AI 2025)[1]. While technological development continues at an accelerating pace, much of EHF research appears to remain stuck in the methodology of the previous century.

Yes, we wholeheartedly agree with Baber (2025) and Todd and Thatcher (2025) that stimulus-response compatibility (Fitts and Seeger 1953) is an important principle and that the ILO/IEA *Ergonomic checkpoints* document (International Labour Office 2010) contains valuable solutions to workplace-related problems[2]. However, our target article focuses on modern EHF research, not on long-established design principles.

Impact should also not be inferred from the membership count in professional organisations, the number of institutions, or the sizes of conferences. These are measures of activity, not necessarily impact. Instead, the success of EHF *science* should be assessed based on the extent to which it still fulfils its mission: "*to promote efficiency, safety, and effectiveness by improving the design of technologies, processes, and work systems*" (Russ et al. 2013, p. 802).

The EHF scientific community has remained "*strangely quiet*" regarding AI developments (Grote 2023, p. 1702). Other scientific disciplines are advancing in this area without much EHF consultancy at all. This was evident, for example, at *Robotics: Science and Systems (RSS)*, one of the most prestigious conferences in the field of robotics. A significant number of papers were concerned with human-robot interaction (9% of the 134 papers included the word "human" in the title) and addressed topics such as learning from human demonstrations, modelling human intentions, teleoperation methods, and human-robot collaboration. However, EHF literature was cited only very sparingly in the proceedings (Kulic et al. 2024). This stands in contrast to the past, when EHF played a more prominent role in the robotics field (e.g., Sheridan 1992). We concur with Hancock (as quoted in Salmon et al., 2025, p. 765; see also HH) that the presumptuous ease with which engineers and others from the hard sciences describe or model human behavior in interaction with technology, thus positioning themselves as 'experts', is "*at the heart of our lack of recognition, or even dismissal*".

Another example of EHF's detachment from technological trends is Tesla's Full Self-Driving (FSD) versions 12 onwards, which appeared at the beginning of 2024. At the end of 2024, this automated driving system had accumulated billions of kilometres using an end-to-end neural network (Tesla Inc 2025), a development that introduces new demands on the human operator (De Winter, Eisma, and Dodou 2025). Yet, at the time of writing, there appear to be effectively *zero* EHF-related articles analysing this product. Meanwhile, numerous published EHF articles focus on displays and interfaces that are unlikely to ever be implemented in real-world applications.

The above observations suggest to us that large portions of EHF academia are self-contained, disconnected from reality, and in need of revitalisation. We agree with Walker and Greening (2025) that we were not bold enough. We have to adopt a more data-driven mindset and improve our skill set and understanding of AI; otherwise, we risk becoming irrelevant.

Regulations do not equate impact

Our criticism regarding the research-practice gap is supported by several commentators (HH, S, SC, WG, Y, TT). The commentators also propose recommendations, such as creating a better alignment among organisations (P), closer multidisciplinary collaborations (HH, TT), ensuring knowledge transfer (ES, Y), and achieving a more practically oriented positioning (SC).

Despite the mean score of 4.95 on a 10-point scale that EHF scientists and practitioners previously gave to the impact of EHF (Salmon et al. 2025), many of the current commentators seize the opportunity to point out that EHF does, in fact, have a strong impact, for example, on safety and productivity (ES, P, TT) as well as on regulations, policies, and standards (B, ES, S, TT, W, Y). Someone even stated on LinkedIn: "*This graphic I made shows clearly the explosion in HF related regulations since 2010 … so I have to wonder what on earth they are on about*" (Vink 2024).

While some may regard the impact of EHF on standards and regulations as a measure of impact, we regret to say that we find this perspective rather short-sighted. French President Macron remarked, "*We are overregulating and under-investing. So just if in the 2 to 3 years to come, if we follow our classical agenda, we will be out of the market. I have no doubt.*" (reflecting on Europe's situation; Berlin Global Dialogue 2024). Similar reflections can be found in the well-known Draghi Report (Draghi 2024, e.g., p. 145). The outcome of AI-related regulations in Europe is telling, with various

AI breakthroughs initially being unavailable here (Davies 2024).

Building on our target article, the mechanism behind EHF-related standards and regulations seems to be as follows: (1) new technology is introduced by companies, (2) EHF researchers take notice and highlight elements that have gone wrong (e.g., an incident or accident), (3) EHF researchers contribute to new safety-related documents and regulations, and (4) EHF claims to be influential due to its role in co-shaping these documents and regulations (see Rae et al. 2018, for a similar reflection on safety-related bureaucratic creep).

Of course, regulations serve an important purpose as they can act as guardrails to ensure safety and accountability. However, regulations can also stifle innovation. Additionally, regulations are frequently subject to negotiation and dilution, while standards are often ignored or remain expensive (SC). Our focus should be on collecting and generating data, conducting analyses, and developing new ideas and solutions, rather than on justifying one's relevance through the accumulation of rules and regulations.

Not pessimistic, but optimistic

A considerable number of commentators view our target article as overly pessimistic and dismiss our grim outlook on the future (P, ES, TT, W, Y). It depends on one's perspective. We are pessimistic about current trends in EHF but optimistic about the societal benefits of technological innovations.

We are working on the application of AI in education and research, and we see the tremendous potential of AI for EHF. While we cannot dive too deeply into this matter in this rebuttal, we would like to lift the veil with an example. We are now using AI for more complex tasks, such as classifying textual or interview responses, where the latest generation of large reasoning models excels (Zhang et al., 2025). Additionally, we are exploring the use of hypothetical individuals, or "personas", for pretesting questionnaires (De Winter, Driessen, and Dodou 2024).

Here, we apply a vision-language model to the classic knobs-and-dials work of Grether (1949) (see Figure 1) and obtain interpretable outcomes (Table 1), while acknowledging that some assessments (such as 'visual appeal') are subjective and the AI's depth of 'understanding' of dials from images alone is open to question. Regarding criterion validity, we find strong correlations between the language model's ratings and both the error rate and the mean number of seconds per reading among 176 participants, as determined by a paper-and-pencil assessment by Grether (1949) (see Figure 2 for an illustration)[3]. Conversely, it could be powerful to predict the outcomes

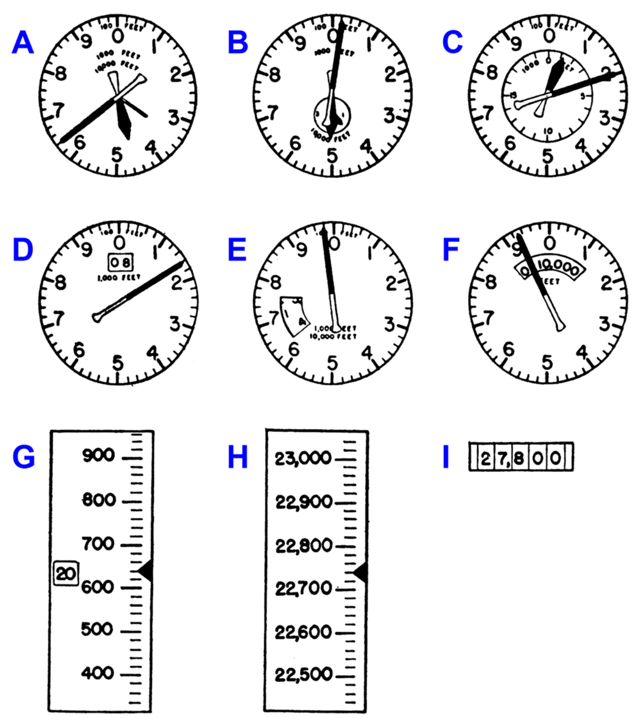

Figure 1. The nine instruments (from Grether 1949; images are in the public domain; scan of Fitts 1951a).

Table 1. Mean responses provided by Google's Gemini 2.5 Flash Preview to 8 statements and 9 dials.

	A	B	C	D	E	F	G	H	I
1. This dial allows the altitude to be read quickly.	29	42	41	87	58	64	88	90	97
2. The distinction between thousands and hundreds of feet is clear on this dial.	52	62	64	94	57	52	91	94	98
3. The altitude reading on this dial is accurate even at a quick glance.	24	38	38	87	52	56	89	91	98
4. This dial effectively displays both large and small altitude increments.	77	79	77	89	63	60	84	81	93
5. This dial allows for easy qualitative reading of altitude changes.	72	76	75	79	76	77	86	88	10
6. The dial is visually appealing	46	54	50	75	58	63	67	66	50
7. This dial design minimizes the likelihood of errors exceeding 1,000 feet when reading altitude.	15	35	37	93	54	59	93	94	99
8. This dial contains fast-moving elements.	81	81	80	76	69	65	72	69	47

Note. Colour coding is applied to each row, ranging from the lowest value (red or green) to the median value (yellow) and the highest value (green or red). Google's *gemini-2.5-flash-preview-05-20* was prompted as follows: "*Score the 9 images on the following 8 statements, on a scale from 0 (absolutely not the case) to 100 (absolutely the case). Output the numbers separated by spaces on one line, nothing else*". Statements and images were presented in random order. The prompting process was repeated a large number (475) of times.

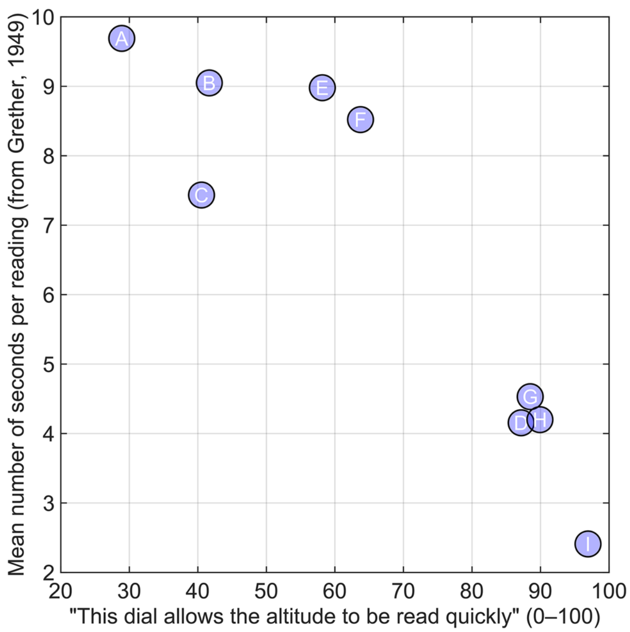

Figure 2. Scatter plot depicting a relationship between Grether's (1949) results and vision-language-model-based scores.

of certain experiments or design activities using AI, even before involving actual human participants. We expect that the design and evaluation of products and services will soon be largely AI-supported and proceed at an accelerated pace. While some EHF researchers are considering such ideas (e.g., Zakreuskaya et al. 2024), we encourage greater activity in this area.

Too narrow a focus?

Some commentators argue that we adopt too narrow a focus by ignoring areas such as physical ergonomics, rail, and process automation (S, W). It is true that, particularly in the journal *Ergonomics*, physical ergonomics plays a substantial role, with several well-cited articles on topics such as exoskeletons and issues such as posture, injury, and pain in modern-day tasks. These are important topics, though a minority within EHF science. It is often more appealing to write a paper on hypothetical 'hot topics', typically in the form of abstraction. This reflects the academic productivity trap we highlighted in our target article, i.e., pursuing research not out of real-world necessity but as a means of psychological fulfilment within the constraints of an industrialised academic system.

The commentators also note that our target article approaches EHF from a cognitive experimental perspective, causing us to overlook the benefits of systemically oriented approaches (B, S, WG, W, Y). Terms mentioned include: Cognitive Work Analysis, macroergonomics, activity-centred ergonomics, wicked problems, 'wholistic', naturalistic, socio-technical systems, and embodied cognition (B, ES, S, TT), while stereotypically rejecting Fitts's list (B) (Fitts 1951b), the well-known list of human versus machine abilities from a report more often critiqued than read (De Winter and Dodou 2014; also Hancock 2009, p. 86).

We endorse the message of authors such as Hollnagel and Woods (1999) that EHF should not be over-reliant on physicalistic stimulus-response experiments. However, our proposed solution lies in data-driven research and alignment with the engineering sciences, not in creating schematic diagrams and anti-reductionist thinking. The perils of systems thinking were well expressed by James Reason, father of the systemic model, in his later contributions: "*Are we casting the net too widely in our search for the factors contributing to errors and accidents?*" (Reason 1999) and "*Has the pendulum swung too far?*" (Reason 2008, p. 136; see also De Winter 2014).

While we prefer to reserve this topic for a future debate, we would like to caution that systems thinking may well be a trap. Systems thinking can be misleadingly inviting with its holistic perspective, but ultimately so tangled with interconnections that it obscures scientific thinking. Those who venture too far risk losing sight of the scientific method, wandering in a situation where everything relates to everything and nothing is empirically testable.

Constructs

Our criticism of EHF constructs, such as workload and situation awareness (SA), is dismissed as incorrect, because the constructs are considered valid and useful, yet sometimes misapplied (B, ES; see also Parasuraman, Sheridan, and Wickens 2008). Others agree with us that the foundation of EHF constructs is weak and should be subjected to improved theory formation, interpretation, and application (HH, B, Y). Additionally, some of the commentators agree that EHF must evolve from pen-and-paper instruments towards data-driven methods, and they recognise that many EHF publications no longer correspond with the complexity of current practices (SC, WG).

De Winter has been giving lectures on EHF for many years, including on the topic of 'workload', and has yet to formulate an internally consistent explanation (for details, see Matthews, De Winter, and Hancock 2020). The literature is unclear about whether workload is uni- or multidimensional, bounded or unbounded, whether it has an optimal value (or if lower is always better), and whether it can be distinguished from arousal, stress, effort, or perceived difficulty. We are not alone in occasionally feeling disillusioned by published EHF 'theory' (HH). In his lectures, De Winter therefore adopts a pragmatic and outcome-oriented model, by equating workload to the measurement itself (e.g., pupil dilation corresponds to higher workload within a clearly defined and designed experimental context).

A great deal has already been written about SA, which is probably the most well-known EHF construct and, at the same time, perhaps the most criticised. This criticism could be interpreted as jealousy from those who wish they could produce well-written and highly-cited work like Endsley (1995). However, there may also be a kernel of truth in the critiques, which suggest that SA is merely a new label that emerged within a particular *Zeitgeist* and which can be conveniently used to retrospectively explain errors and accidents (e.g., Dekker 2015).

It is true that SA measures are predictive of task performance. According to a meta-analysis, the summary correlation is 0.26 (Bakdash et al. 2022), where it does not seem to matter which method is used, whether it is a single-item self-reported SA or more elaborate tests such as SAGAT. Perhaps the correlation could indeed approach 0.50 in optimally created conditions, such as with many repetitions of experimental trials (De Winter et al. 2019).

However, the prevalence of the term and its positive correlation with a criterion do not, in themselves, establish validity. In individual-differences research, self-report measures (whether related to SA, workload, self-confidence, self-efficacy ratings, or otherwise) almost always correlate 0.2 to 0.5 with performance measures. Construct proliferation, the practice of rebranding fundamentally similar concepts while eagerly correlating them with external criteria, is a well-known problem in the psychology literature (e.g., Le et al. 2010). Statistical models or multitrait-multimethod approaches will be needed to clarify the extent to which 'low SA' differs from 'being distracted', 'being forgetful', or 'believing one could have done a better job'.

As Walker and Greening (2025) rightly point out: "*the world has moved on*". We can endlessly linger over correlation matrices, where all relationships are positive and follow the same familiar pattern, or we can acknowledge that with the new developments in AI, it is possible to let the data speak for itself: large amounts of semantic data can now be summarised into performance predictors without the need for explanatory constructs. It may also be noted that AI is increasingly being used as a symbiotic aid to humans, intended to *enrich* cognition, which means that the traditional 'loss of SA' narrative is becoming less interesting and relevant.

Conclusion

Many of the commentators provide historical reflections and note that our critique is not necessarily new. They indicate that similar discussions have been a defining feature of the field for 75 years (B, HH, S, W). It is also argued that the problems we highlight are overstated and not unique but rather characteristic of the academic enterprise as a whole (ES, HH, S, Y). Overall, we feel that our target article has been met with a relatively 'soft reception': our points are partially acknowledged but simultaneously downplayed.

We feel that our message is too important for it to be nuanced and contextualised so much; the future of EHF science is at stake if we are not woken from this "dogmatic slumber" (cf. Kant, 2004, p. 10). The latent movement of individuals who ignore EHF (or are unaware of its existence), as well as the exponential pace of technological development, are being drastically underestimated.

Time will tell what level of adaptability is required in the 'survival of the fittest' of the academic system. We predict that within 5–10 years, Big Tech companies will launch highly advanced products, such as cars capable of driving driverlessly, and generative AI that extensively supports or even replaces the work of office workers, designers, and academics. We are concerned that EHF researchers, in such a future, will continue to discuss 1990s topics such as 'loss of situation awareness' and 'ironies of automation' in their symposia and journals, not sensing the greater irony that their own situation has long been lost, outpaced by recursively self-improving AI, which, unlike them, no longer needs to discuss progress to achieve it.

As Hancock proclaimed at the beginning of the 21st century in his HFES presidential address: "*It is our parade*" (Hancock 2000; Howell 2001); in other words, how new technology should be used is precisely where EHF should have a voice. We must gain control over big data and AI, for example, through the use of AI for product design and evaluation. If we do not engage in serious innovation and find a new role within these developments, the old era of EHF research will come to an end, and we will have missed one of the greatest opportunities of the century.

Notes

1. This current AI revolution differs from previous waves such as symbolic AI (1950s–1980s) and expert systems (1980s–1990s) by exploiting vast amounts of data, computing power, and neural networks to achieve human-like capabilities in language, vision, and creativity.

2. In our target article, we recommend replication studies, as they enable researchers to gain a deeper understanding of the EHF classics that have shaped design and work principles.
3. A counterargument could be made that the vision-language model may have been trained on Grether's (1949) paper or on related works, and, as a result, generates output akin to a stochastic parrot. While this topic can be debated, we argue that such criticisms of generative AI are often exaggerated (cf. Onkhar et al. 2025, assessing novel images).

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Data availability statement

Walker and Greening (2025) consider the lack of open data within EHF to be a non-issue compared to the other problems we highlight in our target article. We, however, believe that not having access to data and code *is* an existential problem. Without code and data, what remains? Words, tables, and figures, with limited opportunity to build upon them; in other words, the production of a new paper without progress. While we would welcome a debate on this topic at another time, we take this opportunity to share the code underlying Table 1 and Figure 2: https://doi.org/10.4121/240b19a6-c816-414c-85e1-ca030414002e.

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