History, present, and future of cognitive ergonomics in Europe

Gerrit van der Veer
VU
Amsterdam, Netherlands
g.c.vander.veer@vu.nl

Oronzo Parlangeli
University of Siena
Siena, Italy
oronzo.parlangeli@unisi.it

Maurice Mulvenna
School of Computing
Ulster University
Belfast, United Kingdom
md.mulvenna@ulster.ac.uk

Abstract

Abstract: This paper presents a comprehensive overview of the evolution, current landscape, and future trajectory of Cognitive Ergonomics (CE) in Europe, based on discussions at the ECCE conference in 2024 in Paris, France. CE, grounded in disciplines such as cognitive psychology, computer science, and human factors, has evolved through technological and methodological shifts. Historically, CE addressed issues of human error and usability in early computing contexts, progressing from individual-focused models to complex socio-technical and human-AI systems. European developments have been shaped by regional paradigms—Scandinavian participatory design, British psychological frameworks, Italian automation methodologies, French task analysis, and interdisciplinary German approaches—reflecting diverse academic and industrial contexts. Human error research, particularly its systemic framing and ethical dimensions, has remained a central theme, with increasing relevance in emerging intelligent technologies. Recent trends highlight the integration of generative AI, brain-computer interfaces, and human-machine collaboration. Future challenges include addressing ethical concerns, preserving human autonomy, and promoting sustainable interaction design. This review underscores the continued importance of CE in guiding responsible technological innovation and calls for stronger collaboration between researchers, industry, and policymakers. By examining CE's multidisciplinary roots and regional expressions, the paper aims to contribute to a deeper understanding of its evolving role in shaping human-centered technology.

CCS Concepts

• **Human-centered computing → HCI design and evaluation methods**; **HCI theory, concepts and models**; **Interaction design**.

Keywords

Cognitive ergonomics, Human computer interfaces, Human-centred design

ACM Reference Format:
Gerrit van der Veer, Oronzo Parlangeli, and Maurice Mulvenna. 2025. History, present, and future of cognitive ergonomics in Europe. In *36th Annual Conference of the European Association of Cognitive Ergonomics (EACE) (ECCE 2025), October 07–10, 2025, Tallinn, Estonia.* ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3746175.3746192

This work is licensed under a Creative Commons Attribution International 4.0 License.

ECCE 2025, Tallinn, Estonia
© 2025 Copyright held by the owner/author(s).
ACM ISBN 979-8-4007-2033-8/25/10
https://doi.org/10.1145/3746175.3746192

1 Introduction

On October 11, 2024, the European Association of Cognitive Ergonomics (EACE) facilitated an interactive forum at ECCE 2024 in Paris, France. The forum used digital participation tools to explore interactively the history, present state, and future of Cognitive Ergonomics (CE) in Europe, along with its evolving domain and significance. Participants engaged in discussions and shared ideas through an interactive tool, ensuring an inclusive exchange of insights. The topic areas covered on the forum were structured around these CE themes:

- Disciplinary roots of CE
- CE paradigms
- CE in Europe
- CE outside Europe
- CE Futures

and these are now discussed in turn.

2 Disciplinary roots of cognitive ergonomics

Cognitive Ergonomics has its roots in various disciplines, including process control, art, education, and medicine. Historically, physics and physiology have played significant roles in shaping cognitive approaches, yet contemporary studies often overlook the integration of physics, despite its foundational influence on key CE concepts such as workload, effort, time, and visual exploration. The field also draws from cognitive psychology, ergonomics, computing, cybernetics, information theory, sociology of innovation, work psychology, and decision-making. Contributions from neuroscience, science and technology studies, philosophy, ethics, and social psychology further enrich the discipline, expanding its application to accessibility and human-centered design.

3 Paradigms in cognitive ergonomics

The evolution of CE paradigms has been shaped by an inventory of past and emerging approaches. New paradigms often emerge as reactions to novel technical advancements, influencing areas such as programming languages, usability, user interface design, mental models, and user experience. Key perspectives include human information processing, cognitive load, attentional capacity, mental workload, and human-computer interaction. The field also encompasses varied focuses, including company-, designer-, user-, stakeholder-, system-, and environment-centric approaches.

In particular, distinct strands exist within CE, such as cutting-edge technologies such as virtual reality, applied psychology in machine interaction, interaction design, and sociotechnical systems that examine group interactions in work and political environments. In addition, CE benefits from both experimental psychology and real-world ecological studies, balancing methodological rigor with practical applicability. In the field of CE, human error has been one of the most widely debated areas of study in Europe, marked by a considerable diversity of approaches.

Several phases can be identified. Initially, almost a century and a half ago, attention to human error focused on perceptual, cognitive, and psychological processes [21, 35], with an emphasis on the individual. Over time, scholars expanded their perspective to consider interactions between operators, contexts, and technologies. This shift began notably in the 1950s [37], when human error began to be understood within sociotechnical organizational models. Early CE paradigms were triggered by the available and developing state of technology. The computers that were available around 1960 had limited hardware memory (e.g., 12 K memory words of 32 bits, a single accumulator), input/output through a row of switches and lamps, and a connected telex machine (that read / punched 5- or 7-hole symbols in paper tape). The most advanced languages for these machines were the procedural programming language FORTRAN [4] and ALGOL 60 [5], and the list processing language LISP [26]. In 1963, Engelbart demonstrated the first computer mouse, a large step in ergonomic human-computer interaction design [15].

As programable computers were immediately used in many disciplines and for many professions, the choice of programming language and program paradigms were found to have an ergonomic effect, both on the original process of programming, but also on maintenance and sustainability. Edgar Dijkstra strongly advocated for procedural design of programs and against the use of go-to commands [14].

An early operating system, annex programming environment (since 1969), intended to be used by scientists as well as office workers, was UNIX [32], though Cognitive Psychological analysis revealed that the use by non-experts required considerable attention [27].

4 Cognitive ergonomics in Europe

The European situation of CE started at several locations. Professionals originally published, and read, in their own language, but English as a second language was increasingly common for international conferences, scientific collaboration, and Europe-wide sponsored projects. The development of User Interface Management Systems (UIMS) [28] was a typical European breakthrough, triggering attention for user needs and for adaptive systems. Conference series developed focusing on the relation between Psychology and Informatics [36], leading to the concepts of Software Ergonomics and Interactive Systems [19].

An originally typical Scandinavian focus was on “work”, collaboration, and participatory design [11]. British and French university teams collaborated in European ESPRIT projects on Process Control and related theory development [10] [9] and on the Psychology of Programming Interest Group (https://ppig.org). In Spain, Cognitive Psychology groups started cognitive psychological research by focusing on the user’s mental model of the system [13], Design for Cultural Heritage [34], and on design for users with special needs [2].

A pivotal moment that brought human error to the forefront of scholarly attention was The NATO Conference on Human Error, organized by Neville Moray and John Senders in Bellagio, Italy, in September 1983. During this event, the 23 participants were invited to reflect on a set of key issues. It was on this occasion that David Woods presented a position paper advocating for a shift in focus "behind human error"—toward the various aspects of design that can lead to what they termed system-induced error. These were also the years in which Erik Hollnagel and David Woods were developing their new approach known as Cognitive System Engineering [20], and around the same period, Jens Rasmussen introduced his action control model, commonly referred to as the skill-rule-knowledge model, later detailed in his book Information Processing and Human-Machine Interaction [30](1986).

At the end of the 20th century, focused academic centers developed, e.g. the Man-Computer Interaction Research project (MACINTER, 1979-1986) at Humboldt University, related to the International Union of Psychological Science (IUPsyS), with colleagues from German-speaking and other European countries.

Conferences like EURINFO ’88 – “First European conference on information technology for organizational systems”, and EUTECO ’88 – “Research into Networks and Distributed Applications”, served to report and disseminate results and stimulate more international collaboration, as did the COST Action of the European Communities.

In response to both theoretical and practical pressures—especially as incidents and disasters in service and high-risk production systems increased—British psychologist James Reason [31] introduced a classification of human error, distinguishing between execution errors (slips and lapses) and planning or problem-solving errors (mistakes). He also developed the Swiss-cheese model to illustrate how multiple layers of organizational defenses can fail, leading to accidents. That book already contained a vast amount of research devoted to understanding human error, reflecting the wide range of analytical approaches available at the time, an impressive body of work that laid the foundation for influential theoretical developments.

Among the many contributions in this flourishing intellectual landscape, Liam Bannon [8] deserves mention for his theoretical reflections on the "social" nature of work, and for his argument that computer systems should support—not hinder—human activity. Equally illuminating are the contributions of Jean-Michel Hoc, who situated human error within the collaborative processes between natural and artificial agents. Rather than viewing error as a deviation from a normative standard, he conceptualized it as the result of cognitive regulation under conditions of incomplete information, time pressure, and increased workload [18].

Theoretical reflections on human error have been consistently supported by both laboratory and field studies. Among the many contributions, the work of Frese and colleagues stands out for having expanded the understanding of errors in everyday operational activity, highlighting the potential positive value of errors—for instance, in promoting the discovery of new interactive possibilities with the system [16]. In a seminal study conducted at the University of Giessen in Germany, they recreated a realistic computer training context. Participants, divided into two groups, either received or did not receive training specifically aimed at error management.

Their findings showed that error management training can improve performance, particularly in tasks not performed under time pressure.

Other studies have focused on real-world contexts. For example, Mazaheri et al. [25] analyzed 115 grounding incident reports from the Finnish Safety Investigation Authority and the UK Marine Accident Investigation Branch, along with 163 near-grounding incident reports from the ForeSea and Finnpilot databases. This field-based data analysis led them to develop a revised version of the Human Factors Analysis and Classification System (HFACS) as a framework for reviewing incident reports. Their findings indicated that after mechanical failures, human error is the second most reported cause of incidents. However, the authors pointed out that this may largely be the result of the presence of a blame culture in the reporting practices of the sector.

Currently, research on human error is increasingly addressing technological contexts, particularly those involving interaction with intelligent technologies. This includes research into morally unacceptable behavior produced by social robots [17, 22, 33, 38] as well as studies on errors committed by Artificial Intelligences and judged in terms of severity by human observers [1, 29, 39]. Further investigations focus on errors emerging in integrated human–intelligent system interactions [3, 12, 23, 24].

In summary, Europe has developed—and continues to move toward—a wide range of approaches to the study of human error, ranging from individual-centered frameworks to integrated models that account for the interactions between humans, organizations, and evolving technologies, reflecting the diverse cultural and scientific perspectives across countries.

The development of CE in Europe varies across regions, with different schools of thought, industry applications, and influential figures shaping its trajectory. Historically, European developments in CE have been influenced by regional variations in academic and industrial research. In the German-speaking region, early research focused on user interface management systems and interdisciplinary collaboration between informatics and psychology. Scandinavian countries pioneered participatory design, emphasizing user involvement in system development. The United Kingdom contributed significantly through cognitive psychology and human factors research, leading to practical applications in industrial design. France, with institutions such as INRIA, played a vital role in advancing task analysis and cognitive ergonomics in process control systems.

In Italy, CE was once a unified discipline but has since fragmented into specialized fields such as SIGCHI. However, Italian pioneers such as Sebastiano Bagnara played a crucial role in integrating cognitive psychology with human-computer interaction and interaction design. His contributions span theoretical research, ergonomics, and applied psychology, influencing education and training methodologies in automation [7] [6]. Efforts to reintegrate these areas through a shared ethical perspective could enhance cohesion and impact. Similarly, French-speaking ergonomics has traditionally emphasized field-based applications over experimental research, with ongoing discussions about the integration of diverse perspectives, including UX, neuro-ergonomics, and occupational health. Industry engagement with CE remains limited, with companies more frequently addressing user experience and human factors rather than explicitly recognizing cognitive ergonomics.

5 Cognitive ergonomics outside Europe

Beyond Europe, CE follows varied trajectories influenced by regional academic traditions, technological advancements, and industry needs. Past paradigms in global CE have responded to emerging technologies, fostering approaches like user-centered design, participatory design, and human-media interaction. Cross-cultural studies highlight the challenges of differentiating national identity from broader cultural influences, raising questions about the role of beliefs, religion, and economic development in shaping CE applications. Ethical considerations, regulatory frameworks, and international collaborations are critical factors in advancing CE on a global scale.

6 Future directions in cognitive ergonomics

The future of CE encompasses numerous emerging trends, including advancements in brain-computer interfaces, generative AI, and participatory design. Discussions on AI's role in CE suggest that while AI can complement human capabilities, ethical design and governance are necessary to mitigate unintended consequences. The concept of human-AI collaboration is gaining traction, emphasizing the importance of cognitive ergonomics in guiding responsible AI development.

Another area of interest is the evolving relationship between humans and technology, particularly regarding attention, working memory, and the potential long-term effects of digital integration. Some researchers question whether society might eventually limit AI automation to preserve human well-being and autonomy. The role of CE in sustainable development, low-tech solutions, and ethical technology adoption will also be critical in shaping future research and practice.

7 Conclusions

The field of Cognitive Ergonomics continues to evolve, influenced by interdisciplinary contributions, technological advancements, and regional variations in its development. While CE has historically integrated diverse academic perspectives, there is a growing need for increased collaboration between researchers, industry practitioners, and policymakers. By addressing emerging challenges in AI, human-computer interaction, and sustainability, CE can continue to enhance user experience, cognitive well-being, and the design of future technologies. The discussions at ECCE 2024 underscored the importance of maintaining a dynamic and inclusive approach to CE, ensuring its relevance in an ever-changing technological landscape.

Acknowledgments

This study acknowledges the contributions by the attendees at the 2024 European Conference on Cognitive Ergonomics (ECCE) in Paris, France, chaired by Stéphane Safin, Jean-Marie Burkhardt and Flore Barcellini, using the interactive Padlet system to record attendee perspectives on cognitive ergonomics in Europe.

References

[1] U. Agudo, K. G. Liberal, M. Arrese, and H. Matute. 2024. *The impact of AI errors in a human-in-the-loop process*. Principles and Implications, 9(1), 1, Cognitive Research.

[2] A. Arruabarrena and J. G. Abascal. 1989. Dispositivos de comunicación. In *Aplicaciones del ordenador y de las nuevas tecnologías en la ayuda a personas con discapacidad*, L. Gardeazabal (Ed.). Servicio Editorial de la UPV-EHU, 103–126.

[3] D. Babushkina. 2023. Are we justified attributing a mistake in diagnosis to an AI diagnostic system? *AI and Ethics* 3, 2 (2023), 567–584.

[4] J. Backus. 1998. The History of Fortran I, II, and III. *IEEE Annals of the History of Computing* 20, 4 (1998), 1998.

[5] J. W. Backus et al. 1960. Report on the algorithmic language ALGOL 60. *Commun. ACM* 3, 5 (1960), 299–311.

[6] S. Bagnara, D. B. Boles, F. Simion, and C. Umiltà. 1982. Can an analytic/holistic dichotomy explain hemispheric asymmetries? *Cortex* 18, 1 (1982), 67–77.

[7] S. Bagnara, O. Parlangeli, and R. Tartaglia. 2010. Are hospitals becoming high reliability organizations? *Applied ergonomics* 41, 5 (2010), 713–718.

[8] L. J. Bannon. 1986. Computer-mediated communication. User Centered System Design: New Perspectives on Human-Computer Interaction. In *Hillsdale*. Lawrence Erlbaum, NJ, USA, 433–456.

[9] P. J. Barnard, N. O. Bernsen, J. Coutaz, J. Darzentas, G. Faconti, N. H. Hammond, M. D. Harrision, A. H. Jørgensen, J. Löwgren, A. Maclean, J. May, and R. M. Young. 1995. *The Amodeus Project - ESPRIT Basic Research Action 7090 – Final Report*. MRC Applied Psychology Unit, Cambridge UK.

[10] P. J. Barnard, A. MacLean, and M. D. Wilson. 1988. Navigating integrated facilities: initiating and terminating interaction sequences. In *Proceedings of CHI'88, ACM*.

[11] G. Bjerknes, P. Ehn, and M. Kyng. 1987. *Computers and democracy-a Scandinavian challenge*. Gower Publishing Ltd.

[12] I. Carnat, G. Comandé, D. Licari, and C. De Nigris. 2024. From human-in-the-loop to LLM-in-the-loop for high quality legal dataset. *i-lex* 17, 1 (2024), 27–40.

[13] J. J. Cañas, M. T. Bajo, R. Navarro, F. Padilla, and M. D. C. Puerta. 1998. Representación mental y programación de ordenadores Mental representation and computer programming. *Cognitiva* 1, 1 (1998), 239–255.

[14] E. Dijkstra. 1968. Go to considered harmful (1968) CACM 11 nr 3 p 147. (1968).

[15] Douglas C Engelbart and William K English. 1968. A research center for augmenting human intellect. In *Proceedings of the December 9-11, 1968, fall joint computer conference, part I*. ACM, 395–410.

[16] M. Frese, F. Brodbeck, T. Heinbokel, C. Mooser, E. Schleiffenbaum, and P. Thiemann. 1991. Errors in training computer skills: On the positive function of errors. *Human-Computer Interaction* 6, 1 (1991), 77–93.

[17] I. Giorgi, F. A. Tirotto, O. Hagen, F. Aider, M. Gianni, M. Palomino, and G. L. Masala. 2022. Friendly but faulty: A pilot study on the perceived trust of older adults in a social robot. *IEEE Access* 10 (2022), 92084–92096.

[18] J. M. Hoc. 2001. Towards a cognitive approach to human–machine cooperation in dynamic situations. *International journal of human-computer studies* 54, 4 (2001), 509–540.

[19] H.-J. Hoffmann. 1988. *Notizen zu Interaktiven Systemen, Heft 17. Fachgruppe Interaktive Systeme der Gesellschaft fur Informatik e.* V, Germany.

[20] E. Hollnagel and D. D. Woods. 1983. Cognitive systems engineering: New wine in new bottles. *International journal of man-machine studies* 18, 6 (1983), 583–600.

[21] W. James. 1890. *The Principles of Psychology*. Holt, New York.

[22] D. Kontogiorgos, A. Pereira, B. Sahindal, S. Van Waveren, and J. Gustafson. 2020. Behavioural responses to robot conversational failures. In *Proceedings of the 2020 ACM/IEEE International Conference on Human-Robot Interaction*. 53–62.

[23] O. Korostin. 2025. Analysis of AI effectiveness in reducing human errors in processing transportation requests. (2025). arXiv:2503.15517 arXiv preprint.

[24] N. Köbis, J. F. Bonnefon, and I. Rahwan. 2021. Bad machines corrupt good morals. *Nature human behaviour* 5, 6 (2021), 679–685.

[25] A. Mazaheri, J. Montewka, J. Nisula, and P. Kujala. 2015. Usability of accident and incident reports for evidence-based risk modeling–A case study on ship grounding reports. *Safety science* 76 (2015), 202–214.

[26] J. McCarthy, R. Brayton, D. Edwards, P. Fox, L. Hodes, D. Luckham, K. Maling, D. Park, and S. Russell. 1960. *LISP I Programmers Manual*. Artificial Intelligence Group, M. I. T. Computation Center and Research Laboratory, Boston.

[27] D. A. Norman. 1981. The Trouble with UNIX (1981) Datamation. *November* 1981 (1981), 139–150.

[28] G. Pfaff. 1983. *Proceedings of the workshop on user interface management systems*. Springer-Verlag, Berlin.

[29] A. Placani. 2024. Anthropomorphism in AI: hype and fallacy. *AI and Ethics* 4, 3 (2024), 691–698.

[30] J. Rasmussen. 1986. *Information processing and human-machine interaction*. Elsevier, Science Inc.

[31] J. Reason. 1990. *Human error*. university press, Cambridge.

[32] D. M. Ritchie and K. Thompson. 1974. The Unix Time-sharing System. *Commun. ACM* 17, 7 (July 1974) (1974), 365–37.

[33] M. Salem, G. Lakatos, F. Amirabdollahian, and K. Dautenhahn. 2015. Would you trust a (faulty) robot?. In *Effects of error, task type and personality on human-robot cooperation and trust*. In Proceedings of the tenth annual ACM/IEEE international conference on human-robot interaction, 141–148.

[34] M. Sendín, J. Lorés, C. Aguiló, and A. Balaguer. 2001. Un modelo interactivo ubícuo aplicado al patrimonio natural y cultural del área del Montsec. *IHO series* 153 (2001), 22–25.

[35] J. Sully. 1881. *Illusions*. Kegan Paul & Co, C.

[36] M. J. Tauber, D. E. Mahling, and F. Arefi. 1994. Cognitive aspects of visual languages and visual interfaces. (1994).

[37] E. L. Trist and K. W. Bamforth. 1951. Some social and psychological consequences of the longwall method of coal-getting: An examination of the psychological situation and defences of a work group in relation to the social structure and technological content of the work system. *Human relations* 4, 1 (1951), 3–38.

[38] S. van Waveren, E. J. Carter, and I. Leite. 2019. Take one for the team: The effects of error severity in collaborative tasks with social robots. In *Proceedings of the 19th ACM international conference on intelligent virtual agents*. 151–158.

[39] J. Zerilli, U. Bhatt, and A. Weller. 2022. How transparency modulates trust in artificial intelligence. *Patterns* 3, 4 (2022).