# A Manifesto for Cognitive Ergonomics: Re-evaluating technology usability for the 21st century

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## ABSTRACT

Computer infiltration into the workplace and society has been extensive, yet the ideals of efficacy, efficiency and satisfaction have not been wholly met. We propose an ambitious framework to take forward Cognitive Ergonomics. We define Cognitive Ergonomics as an interdisciplinary field of research and practice dedicated towards:

- Improving human wellbeing, mankind and our environment
- By understanding and supporting human cognition
- When at work or performing goal-directed tasks
- With computers and other engineered artefacts.

This revitalizing framework will be based on:

- Interdisciplinary Research
- Research-based Policy
- Education

The proposed interdisciplinary framework will refocus on the classical facets of usability and include work-relevant emotions as well as understanding the minimal requirements for successful interactions (including understanding agency). The research-based policy will focus on efficacy in terms of human cognitive ergonomics in a holistic perspective (i.e. producing the effects we want without adverse effects). This will include complex questions about interface design in the context of the organisational and business models that influence its development (e.g. monetization). The educational concerns will focus on efficiency and include minimal programmes for all computer scientists and all end-users, as well as the consequences of digital mediation in learning generally. This framework will differentiate cognitive ergonomics from its cognate fields of Human-Computer Interaction and Psychology, and address a gap between the social sciences and engineering that has become more urgent in the past 5-10 years. It is ideally suited to be carried forward by the European Association of Cognitive Ergonomics, as this framework is specifically a collaborative effort grounded in European intellectual and scientific tradition; a perspective that offers a much-needed contrast and complement to Anglosphere research and development agendas in interactive technologies.

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## CCS CONCEPTS

• **HCI design and evaluation methods**;

## KEYWORDS

cognitive ergonomics, sociotechnical systems, work-related emotions

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## 1 WHERE WE ARE NOW

### 1.1 People Serving Machines

The use of computers and data processing in the workplace is an unmitigated technological success – if you judge success by ubiquity. Thomas Watson, then President of IBM, predicted in 1943, "I think there is a world market for maybe five computers." Now they are everywhere, but that does not seem to have solved all of humanity's problems.

In fact, that seems to be part of what is contributing to our current problems [11]. What seems to have gone wrong is the way we are using computers. They were imagined to be a tool that would reduce workloads and make us happier, but in most cases the opposite has happened [16]. Where computers are typically limited and rely on narrow parameters, humans are extraordinarily versatile, such that work processes have outsourced many of finicky bits of the data processing burden (e.g. data gathering, data input and so-called 'Wizard of Oz' sleights of hand) to human users – whose time is often exploited as a free or low-cost resource.

There are many reasonable questions that could be raised by users of digital systems, including "Why am I constantly filling in forms and checking tick boxes that I don't understand and don't agree with?"; "Why is it one second to click yes and five minutes to "adjust privacy settings"?" and perhaps even "When I waste an hour filling in an online form to get a refund from a company that has plainly let me down, can I charge the company for my time to fill in their form?".

We see a disproportionate burden of processing outsourced to human users, often described under the rubric "prosumption". We need to ask ourselves, "What is interaction, and what do we need to know for it to be functional?" To design successful interfaces and interactions, we really only need to know what the rules and expectations of the interaction should be, yet much research and

practice seems obsessed on knowing or finding out who the end-user is.

### 1.2 Privacy and Personal Autonomy

The GDRP recognises the assault on privacy and dignity by unregulated data harvesting and brokering. It seems as though we cannot fix the privacy problems at source because current internet design and practice allows for anonymity and disguise [8]. Is there such a stark choice that you can have either privacy or the internet, but not both? Might there be ways to improve best practice or regulate systems that would greatly reduce these problems without completely eviscerating the benefits of the computer and the internet as a tool?

### 1.3 The Role of Cognitive Ergonomics

Can cognitive ergonomics address these thorny issues? We define Cognitive Ergonomics as research and practice dedicated towards:

- Improving human wellbeing, mankind and our environment,
- Through understanding and supporting human cognition,
- When at work or performing goal-directed tasks
- With computers or other engineered artefacts.

Success in computing and technology will be when we stop thinking that the only solution to our pressing problems is for mankind to go to Mars.

### 1.4 Whose cognitive ergonomics matter?

Who should be the beneficiary of cognitive ergonomics research? Mark Zuckerberg? Jeff Bezos? The computer? In cognitive ergonomics the human user is paramount. In our opinion, the cognition of the human user in interaction with technology of primarily functional design should be re-evaluated for the 21st century. It should incorporate developments since the laudable inception of the field, and readjust the course for the present era.

We are not short of challenges; if anything, a clearly defined, inspiring, useful and achievable focus in a sea of research problems is the first and foremost challenge. We argue that the existing work of the European Association of Cognitive Ergonomics, its community of committed researchers, and its body of literature to date provide an ideal basis for this reassessment of the problem space in the present times. Questions our colleagues have addressed include the safety and efficiency of processes, the design of interfaces to support human users, and sufficient and appropriate engagement with adjacent fields of research.

## 2 INTERDISCIPLINARY RESEARCH

### 2.1 Research over Theory

We propose a grounded perspective on usability in the 21st century, based on integrated research within meaningful theoretical frameworks. A increased focus on producing primary research will enable EACE to support the development of government policy in and across Europe. Theory naturally will also play a part in understanding interaction, but research and data gathering will breathe new life into these reconfigured efforts. Currently the knowledge gap in how human cognition fares in the present technological moment is mostly focused on the failures of either the computational system or the human agent. We wish to promote a focus on the nature and articulation of interaction itself, to augment applicable knowledge of how human cognition, understood rigorously and broadly, can be supported by technology. We do not need computation to teach us how to be human in the present moment – we need to create technology that does not fetishise the subservience of human users, and (as outlined in the previous section) which is created with respect for human cognition and creativity. Below, we outline some more appropriate aims and definitions for the fields of usability and UX, now grown up.

### 2.2 UX at Work

User experience has cast its net so wide that the issues for the human user at the workplace may be overlooked. For example, much user experience is focused on beauty [10]. While visually attractive design is admirable and pleasant, we do not necessarily need our systems to be "beautiful". Beauty changes rapidly in response to taste and innovation. The problems people have at work are not a matter of taste, nor are they vague. The problem at work is that there is a lot of verification, encumbered by time-wasting and repetitive tasks. Much of the verification is not part of the value creation, it is simple oversight. We should be researching how sociotechnical systems can contribute to oversight – but the computer's role should be as a responsible tool, not as an authority.

### 2.3 Work-related Emotions

Satisfaction is a key issue at work, and it is plainly dependent on emotions. We need to open the box and look at how emotions contribute to work [14] (and learning [20]) and work satisfaction, and how that has allowed for some of the more obvious ethical decay that has occurred [7]. When people feel constant anxiety in the workplace or about the future, we know it has an effect on performance [12]. While we are all familiar with exquisite boredom and how it can lead to disengagement [32], there are other more complicated relationships with emotion that need to be unpacked.

For example, the mild anxiety associated with uncertainty (popularly known as confusion) is an essential waypoint in the acquisition of conceptual breakthroughs, yet only some individuals find its presence acceptable [30] – others find it unbearable [18]. In a similar way, many assume that frustration is fundamentally demotivating, yet it is recognised as a key emotional component of games and gamification [15]. Disappointment is also a fruitful area for research [27], as it leads to powerful disincentives and negative emotions. The status-seeking need for competition is almost certainly a contributor to runaway problems with unethical work environments, and this is patently a fruitful area for research. Fatigue is not simply a physical state, but it is a motivational state that is driven centrally [3]. We should be investing in neuroergonomics [17] and physiological ergonomics [1], where we determine fatigue on site using sensors, physiology and geolocation in real workplaces.

## 3 RESEARCH-BASED POLICY

### 3.1 Regulation of Platform Providers

Who should be held accountable when platforms benefit themselves at the expenses of their users, or their environment? We like to

blame the humans for losing situational awareness, but in a sociotechnical system the entire system needs to be held accountable [23]. Like a public utility, platforms "live" (and underpin debate and participation) in the public sphere, and they benefit from sharing our environment and infrastructures [5]. Nobody thinks energy providers should be allowed to organise the world in a way to indulge their most self-serving whims. We need to research how regulation might work for sociotechnical systems, and produce research that informs policies that steer development towards not just future-proofing technology, but future-proofing our future relationship with technology.

As a part of this continued debate, we need research into technological policies to support and protect discourse and dissent as free speech in sociotechnical systems. However, wide-spread but personalised lies are not the same as free speech. Nor can such untruths be categorised simply as "false advertising" or libel: the regulations or laws required to address networks of lies are plainly different. The computer should "grow up"; with increasingly ubiquitous computation, users are the "constituents of technology" and need to hold it accountable, as part of the sociotechnical system [2]. There are norms that people are subject to [22], which prevent crime and chaos; sociotechical systems also need to be regulated in such a way that no one can accept a large scale plan to "move fast and break things" [26]. Given that sociotechnical systems are neither saintly nor neutral, should there be limits on what data is being gathered and kept? We need a mature relationship to technology where the computer lives up to its responsibilities.

### 3.2 Diversity and Inclusivity

Issues of representation are no longer discrete; they intersect with how we work, how money is made, and how progress is thought of, realised and measured. The European research community across the social sciences and engineering stand on an intellectual legacy that afford us the latitude to meaningfully address models and metaphors of agency, its translation and implementation in computational systems, and the consequences at scale.

Human users are critical components of computational systems, but typically modelled as data objects, as if they were moving mechanical parts conceived to aid the completion of the interaction with a weighting towards the computer's terms. Social injustice is compounded by its reliance on demographic stereotypes, which we see at scale and in action on social media platforms, and which are often unknowingly reconstructed like Frankenstein's monster by machine learning [29]. The platforms may have given more people a voice, but – like an echo-chamber – they remain guided by existing hegemonies of visibility and influence. You can shout, but the important question is who will listen. If platform-driven identitarianism continues unabated, public discourse will be increasingly siloed, and the centre ground undermined.

### 3.3 Redressing Power Inequalities

We are seeing a rise in populism and polarised demographics both politically and in popular culture, which correlate with the focus on demographic fine-slicing and targeted messaging that is at the core of the business models of digital platforms for mass participation. Any challenge to this polarising targeted marketing is unlikely to come from within commercial software engineering or through self-regulation, as there is a direct conflict of interest. More empirically grounded models for digital representation need to address our capacity for dynamic change, and model us as such. The development of alternative models will require interdisciplinary empirical research to inform policy makers, who typically have little expert knowledge and rely on the research community for data and other types of evidence to guide policy.

Redressing the existing imbalances of representation and access will not originate in Silicon Valley. Dominant business objectives are likely to continue to disincentivize solutions that move away from data predation and identitarianism; the European union is presently the most likely milieu for the development of policies that steer infrastructure development towards better protections for privacy, public discourse and democracy. Interdisciplinary research on digital representation could bring together physicists, political scientists and critical infrastructure researchers with interaction designers, media philosophers and computer scientists to develop models for online mass communication based on observations of crowd behaviour at scale that utilise only such information about system users that is necessary for function and form. These models might incorporate, for example, short-term local access to data [13], fluid dynamics [31] and regulated schemes for protected identities online [28].

## 4 EDUCATION

There are three groups of stakeholders where Cognitive Ergonomicists can contribute to education: computer scientists, students in general, and educators.

### 4.1 Students

The current computer driver license is heavily focused on the Microsoft Office suite (and the free alternatives), but these are not the only key issues facing learners. All learners need to know about how to use the digital technologies and online resources for learning [21, 25]. As scales of efficiencies are increasingly demanded of educators, time spent with individual pupils has become less commonplace for average students. However, educational technologies for learning have sprouted up in many fields, especially in maths, physics and engineering [4].

### 4.2 Computer Science, Engineering and Design

The simplest basics of usability should not be a specialism for researchers. Every interactive system and web designer should be asking themselves, "How long will it take to fill in my form?", and "Do we really need all this information to provide basic service?", and "Given that I am asking for this data, what would it cost if I actually paid for this information and data entry?" Every computer scientist should do it, and it should be easy enough for every designer to do. This kind of thinking should be a part of every computer form out there. It is already a part of the publication process for for online questionnaires (CHERRIES)[6].

### 4.3 Research into Digital Education

For young people, going to full time education is like work. Learning is its own occupation, and it has aspects that are similar to cognitive

ergonomics. The opportunities for digital education have been considered for some time within the education/sociology literature [9, 19]. However, the quantification and the consequences of Digital Education have been left largely unexplored. For example, only recently computer-interactive behaviours have come to light that learners can perform in order to improve their memory for facts [24]; research may reveal that there are more of these.

## 5 A UNIQUE GAP FOR RESEARCH

We propose that cognitive ergonomics, particularly in a European context, is ideally placed to address the gap between:

- HCI and engineering
- psychology and the human sciences.

The field incorporates "interaction" in its broader consideration of communication, meaning and human behaviour in relation to technology. Compared to engineering and computer science, we are more interested in the consequences of technological profusion than in the process for its own sake. Compared to psychology, we have a specific role for understanding the consequences of making computers ubiquitous – both to the person, and to society. Finally, to the study of business and enterprise, we can add a scientific basis, as well a liaison point between workers, their tools, and organisational psychology.

The key to all of this is that the human user remains the centre of our focus – with technology always there to help. Seeing these opportunities in the current technological landscape suggests that we have much stimulating work to do, and a community to do it with. Questions for the proposed research may include what policies do we need to deal with bad-faith actors? What type and nature of information is needed - and not needed - for optimal interaction? What are viable models for supportive technology in occupational fields where errors present exceptional risks, including aviation and the broader field of logistics? And we should also take an active interest in online banking, democratic processes, refugee and climate research to address present crises. Researchers in these fields now incorporate digital technologies, crowd platforms, and multi-national collaboration using online platforms, and have to find innovative approaches to organisational structure and research. The field of cognitive ergonomics was designed to field questions around human consciousness in relation to occupational technologies of the future, and that future is now here.

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