

What is Extreme in Human-Computer Interaction Research?

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Abstract

Researchers in human-computer interaction have often approached interactive system design and engineering involving atypical users, novel technological advancements, and unconventional environments that deviate from the average, moderate, or standardized. This paper examines the extent to which researchers characterize their work as *extreme*, through a targeted literature review and an analysis of the linguistic connotations of the term. We emphasize *extreme users*, who display exaggerated behaviors, acquire extraordinary abilities, and engage in high-stakes, high-performing collaborations. We also highlight *extreme platforms* that facilitate input and output modalities surpassing conventional limits, foster intense synergy between users and machines, and employ boundary-pushing design approaches. Lastly, we discuss *extreme environments*, whether physical, digital, virtual, or mixed, which pose very serious, severe, and potentially risky conditions. We conclude with the benefits for the HCI field of engaging in more scientific and technical explorations driven by “extreme” interaction elements.

CCS Concepts

• **Human-centered computing** → HCI theory, concepts and models; Interactive systems and tools.

Keywords

Extreme environments, extreme users, extreme behavior, extreme abilities, extreme platforms, extreme input/output, extreme design

ACM Reference Format:

Radu-Daniel Vatavu and Jean Vanderdonckt. 2025. What is Extreme in Human-Computer Interaction Research?. In *Adjunct Proceedings of the 27th International Conference on Mobile Human-Computer Interaction (MobileHCI '25 Adjunct)*, September 22–25, 2025, Sharm El-Sheikh, Egypt. ACM, New York, NY, USA, 7 pages. <https://doi.org/10.1145/3737821.3749561>

1 Introduction

Advancements in multisensory feedback and digital content generation across environments spanning from physical to virtual, have led to research and design opportunities where interactions with computer systems feel atypical, non-standard, and unconventional.

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ACM ISBN 979-8-4007-1970-7/25/09
<https://doi.org/10.1145/3737821.3749561>



Figure 1: The term “extreme” has been used in HCI research to address all core elements of interactions with computer systems—*users*, *platforms*, and *environments*—to describe experiences that are far from the ordinary. For example, in this photograph taken during one of our experiments conducted at the Euro Space Center, the user is suspended in mid-air to experience intense sensations delivered by a highly immersive platform with overwhelming multisensory feedback, simulating walking on Mars—an extreme environment characterized by its unique gravitational conditions.

In this landscape, a focus on *extreme* contexts of use is what pushes the boundaries of human-computer interaction (HCI) research.

All elements of interactions with computers—*users*, *platforms*, *environments* [3]—can be impacted by the “extreme.” Figure 1 illustrates an *extreme user* with unique abilities gained by engaging with an *extreme platform* that evokes intense multisensory sensations to depict an *extreme environment* imposing challenging physical conditions. The corresponding interactions can be described through the lens of impressive abilities mediated by technology [43], exaggerated sensations stemming from multisensory feedback [45], as well as a risky experience because of the potential danger of being suspended in mid-air. These characterizations—impressive,

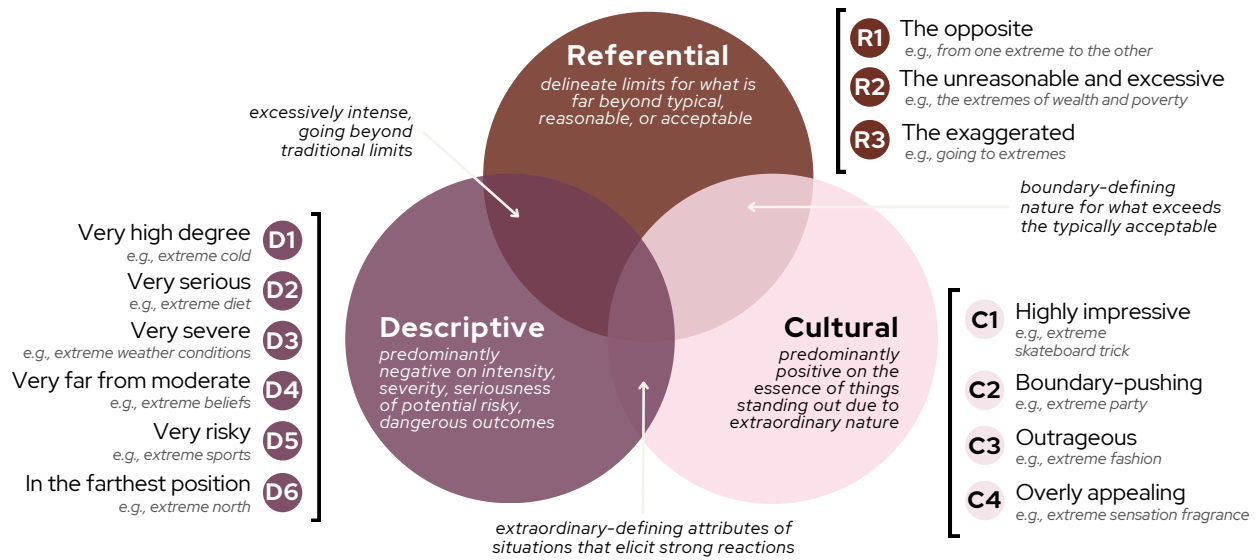


Figure 2: Connotations of the word “extreme,” with three roles: *referential*, *descriptive*, and *cultural*; see Figure 3 for applied meanings in HCI research. The choice of a Venn diagram illustrates the overlapping semantic implications in everyday language.

exaggerated, risky—are just some of the possible ways to describe contexts of use such as these, while the linguistic connotations of the term “extreme” abound in nuanced meanings [4,8,25,28] and continue gaining new valences [41]. The language we use shapes our thinking, which in turn influences how HCI researchers address interactions involving atypical users, novel technological platforms, and unconventional environments. For example, the *exsitu*¹ research lab sets as objective exploring the limits of HCI, specifically how extreme users interact with technology in extreme situations.

In this context, we contribute an examination of the connotations used in HCI research that explicitly investigated the “extreme,” through a targeted literature review of twenty-eight scientific papers. We highlight *extreme users* in terms of their abilities, behavior, and collaboration; present insights on *extreme platforms* concerning input, output, synergy, and design approaches; and exemplify *extreme environments*, spanning physical to virtual settings.

2 What Does “Extreme” Mean in Everyday Language?

We consulted several popular dictionaries [4,8,25,28] as well as an urban dictionary of slang words and phrases [41] to capture both traditional definitions and the evolving cultural nuances of the term “extreme” in everyday language; see Figure 2 for an overview. The etymology of the term, according to [25], shows an origin in the Latin “*extremus*,” which is a superlative of “*exter*, *exterus*” with the meaning of being on the outside. As an adjective, the word “extreme” describes objects, places, or situations that are unusual or exceed commonly accepted limits [4,8,25,28], and means:

- **Very high degree.** An entity is described as extreme when it exists to a very high degree [8,25], significantly exceeding the usual level or amount [4], as in extreme caution.

- **Very serious.** An outcome is deemed extreme when its cause or action goes to great or exaggerated lengths [8,25], which are perceived as being very serious, as in the case of an extreme diet or extreme punishment.
- **Very severe.** When something is extreme, it exceeds the ordinary, usual, or expected [25] in a way that is evaluated as very severe or bad [4], such as extreme weather conditions.
- **Very far from moderate.** Being extreme also means most advanced or thoroughgoing [25] in terms of beliefs and opinions that are seen as being very far from the consensus [4,8]. A relevant example is someone adopting extreme views.
- **Very risky.** An activity or form of sport that involves an unusually high degree of physical risk [25] or danger [8], or a person engaging in such an activity, can be described as extreme, as in an extreme snowboarder.
- **In the farthest possible position.** An object or place situated at the farthest possible point from a referential center [4,25] or adopting the farthest possible position [8] can be described as extreme, as in the extreme north.

As a noun, the word “extreme” has linguistic connotations that emphasize deviation from a reference [4,8,25,28], with the meanings:

- **The opposite.** An extreme can refer to something situated at or marking one end of a range [25], opposite or very different from another [4], or one of two opposite conditions [8]. For example, one may talk about the extremes of hot and cold.
- **The excessive.** An extreme is something very excessive [25], in the largest possible amount [4], and far beyond what is reasonable [8], leaning toward a critique or judgment, such as the extremes of wealth and poverty.
- **The exaggerated.** An extreme is a specific measure or expedient [25] taken to the greatest possible degree [8] to make an intentional action or statement more forceful. A relevant example for this usage is the expression of going to extremes.

¹<https://www.lisn.upsaclay.fr/recherche/departements-et-equipements/interaction-avec-lhumain/ex-situ>

In a contemporary cultural context, the word “extreme” often retains its core idea of excessive intensity or the less ordinary situation of pushing boundaries, but applied more flexibly to depict the positive and fulfilling expressive [41]. Thus, extreme can mean:

- **Highly impressive.** The word “extreme” can be used to emphasize the degree in which something is perceived as highly impressive by a given audience. A relevant example is witnessing an extreme skateboard trick.
- **Boundary-pushing.** An event or action that pushes boundaries can be described as extreme, such as observed human behavior at an extreme party or avant-garde performances that challenge societal values through extreme art.
- **Outrageous.** An object, attitude, or event can be described as extreme if it defies expectations and is, therefore, perceived as outrageous with respect to well-established norms. For example, an extreme outfit may provoke such reactions.
- **Overly appealing.** There is an overuse of the word “extreme” for marketing purposes to make products appear more appealing, especially to a younger audience. Relevant examples of this usage are extreme yogurt or extreme gel polish.

These connotations emphasize the *descriptive*, *referential*, and *cultural* roles of the word “extreme,” from predominantly negative in the former to positive in the latter where it becomes a playful expression; see Figure 2. We believe that this linguistic versatility can be effectively used in HCI to characterize multinuanced interactions, such as extreme online user behavior [30] can be *excessive*, whereas extreme input [15] is *boundary-pushing*, along with positioning interactions relatively to standard norms, such as the extremes on the reality-virtuality continuum [26]. Next, we focus on understanding how the term “extreme” has been used in HCI to characterize interactions between users and computers.

3 A Targeted Literature Review of the “Extreme” in HCI Research

To grasp the extent of HCI research centered on interactions involving elements qualified as extreme, we conducted a targeted literature review drawing on the procedure of systematic reviews [38], but without performing a comprehensive or extensive search. This approach, resembling more a rapid review [10], is justified for our specific scope where many connotations of the keyword exist, making a complete analysis impractical. Thus, we targeted our scope to the ACM Digital Library—the most comprehensive electronic database of bibliographic literature in computing and information technology,² and home to scientific articles published at SIGCHI³ venues. The following query syntax, “query”: {Title: (extreme)} “filter”: {ACM Content: DL}, returned a total of 731 records in January 2025, which we processed based on the following eligibility criteria:

- **Availability of full text and peer-reviewed references only.** The full text must be available, in English, and peer reviewed, i.e., papers published in conference tracks and journal articles, but not proceedings entries, keynotes, panels, tutorials, etc. Following this criterion, 36 records (4.9%) were excluded.

- **Specificity to HCI.** We excluded papers where the word “extreme” was used outside an HCI scope, e.g., extreme programming [12] or extreme learning machines [21]. Following this criterion, 656 records (89.7%) were excluded.
- **No buzzwords.** We excluded references where “extreme” was used as a buzzword. For example, Marcus [23] discussed selected posts under the title “Extremes of User Experience and Design Thinking: Beards and Mustaches,” but the text of the work did not use the word “extreme.” Following this criterion, 9 records (1.2%) were excluded.
- **Distinguishability.** When the same research were published by the same authors in different forms, we considered only the most comprehensive one, e.g., we kept the 6-page research article [19] and removed its shorter version [20]. Following this criterion, two records (0.3%) were excluded.

Our final dataset consists of twenty-eight papers published since 2000 across diverse venues, with no single venue dominating. For easy identification, the papers are marked with the ♣ symbol in the References section. In the next stage, we extracted information about what was characterized as extreme in these papers. To this end, we employed Calvary et al.’s [3] framework, comprising three classes of entities specifying the context of use for interactive systems—*users*, *platforms*, and *environments*—to structure our information extraction. Our analysis revealed *extreme users* (e.g., users gaining far-from-ordinary abilities or engaging in exaggerated behavior facilitated by specific platforms or environmental conditions), *extreme platforms* (e.g., technology designs that push boundaries, such as highly immersive multisensory simulations), and *extreme environments* (e.g., environments characterized by severe physical conditions or risky situations with serious impact on life and health); see Figure 3. Next, we discuss examples from our dataset to illustrate connotations of “extreme” in HCI research.

3.1 Extreme Users

We identified cases where *extreme users* gain new abilities far beyond the ordinary [1,13,17,19,32,36], exhibit atypical behaviors [16,30,34,48,49], and engage in intense collaboration [14,24,46].

3.1.1 Extreme abilities. To assist people with tetraplegia in engaging in extreme sports, Alsaleem et al. [1] designed the Tetra-Ski, a power-assisted ski chair that can be controlled with a joystick or a Sip-and-Puff controller, either independently or collaboratively with a tethered skier. Ratto et al. [32] involved blind users in a participatory design session to prototype a specialized tennis ball for use in “blind tennis.” In these examples, existing sensory and motor abilities are augmented through assistive and inclusive design, which enable users to engage in activities little possible without technology mediation. In other examples, extreme abilities are gained in environments that are fully simulated rather than physical. For example, Virtual Super-Leaping [36] is an immersive virtual experience simulating extreme jumping in the sky through a head-mounted display and a haptic device that provides kinesthetic feedback and airflow through synchronized propeller units. This technology enables experiencing an ability not available naturally, characterized as a super power in [36]. Similarly, Embodied Weather [17] is a multisensory VR installation designed to promote public understanding of extreme weather events, such as typhoons.

²The ACM Full-Text Collection contained 772,070 records as of January 2025, when we conducted our literature search.

³<https://sigchi.org>

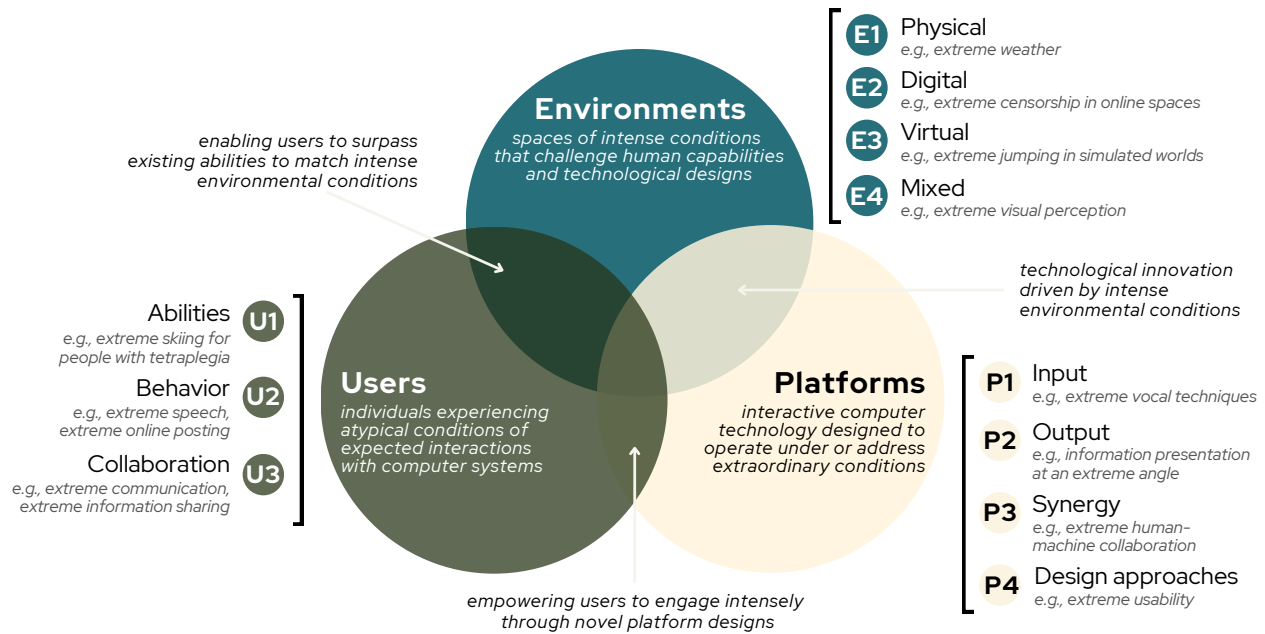


Figure 3: Elements of interaction—users, platforms, and environments—for which extreme attributes or behavior have been examined in HCI research; see Figure 2 for various connotations of the word “extreme” in everyday language.

In summary, connotations of the term “extreme” identified in relation to user abilities are: the accessibility solutions adopt a *very far from moderate* perspective that enables people with tetraplegia to access outdoor sports and may be perceived as *overly appealing* to those who face challenges in accessing such activities; extreme jumping denotes a physical experience of *very high intensity*; the dangers posed by typhoons are *very serious* and *very risky*.

3.1.2 Extreme behavior. Digital platforms, such as social media networks, create dedicated environments for self-expression where user behavior can reach extremes. This includes extreme speech [30] or emotional content that evokes extreme sentiments [29,40], leading to online victims and instigators of hate, potential cases of depression and even suicidal tendencies [40]. Also, extreme online behavior is transparent in some users’ posting activity, characterized by sharp bursts and drop-offs in response to critical events [34] or unusually high posting activity [49]. In mobile game ecosystems with micro-transactions, Zendle et al. [48] examined the extremity of player spending and uncovered a subset of games where the top 1% of gamers were highly financially involved; in this case, the term “extreme” characterizes the excessive and exaggerated financial behavior of some players. Extreme behavior was equally documented in physical environments. For instance, Karlgren et al. [16] explored the sleep practices of extreme sleepers to design technology emphasizing user agency over their life rhythms. In summary, connotations of the term “extreme” identified in relation to user behavior are: extreme speech may be perceived as *exaggerated*; extreme sentiments, especially negative ones, can lead to *very serious* emotional responses; sudden bursts and drop-offs of positizing activity represent *excessive* reactions, reflecting the excessive

nature of crises; and sleep practices that deviate from the societal norm of a “good” eight-hour sleep are *very far from moderate*.

3.1.3 Extreme collaboration. Wilchek et al. [46] introduced Ajna, a wearable augmented reality system for supporting extreme sense-making in emergency scenarios to support critical collaboration for law enforcement, search and rescue, and infrastructure management. Jagannath et al. [14] and Mark et al. [24] were also interested in supporting complex teamwork, e.g., the “war room” [24] is a high-pressure setting where noise and distraction abound, but which leads to high collaboration performance for speeding delivery of space mission proposals. In summary, connotations of extreme are: the extreme emergency conditions are *very serious* and *very risky*; the “war room” is *boundary pushing* in terms of its effectiveness.

3.2 Extreme Platforms

Our analysis revealed that the elements which make platforms be considered extreme reside in the *extreme input* [7,13,15] and *extreme output* [18,35] they offer, as well as in the *extreme synergy* [13,19] emerging between users and platforms.

3.2.1 Extreme input. Holzinger et al. [13] introduced a neural network-based solution to provide real-time feedback on extreme vocal techniques, such as False-Cord and Fry screams, within an interactive training system; in this example, the physical demands of extreme performance require control of vocal cords and breath to a very high degree. Jansen et al. [15] proposed extreme input, which involves using unfamiliar, ambiguous, critical, or provocative stimuli in brainstorming sessions based on extreme ideas, extreme characters, and extreme personas, respectively. These artifacts fructify unfamiliarity and ambiguity to enable reflection upon a broader space of possibilities by bringing users out of their comfort zone.

Djadaningrat et al. [7] also employed extreme characters, represented by fictional users with exaggerated emotional attitudes, to examine sociocultural issues that may occur in the design process. In summary, connotations of extreme input are: vocal techniques are extreme due to the *very high degree* of control to produce them; the extreme nature of unconventional stimuli may require brainstorming participants to grapple with *very serious* concepts.

3.2.2 Extreme output. Extreme spatial configurations were addressed in Sandnes [35], which explored visualizing information under perceptual distortion, presented from an extreme angle, and in Kirshenbaum et al. [18], involving collaborative work on large displays where users positioned at the extreme sides experienced low visibility of content. In these cases, the physical setting induces constraints. Some of the examples discussed in a previous subsection regarding new user abilities mediated by virtual reality simulations [17,36] are also relevant for extreme output. In summary, connotations of extreme output are represented by: extreme placements are *in the farthest possible position*; extreme jumping is *overly impressive*, capable of captivating thrill-seekers with its realism, intensity, and appeal of gaining a super power.

3.2.3 Extreme synergy between users and computers. Hauptmann et al. [11] presented extreme video retrieval as a mixed-search interface combining users' capabilities for rapidly scanning imagery with a computer-based learning loop to present users with the most relevant information; in this example, synergy results across actors with very opposite but complementary skills. The TransVision project [19] comprises three perceptual machines that enable hyper-sensitive, hyper-focused, and hyper-comoditized vision, emphasizing visual perception influenced by digital media. In summary, connotations identified for the term "extreme" are: synergy shows how the *opposite* strengths of two actors create a powerful collaborative system; perceptual machines create a deliberate information *excess* in user perception.

3.2.4 Extreme design approaches. In some cases, the platform is the design process itself [2,6]. For example, Burns and Formosa [2] explored the concept of extreme usability for designing a satellite radio system, emphasizing four fundamental stages—approach, vision, solution, and realization—and four key focal points—diverse-minded team, innovate on access, primary elements, and details. Da Silva et al. [6] proposed extreme designing, an approach analogous to extreme programming, which combines sketching and prototyping with interaction modeling; in this case, the term "extreme" analogs its use in extreme programming, bringing an agile approach to interface design. *Connotations of extreme:* extreme usability is an effort to make a system *overly appealing* to the intended end-user audience; extreme designing is *boundary-pushing* by going beyond conventional approaches to user interface design.

3.3 Extreme Environments

Prior HCI research has also examined interactions in extreme environments. For example, for users engaging in environments with severe physical characteristics, such as firefighters, exposure to life-threatening risks has been addressed through specific technology design, including protective clothing with integrated sensors for monitoring physiological data [33] and stress levels [37],

aimed at increasing operational safety. Communication in hostile environments, where noise or silence-mandated challenges exist, was addressed through communication gloves featuring gesture recognition and haptic feedback [5]. In digital environments, Lu et al. [22] were interested in user access to legal Internet services, such as Google Scholar, under extreme censorship. Furthermore, excessive use of technological platforms, such as smartphones, ends up in mediating all interactions with the world to an extreme degree [9], impacting psychological well-being, physical activity, and engagement with physical surroundings. *Connotations of extreme:* firefighting is a *high-risk* profession, where thermal protective clothing helps mitigate high physical risks; physical environments with hostile constraints pose *very serious* consequences for their users; a significant increase in positive mood, physical activity, and conscious awareness of the surroundings was observed on days without smartphone use, juxtaposing the *opposite* states of behavior and experience represented by *excessive* vs. no smartphone use.

4 Discussion

Our exploration has uncovered diverse connotations of the term "extreme," which we then identified in the HCI scientific literature and categorized according to the three core elements of all interactions: *users*, *platforms*, and *environments*. We exemplified ways in how users can be extreme, e.g., in terms of their behavior, platforms can be extreme in terms of amplifying synergy with users, and physical environments can be extreme in their adverse weather conditions or hostile settings. In the following, we capitalize on our findings to propose a roadmap for future HCI research in examining extreme interactions. We also present limitations of our study and discuss future work opportunities.

4.1 Roadmap for HCI Research on the Extreme

By definition, the concept of "extreme" goes beyond what is typical, moderate, or reasonable and, consequently, necessitates specific approaches for its scientific examination. In HCI research, this involves understanding user behavior that is atypical compared to that of the average user, exploring designs of interactive systems that are unconventional compared to norms and standards, and prototyping interactions in environments that are excessive in their physical or psychological conditions, among others.

The study of the "extreme" is not straightforward and demands methods, designs, and tools that can effectively support researchers in pushing the boundaries of what is possible with clear benefits. For example, by prospecting extreme user abilities and transcending human limitations through technology, novel digital experiences become possible [19]. Engaging with extreme input and output modalities, beyond standardized interactions, unlocks new opportunities in interactive technology that can better suit users, make users more effective, and deliver new kinds of user experiences that appeal due to their unconventional nature [36]. By studying extreme environmental conditions, beyond controlled lab environments and typical in-the-wild settings, new frontiers can be conquered, such as HCI intersecting space exploration [42].

Our preliminary findings on what constitutes users, platforms, or environments to be extreme, derived from the practical applications previously examined in HCI research, form an initial taxonomy.

Complementing this taxonomy with elements from user-centered design frameworks, such as ability-based design [47], reinterpreted to encompass extreme abilities, as well as frameworks on unconventional design, such as non-natural interaction [44] and digital limitations [31], could provide a good starting point for a scientific understanding of the spectrum of extreme computer interactions.

Engaging with both the negative and positive connotations of the term “extreme” will also enhance the implications of HCI research addressing such topics. For example, extreme environments that are hostile, dangerous, and highly risky drive the design of interactive technologies that enable users to remain effective under extreme conditions [5, 37]. The extreme functionality offered by new gadgets and virtual simulators can be both impressive and appealing, enabling out-of-the-ordinary experiences rendered possible by technology [17, 36]. Furthermore, understanding how perceptions of what qualifies as extreme may evolve alongside advances in interactive technology is essential for ongoing research involving extreme users, extreme platforms, and extreme environments. In this context, periodic reviews of the “extreme” in HCI research are essential to continually redefine the boundaries of what is possible in interactive computer systems. This may involve directly adapting the linguistic connotations we have identified to structure contributions in HCI or, alternatively, identifying new dimensions grounded in these connotations that use them indirectly to form new vocabulary, more relevant to the science and practice of HCI.

4.2 Limitations and Future Work Opportunities

Our dataset consisted of only papers available through the ACM DL that explicitly included the term “extreme.” However, expanding the query to other databases, such as IEEE Xplore and Scopus, and incorporating synonyms of “extreme” would likely surface more HCI research relevant to this scope. Integrating the connotations of the term in queries will further expand the coverage of relevant scientific literature. Also, including contributions from performance art, such as by Stelarc [39] on extending the capabilities of the human body, or experimental installations, such as PainStation [27], a variation of the Pong game integrating pain feedback, could further benefit the understanding of extreme interactions involving computers. Second, our research primarily focused on the linguistic connotations of “extreme,” which could be complemented with technological aspects from the lens offered by the context of use [3], as well as by other frameworks to bring in different perspectives. Furthermore, the use of superlative speech in scientific writing, including the term “extreme,” may represent an interesting investigation in its own, complementary to our scope. For instance, as part of the eligibility criteria, we explicitly excluded from our analysis prior work that used the term “extreme” as a buzzword, but focusing on such usage might reveal aspects of scientific writing to further deepen our understanding of HCI contributions.

5 Conclusion

We reported findings from a targeted literature review centered on interaction elements qualified as extreme in HCI research. Our analysis uncovered various connotations of the word “extreme” applied to characterize users, platforms, and environments, which enabled us to develop a preliminary taxonomy of the extreme in HCI. We

believe that interesting future work lies ahead in formalizing scientific explorations that extend beyond typical users, conventional platforms, and familiar environments. Such explorations can yield surprising insights into human factors, unlock novel technological opportunities for designing and engineering interactive systems, and support humanity in conquering new environments. We look forward to an extensive exploration of the extreme in HCI.

Acknowledgments

This work was supported by a grant of the Ministry of Research, Innovation and Digitization, CCCDI-UEFISCDI, PN-IV-P8-8.3-PM-RO-BE-2024-0003, within PNCDI IV, and Wallonie-Bruxelles International (WBI), grant no. 650763 (WBI ref. PAD/CC/VP/TM - Roumanie - SUB/2024/650763)—XXR, Novel Extended Reality Models and Software Framework for Interactive Environments with Extreme Conditions.

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