Towards 3S Computing and Healthier Human-Computer Interactions

Felix Schoeller
Brain Games Lab, Santa Monica, CA, USA
Media Lab, Massachusetts Institute of Technology, Cambridge, MA, USA
felixsch@mit.edu

February 21, 2025

Abstract

The widespread use of computers has had negative impacts on physical, psychological, and social well-being, including sedentary behavior, addiction, anxiety, attention deficit disorders, body dysmorphia, and even suicide. In order to address these issues, we propose the development of a new type of human-computer interface that is characterized by three fundamental traits: they should be silent, screen-free, and social. The interface should operate at the periphery of the perception-action cycle and not constrain the user's freedom. Examples of technologies that embody these traits include non-visual user interfaces, haptic interfaces, and brain-computer interfaces. Grounded in the broader framework of extended cognition, this approach encourages the offloading of cognitive tasks onto the environment in a manner that supports natural human functioning and minimizes cognitive overload.

1 Introduction

The widespread dissemination of computers in their current embodiment has led to fundamental changes in human behavior and social interactions, which now seem to constitute serious threats to physical, psychological, and social well-being. Evidence suggests that prolonged computer use causes severe physical health issues related to sedentary behavior, such as obesity and postural issues [Vendelanotte and Others, 2009, Osama et al., 2018]. Beyond mere physical symptoms, the mental health burden of prolonged computer use includes addiction, anxiety, and depression [Boumosleh and Jaalouk, 2018], attention deficit disorders [Small et al., 2020], personality disorders [Perugini and Solano, 2021], emotional dysregulation [Kirsh and Mounts, 2007], eating disorders, body dysmorphia [Griffith et al., 2018], and even suicide [Rostad et al., 2021]. In the social realm, internet and computer use is associated with social problems such as polarization [Van Bavel et al., 2021] and radicalization [Hollewell and Longpré, 2022], sometimes responsible for major social unrest [Tufekci and Freelon, 2013]. It is not unfair to say that the current human-computer interface is pathogenic — it causes physical and mental illnesses.

When we examine the design of both hardware and software technology, we find that these issues seem to stem directly from state-of-the-art computer interfaces. These interfaces are inherently asocial and restrictive for the user, depriving them of the freedom to use their eyes and hands as needed, and remaining invasive even when they do not perform any function (think of putting your smartphone on a table during dinner). This burden of computing technologies can be significantly lowered with the introduction of novel forms of human-computer interactions enabled by a radically new type of interface. Here, we sketch what this interface could be and the type of healthy human-computer interaction it would allow, which would increase the user's autonomy and lower the interaction's physical, psychological, and social burden. We suggest that human-computer interaction should minimally constrain the user's freedom, and hence should operate at the periphery of the perception-action cycle — that is, interfacing with computers should not cut the user off from their brain, body, or environment.

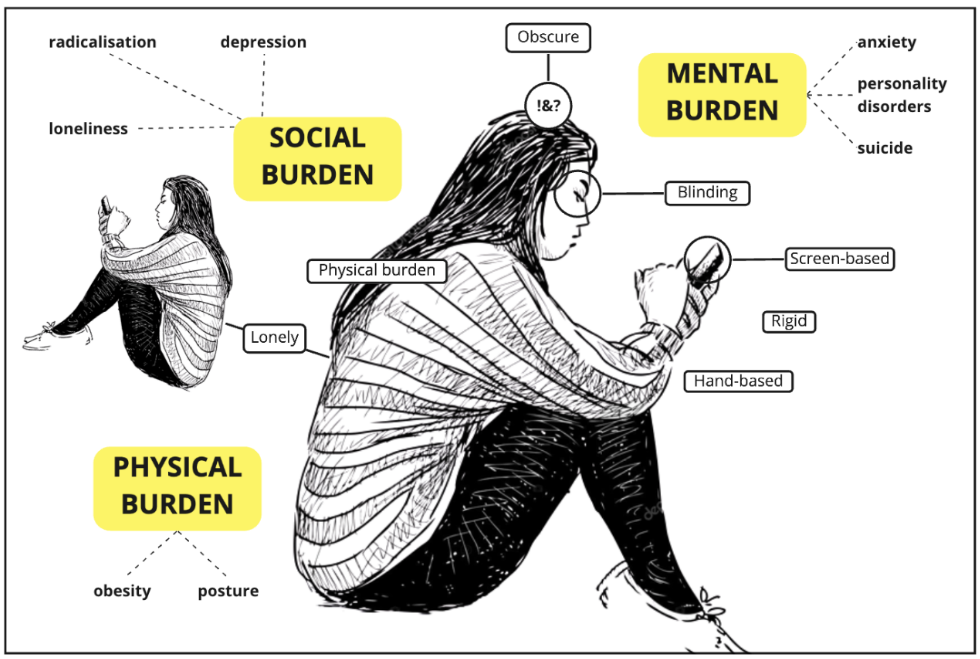

Figure 1: The mental, social, and physical burden associated with current computer interface design.

Since the 1990s, it was thought that natural interaction with the real world should ultimately provide an alternative to the previous command-line interface (CLI) and graphical user interface (GUI). Early visions, exemplified by Wellner's desk, were eventually supplanted by the very successful touchscreen, and there has not been any fundamental shift in human-computer interaction since the mother of all demos at Xerox Park in the 1970s introduced the keyboard-mouse-screen model. These types of interactions are often referred to as "Natural User Interfaces", "Direct User Interfaces", and "Metaphor-Free Computing" [Mann]. This mirrors the notion of Calm Technologies advocated by Mark Weiser as "the most important design problem of the twenty-first century" [Weiser and Brown, 1995]. In recent years, some solutions have emerged around naturalistic interaction, including no-UI design, organic interfaces (such as Kinect), invisible interfaces, or ubiquitous computing. More than 25 years later, we have made virtually no progress in realizing natural user interfaces at the consumer level, and large software companies are increasingly held responsible for the mental and social unrest that has been observed. Extending work from past decades on natural user interfaces and metaphor-free computing, we identify three fundamental characteristics lacking in current computer technologies. For each characteristic, we provide human factor design principles and concrete examples of technologies that embody these traits.

2 Screen-Free Interaction

One of the major problems with current computer interfaces is that they often require visual input, which can pose serious risks for users and dissociate them from their context. For example, screen-induced distraction in vehicles is responsible for an estimated 25% of car accidents in the United States, leading to more than 1.5 million deaths annually. In addition to the risks posed by screen use while driving, visual impairment or blindness can make it difficult or impossible for some individuals to use many common interfaces, limiting their ability to participate fully in society and access essential resources like education and employment. A promising solution to these problems is the use of non-visual user interfaces, which allow users to interact with computers without relying on sight. Such interfaces may include voice-based systems, tactile interfaces that use touch or physical movement, and systems that incorporate auditory or other sensory inputs. By providing alternative methods of input and output, non-visual interfaces can make computers more accessible and user-friendly for all individuals, regardless of their abilities. This approach, sometimes referred to as Non-visual User Interaction (No UI) design, uses non-visual interactions that mimic real-world actions and behaviors, making experiences more familiar and comfortable. For instance, a music player controlled by gestures or a smart home device responding to voice commands can feel far more intuitive than traditional visual interfaces. The potential of human perception extends far beyond mere exteroception, and computer interfaces can be designed to leverage this wider range of inputs and outputs. An effective test of a non-visual interface is to try using it without looking at it, thereby evaluating how well the interface communicates information and enables task performance without relying on visual input.

3 Silent Computing

While the number of computers is increasing and their sizes are diminishing, these devices have become ubiquitous in our everyday lives. In some regions, people spend up to three hours daily online [Insights, Time]. The disturbance induced by constant computer use not only distracts us from our immediate context, but also leads to social isolation, cognitive overload [Tanil and Yong, 2020], and generalized stress and anxiety [Cheever et al., 2014]. These problems of social disconnection and cognitive overload would be mitigated if computer interfaces were designed to be silent — meaning that they do not require constant user attention. Silent computing takes this a step further than screen-free interfaces by enabling systems to operate below the threshold of conscious awareness. For example, consider a thermostat: one does not need to continually check it to enjoy a comfortable temperature because it operates quietly in the background, adjusting automatically based on user preferences and ambient conditions. Similarly, modern tracking systems, such as pedometers or hands-free payment systems, work silently to provide useful information without requiring constant supervision. A current example is the MacID app, which allows users to unlock their computers with their smartphones without needing to enter a password, and glanceability features on smartphones allow quick checks of notifications without unlocking the device. Time tracking apps often silently process calendar data to generate timesheets, thereby reducing cognitive strain. Silent computing has the potential to enable new forms of interaction, even in altered states of consciousness such as sleep, dreaming, meditation, or hypnosis. Technologies like brain-computer interfaces could detect and interpret users' dream states, offering real-time feedback that might influence dream content or provide therapeutic benefits. By allowing computers to operate at the periphery of the user's attention, we may reduce cognitive overload and stress associated with traditional interfaces.

4 Social Interaction

Most current computers are designed for single-user use only, inherently preventing group activity. When observing another user interact with technology without the ability to join in — for instance, when someone does not know a keyboard shortcut that could save time — the observer experiences a sense of exclusion. This inherent isolation contradicts the well-established evidence from neuroscience and primatology that humans are fundamentally social beings. Our survival and well-being depend on social interactions and the formation of deep, lasting bonds. To counteract this, multi-user interfaces and hardware have been developed to facilitate group interaction and collaboration. Examples include multi-touch displays that support simultaneous interactions, gesture-based interfaces that allow group control, shared screens, and collaborative software applications. These technologies enable multiple users to work together, access shared resources, and communicate in real time, thereby reinforcing social bonds and enhancing group creativity.

5 Implementation at Brain Games Lab

At Brain Games Lab, we are committed to developing prototypes that embody the 3S Approach. Our focus is on creating interfaces that are silent, screen-free, and social, and that seamlessly integrate with our cognitive environment. We utilize sensor arrays to gather contextual data such as posture, environmental cues, and physiological signals. Machine learning algorithms then interpret this data to create adaptive feedback loops that anticipate user needs without explicit commands. In our implementations, wearable devices provide gentle, real-time guidance via vibrotactile signals or soft auditory notifications. Our experimental platform, code-named BeSound, explores how subtle audio cues can be woven into the environment to enhance immersion during activities such as reading or meditation. BeSound is designed to serve as an invisible scaffold, offering ambient auditory support that reduces stress and mitigates cognitive overload. Additionally, our research has revealed that carefully designed social interfaces can induce pleasurable chills or frisson — brief, tingling sensations associated with intense aesthetic or emotional experiences — which in turn enhance group cohesion and shared immersion.

The 3S Approach is deeply rooted in the concept of extended cognition, which posits that human cognitive processes extend beyond the brain to include external tools and environmental structures [Clark, 1998, 2008]. According to Arnold Gehlen, humans are inherently "deficient" and rely on cultural and technological scaffolds to augment their cognitive capabilities [Gehlen, 1988]. In the context of computing, offloading tasks such as memory recall, navigation, and scheduling to external devices can free the mind for higher-order thinking. However, poorly designed interfaces can exacerbate cognitive overload rather than alleviate it. By aligning interface design with the principles of extended cognition, we can create systems that serve as cognitive scaffolds, supporting rather than hindering our natural mental processes. Looking forward, the principles of the 3S Approach suggest a range of novel technologies that transcend traditional screens. At Brain Games Lab, we are exploring adaptive lighting systems that adjust to the emotional state of a group, wearable EEG headbands capable of detecting real-time user states, and advanced haptic arrays that provide rich, tactile narratives. These emerging technologies hold the promise of integrating seamlessly into our daily lives, supporting tasks through subtle environmental cues rather than overt visual displays. In such a future, the frictionless integration of body, mind, and environment would become the baseline expectation, and our interactions with technology would be more about enhancing natural human capabilities than dominating them.

6 Conclusion

The 3S Approach — silent, screen-free, and social — offers a novel framework for rethinking human-computer interaction. By situating our work within the context of extended cognition, we argue that well-crafted technologies can serve as essential cognitive partners, offloading routine tasks and freeing mental resources for more creative and socially enriching activities. Despite the promise of this approach, several challenges remain, such as ensuring privacy with pervasive sensing, refining the ergonomics of non-visual feedback, and developing predictive algorithms that minimize false positives. Interdisciplinary research drawing from cognitive science, philosophy, engineering, and design is crucial to overcoming these hurdles and ensuring that new technologies are both effective and ethically sound. The legacy keyboard-mouse-screen paradigm often undermines well-being by monopolizing attention and constraining human potential. Our 3S Approach provides a blueprint for more natural, unobtrusive, and collective forms of interface design. Early implementations at Brain Games Lab, including our BeSound platform, demonstrate both the feasibility and promise of this approach. As we move further into a post-screen future, embracing these design principles may help restore a more balanced and enriching relationship between people, technology, and the environments we inhabit.

Acknowledgments

The author thanks Rajeev Mylapilli and Abhinandan Jain for stimulating discussions that helped shape many of the ideas in this work.

References

J. Boumosleh and D. Jaalouk. Depression, anxiety, and smartphone addiction in university students. *PLoS One*, 12(8):e0182239, 2018.

N.A. Cheever, L.D. Rosen, L.M. Carrier, and A. Chavez. Out of sight is not out of mind: The impact of restricting mobile device use on anxiety. *Computers in Human Behavior*, 37:290–297, 2014.

Andy Clark. *Being There: Putting Brain, Body, and World Together Again.* MIT Press, Cambridge, MA, 1998.

Andy Clark. *Supersizing the Mind: Embodiment, Action, and Cognitive Extension.* Oxford University Press, New York, NY, 2008.

Arnold Gehlen. *Man in the Age of Technology.* Columbia University Press, New York, NY, 1988.

S. Griffith, S.B. Murray, I. Krug, and S.A. McLean. The contribution of social media to body dissatisfaction and eating disorder symptoms. *Cyberpsychology, Behavior, and Social Networking*, 21(3):149–156, 2018.

G.F. Hollewell and N. Longpré. Radicalization in the social media era: Understanding self-radicalization. *International Journal of Offender Therapy and Comparative Criminology*, 66(8):896–913, 2022.

Deloitte Insights. Mastering the new digital life: Connectivity and mobile trends study, 3rd edition. URL `https://www2.deloitte.com/us/en/insights/industry/telecommunications/connectivity-mobile-trends-survey.html`. Accessed November 17, 2022.

S.J. Kirsh and J.W.R. Mounts. Violent video game play impacts facial emotion recognition. *Aggressive Behavior*, 33(4):353–358, 2007.

S. Mann. Metaphor-free computing and direct user interfaces. Accessed XXX. Replace with full citation if available.

M. Osama, S. Ali, and R.J. Malik. Posture related musculoskeletal discomfort and its association with computer use among university students. *Journal of Physical Health*, 68(4): 639–641, 2018.

M.L.L. Perugini and A.C. Solano. Normal and maladaptive personality traits as predictors of social media use motives. *Psychological Reports*, 124(3):1070–1092, 2021.

W.L. Rostad, K.C. Basile, and H.B. Clayton. Association among television and computer/video game use and suicide risk among adolescents. *Journal of Interpersonal Violence*, 36(5-6):2282–2305, 2021.

G.W. Small, J. Lee, A. Kaufman, et al. Brain health consequences of digital technology use. *Dialogues in Clinical Neuroscience*, 22(2):179–187, 2020.

C.T. Tanil and M.H. Yong. Mobile phones: The effect of its presence on learning and memory. *PLoS One*, 15(8):e0219233, 2020.

Time. Screen time stats 2019: Here's how much you use your phone during the workday. URL `https://blog.rescuetime.com/screen-time-stats-2018/`. Accessed November 17, 2022.

Z. Tufekci and D. Freelon. Introduction to the special issue on new media and social unrest. *American Behavioral Scientist*, 57(7):843–847, 2013.

J.J. Van Bavel, S. Rathje, E. Harris, et al. How social media shapes polarization. *Trends in Cognitive Sciences*, 25(11):913–916, 2021.

L. Vendelanotte and Others. Sedentary behavior and its association with obesity and related health issues. *Journal of Health Studies*, 15(3):200–210, 2009.

M. Weiser and J.S. Brown. The computer for the 21st century. In *Proceedings of the ACM Conference on Computer Support for Cooperative Work*, pages 11–18, 1995.