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DOI
10.1145/3565066.3609790

Publication date
2023

Document Version
Final published version

Published in
MobileHCI '23 Companion: Proceedings of the 25th International Conference on Mobile Human-Computer Interaction

The Future of Cognitive Personal Informatics

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ABSTRACT

While Human-Computer Interaction (HCI) has contributed to demonstrating that physiological measures can be used to detect cognitive changes, engineering and machine learning will bring these to application in consumer wearable technology. For HCI, many open questions remain, such as: What happens when this becomes a cognitive form of personal informatics? What goals do we have for our daily cognitive activity? How should such a complex concept be conveyed to users to be useful in their everyday life? How can we mitigate potential ethical concerns? These issues are different from physiologically controlled interactions, such as BCIs, to a time when we have new data about ourselves. This workshop will be the first to directly address the future of Cognitive Personal Informatics (CPI), by bringing together design, BCI and physiological data, ethics, and personal informatics researchers to discuss and set the research agenda in this inevitable future before it arrives.

CCS CONCEPTS

• **Human-centered computing → HCI theory, concepts and models**; *Ubiquitous and mobile computing theory, concepts and paradigms.*

KEYWORDS

neurotechnology, personal informatics, digital health, well-being, work-life balance

ACM Reference Format:
Christina Schneegass, Max L. Wilson, Horia A. Maior, Francesco Chiossi, Anna L. Cox, and Jason Wiese. 2023. The Future of Cognitive Personal Informatics. In *25th International Conference on Mobile Human-Computer Interaction (MobileHCI '23 Companion), September 26–29, 2023, Athens, Greece.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3565066.3609790

MobileHCI '23 Companion, September 26–29, 2023, Athens, Greece

ACM ISBN 978-1-4503-9924-1/23/09.
https://doi.org/10.1145/3565066.3609790

1 INTRODUCTION

In our recent CHI2022 Special Interest Group discussion, we argued that rapid progress in wearable neurotechnology and activity tracking means that our cognitive activity will soon be monitored, quantified, analysed, and interpreted, similar to how wearables already cater to 'improving' our physical health [20]. Tools and technologies that collect personally relevant information with the aim to support self-monitoring and self-reflection are summarised under the umbrella term of Personal Informatics (PI) [7], *Cognitive* Personal Informatics (CPI) includes PI technology that utilises data from and about human cognitive processing. The ultimate goal of CPI is to enable individuals to make more informed decisions, improve their well-being, and achieve their personal goals.

Currently, research that seeks to classify cognitive activity from both on-body [2] and off-body technology [10] is, arguably, as mature as physical activity tracking in the 2000s [13] (see Figure 1). Meanwhile, the average consumer can *already* buy dedicated "brain-monitoring" devices that claim to support cognitive well-being (e.g., meditation exercises using the Muse headband [12], work focus (e.g., Neurosity [16]), to estimate our stress using peripheral physiological data, i.e., tracking our breathing with the Spire Stone [19], via wristbands that learn "to recognize your emotional patterns" (e.g., Feel [9]), recommend physiological regulatory activities such as guided breathing exercises (e.g., apple watch [1]), or estimate our mental readiness for the day ahead (e.g., Oura Ring [17]). While the availability of these devices creates great opportunities, more research must be done to design affordable, diversity-supporting, healthy, sustainable, ethical, secure, and safe cognitive personal informatics devices and interactions.

The Research Gap and Open Questions. Being able to track cognitive activity does not mean we understand what it means for CPI. What is the goal of tracking cognitive activity? Who has the autonomy to determine the utilisation of our scarce cognitive resources? Is lowering stress the primary objective, and from which stakeholder's perspective? Or, is the goal to increase mental workload to the optimal extent of users' capacity? What is the ideal stress or workload pattern to target daily, and how would this apply to a society of diverse individuals and situations? How will technology appropriately communicate that we are exhibiting an unhealthy cognitive lifestyle? How will we achieve the necessary literacy in

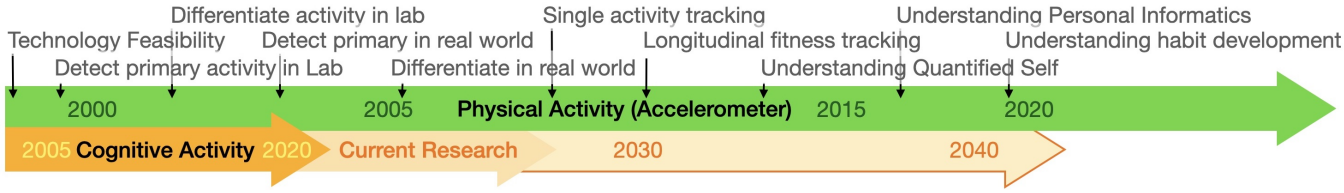

Figure 1: A proposed comparison of where cognitive activity tracking is compared to physical activity tracking

users to interpret the data they are confronted with? To what extent is CPI inclusive of or harmful to people from underrepresented groups, especially people with disabilities?

These are not questions about the classification accuracy of cognitive activity, which will move (as physical activity data did) towards being primarily a machine learning challenge. Instead, these questions address the interaction and design of devices that could significantly impact how sensitive decisions are made and how we integrate CPI into our daily activities and lives [3, 18, 21]. Hence, it is a pressing concern to understand the meaningful forms of personal data that can be revealed, to define the (un)healthy lifestyles that could result from deploying such devices [15]. Separate from state classification, we do not know what a meaningful measure of activity will be for people. Is there a cognitive unit analogous to taking a physical 'step'? If so, what is the cognitive equivalent of reaching 10,000 steps per day? How do we define good patterns of cognitive activity and responsible metrics that will have far-reaching implications for implementation in terms of how we would monitor, quantify, analyse, and interpret them?

Moreover, access to CPI raises interesting questions about the interaction dynamics between humans and intelligent systems. What are our beliefs about the competence of technology and its ability to assess our cognitive performance? For example, research has shown that humans performed better on anagram solving when they believed that task difficulty was moderated by a system assessing their mental capacity via physiological sensing, even though this was a sham treatment [14]. How can we mitigate these effects, and how does the trust in these systems develop over time?

How do the systems monitoring and handling physiological data react and provide timely feedback [8]? Should a system be designed to adapt to the physiological makeup of individuals or base its assessment on an "average" user [5]? Is it ethical to design systems with access to early and primitive information-processing systems of targeted users? It might seem sensible to design notification displays that alert drowsy drivers by exploiting physical properties that signal the approach of threat (e.g., looming intensities) [11]. But where should we stop? Is it ethical to continuously shift and adapt one's entire sense of "reality" in congruence with one's mental state and resource capacity [4, 6]?

Beginning to address all of these open HCI questions requires the involvement of a diverse set of researchers, such as experts in personal informatics, neuroergonomics, the future of work, and digital health and well-being.

The Right Time for a Workshop. A key challenge for HCI research is for individuals, society, and technology to be at the right stage to understand and answer research questions. While physiological computing has been maturing, the arrival of consumer neurotechnology creates opportunity but also a pressing demand to study how such technologies should be designed. Consumer neurotechnology was previously subject to speculation regarding its potential benefits [15, 21] and risks [15]. With advances in neurotechnology, we can now investigate its use in people's personal and professional lives. However, there is a lack of understanding regarding the benefits and goals of neurotechnology, as well as unresolved concerns related to privacy, trust, and ethics. Therefore, *now* is the time to study these open questions.

In 2022[1], we ran a 1-hour discussion forum to identify the scope of interest in this topic [20]. Around 30 participants came together from a range of communities, including activity tracking, personal informatics, ethics, well-being, visualisation, computer-mediated communication, and the future of work. To move beyond the initial discussions of the SIG, the **aims and expected outcomes** of this workshop are to

(1) enable emerging micro-community to present insights from their research
(2) develop the community agenda initially laid out at the 2022 SIG discussion
(3) collectively plan community development activities for the future
(4) strengthen the network between researchers and foster interdisciplinary collaboration in the community

2 THE ORGANISERS

Christina Schneegass. (main contact) is an assistant professor for Cognition & Design at Delft University of Technology. She has evaluated EEG as a method to assess language comprehension in learning systems. Her research aims to incorporate users' cognitive processes into the design and evaluation of technology to develop systems that empower users in their increasingly complex relationship with novel technologies. **Christina will lead from the perspective of user-centred design for cognition-aware systems and cognitive augmentation.**

Max L. Wilson. is an associate professor at the University of Nottingham, focused on evaluating the mental workload involved in completing work tasks and created by differences in user interfaces, using qualitative investigations and quantitative studies using fNIRS. Max has also worked on brain-controlled movies that have toured around the world using consumer brain devices. Max is also a member of the IEEE Brain NeuroEthics Committee. **For this**

[1]CHI2022 SIG Discussion: From Brain-Computer Interaction to Cognitive Personal Informatics [20]

workshop, Max will lead from the perspective of designing future apps for monitoring CPI.

Horia A. Maior. is an assistant professor in HCI within the School of Computer Science and the Horizon Digital Economy Institute at the University of Nottingham, with a focus on Mental Workload as Personal data, and the wider use of brain and physiological data in trustworthy autonomous systems, manufacturing, and other industry environments. **Horia will lead from the perspective of trust in information estimated about people.**

Francesco Chiossi. is a PhD researcher in the Media Informatics Group at the Department of Computer Science of LMU Munich. He obtained an M.Sc. from the University of Padua in neuroscience and applied cognitive science. His work focuses on implicit measures of human behaviour, such as electrodermal activity and electroencephalography, as an implicit input to design physiologically-adaptive systems across the virtuality continuum. More recently, he is also interested in the effect of digital media and context switching on our cognitive capacity. **Francesco will lead from the physiological computing, adaptive system and media design perspective.**

Anna L. Cox. is a professor of HCI at the UCL Interaction Centre, at University College London. Anna's research focuses on understanding the relationships between the design of information and communications technologies (ICTs) and behavioural outcomes, and leveraging these relationships in the design of novel interfaces and systems to support people in managing their work and well-being. **Anna will lead from the perspective of the future of work.**

Jason Wiese. is an assistant professor in the School of Computing at the University of Utah. Jason's research is positioned in personal informatics and personal data and spans multiple domains related to health, well-being, and accessibility. Much of his recent work has focused on people with upper-body motor impairments, especially high-level spinal cord injuries. **Jason will lead from the perspective of accessibility and inclusion in the context of developing personal cognitive informatics.**

3 PRE-WORKSHOP PLANS

The plan for this workshop began with the special interest group discussion held at CHI2022 [20]. From this SIG, we have established a community on Slack[2] and started a Medium Blog[3]. Organising this workshop is the important next step in the long-term plan discussed at the SIG, and members of the new micro-community on Slack were invited to contribute to the organisation of this new workshop. As per the SIG, a dedicated webpage will be hosted on our brain data research website[4]. We will promote the workshop on the Slack server, in research groups, and at upcoming HCI conferences. The aim will then be to generate short video promotions with key community members. These videos can then be shared by the people involved to reach a variety of communities involved in CPI. Standard CfP releases via mailing lists and social media channels will also be used to increase the reach and inclusivity of the event.

[2]CPI Community Slack Server
[3]Medium Blog Cognitive Personal Informatics
[4]MobileHCI23 Workshop Website

Review of Submissions. We will review submissions based on their potential to generate meaningful discussion during the workshop, with a focus on provocative perspectives and interesting research outcomes. The workshop organisers will be responsible for reviewing and accepting submissions, with input from the existing Slack community if necessary. Once accepted, we will work with participants to accommodate their accessibility needs within the workshop format.

Pre-Workshop Online Engagement. To maximise the benefit of in-person interactions and ensure the visibility of contributions, accepted submissions for the workshop will be asked to produce a ~5-minute research video prior to the conference. These videos will serve as the primary mode of presentation for the submitted work and will be released on a fixed schedule on a YouTube playlist between acceptance notifications and the start of the conference. The videos will be posted with provocative questions to encourage online participation (people online and expected participants) and feedback, and the resulting comments will be integrated into the workshop structure as relevant.

Key Invitations. To develop a new community, it is crucial to involve key people with important perspectives on the topics. We will invite relevant speakers to fill topical gaps depending on the submissions received for the workshop.

4 WORKSHOP PLAN

The workshop spans a **full day** and will be built into four quarters (arranged around the natural breaks in the conference). In all parts, the aim is to encourage discussion, especially before breaks and lunch, where the most natural discussions are likely to take place. While in-person participation is encouraged, the program will cater to in-person and online participants in case of unforeseen circumstances (e.g., visa issues). For each section of the program, one organiser will be leading the in-person workshop, while a second organiser will be facilitating the online participation and discussion.

(Q1) Engaging Start (Schneegass & Wilson). To stimulate and encourage community amongst the participants, we will follow a very brief introduction to the day with interactive activities. Due to the expected diversity in participants' research backgrounds, we will start by letting them self-organise into different groups based on identifying statements (e.g. qualitative researcher or quantitative researcher). The ultimate aims of Q1 are a) to explicate the scope of the workshop and the expertise in the room, b) to highlight the variety of expertise, and c) to end up with mixed groups around the tables. Further, by doing so, we aim to avoid being on laptops and settling into a passive form of listening to talks. Once in mixed groups, the remainder of Q1 will focus on important shared research questions and create a physical post-it mindmap on an available large surface. This exercise will flow naturally into the first coffee break.

(Q2) Hybrid Panel Discussions: Research Roots (Wilson & Chiossi). The first panel activities will focus on provocative themes that recur across submissions, particularly those highlighting the different communities that have established research that speaks to the CPI agenda. We will generate these provocative themes from the submissions before the workshop and will invite key guest

speakers in these themes as remote panellists. The panel will be hybrid and moderated by Wilson remotely. In the form of brief 2min panel statements, these themes will be discussed around the table and with our remote panellists and concluded by feedback to the panel from the room. We expect to cover ~3 statements and achieve at least two of these between break and lunch.

Discussion Lunch. Depending on the arrangements available for lunch in the area, we aim to send groups (arranged in Q1) to lunch to continue discussions. We will ask each group to come back to the afternoon session with a considered set of key open research challenges for the community, as developed by discussions about the morning.

(Q3) Future Ethics Focus (Wiese & Maior). To avoid a post-lunch slump, this session will first bring the ideas back to the room from lunch and starts with updating the big mind map. The second part of this early afternoon activity will focus on responsible research and innovation. As a community, we expect this to be a key focus issue for the future, with cognitively-focused technology presenting a number of potentially invasive challenges. We intend to use the Legal and Moral-IT cards on tables to provoke discussion. Either submitting authors or invited speakers will be invited to co-facilitate this activity, where they have already considered aspects of this theme.

(Q4) Future Research Plans (Cox & Schneegass). After the afternoon coffee break, the final session will set the sights on the future, focusing on future visions of research. Beginning with a panel-led discussion from workshop submissions, participants will focus on developing future research ideas by creating motivating scenarios on story cards. Following this activity, we will run a future-research speed-dating activity, where participants rotate in short bursts to discuss potential future collaborations. We will conclude with a brief discussion of post-workshop activities.

As experienced organisers[5], we will leave scope to adapt the plan, both as the workshop approaches and as the day progresses. If the outcomes of the morning and lunch highlight specific discussions that should be continued rather than interrupted by the schedule, we will extend Q2 after lunch, moving Q3 to the later afternoon. Session Q4 would be kept short, and the future-research speed dating would be transferred into an online format for post-workshop engagement.

Hybridity and Asynchronous Engagement. The workshop is aimed to be interactive to foster more in-depth and meaningful discussions, encourage networking and enhance community-building. We expect most participants to attend in person but we will enable remote participation under special circumstances such as visa or pandemic issues. We will stream all workshop activities and facilitate online engagement for remote attendees. No special equipment beyond the normal (i.e., WiFi, projector, microphone) will be necessary. Asynchronous access to the workshop contributions will be possible by asking authors to create videos about their submissions released before the workshop. This allows a wider audience to access the material both before the workshop and for years after the conference has taken place.

[5]Wilson, for example, has previously run two successful workshop series: EuroHCIR and RepliCHI

Accessibility and Inclusivity. We expect two accessibility aspects from accepted authors: clear subtitles on videos and annotation of PDFs for screen readers. We will approach our workshop participants to determine how we can support any other accessibility needs for the event day.

5 POST-WORKSHOP PLANS

We plan to use the workshop outcomes to set a scope for a Special Issue in the International Journal of Human-Computer Studies. These may be expansions of workshop submissions or new works submitted based on the call for papers. We also aim to promote and extend our Medium Blog and organise follow-up community workshops, potentially including a Dagstuhl proposal and further workshops at SIGCHI conferences (CHI, IUI, and UbiComp). Additionally, involved authors will provide mentorship to early-career researchers via the CPI Community Slack Server and future events. The website will host papers accepted to the workshop. We will publish the workshop proceedings on CEUR-WS.org.

6 CALL FOR PARTICIPANTS

This workshop explores the potential of cognitive personal informatics, which utilises physiological signals and wearable tech to track cognitive activity, stress levels, focus, and fatigue. With advancements in engineering and machine learning, we can use this data to shape our goals and change our behaviours. Instead, this workshop looks forward to when our cognitive activity can be easily tracked and presents itself as a new form of personal informatics that we might use to shape our goals and change our behaviours. We invite contributions aligned (but not limited) to the following topics:

- Studies of how people manage their cognitive activity frequently and or longitudinally.
- Research that shapes our understanding of CPI.
- Research into communities that could benefit from or be harmed by (mis)use of CPI.
- Research into the design of systems or applications for CPI.
- Research into how cognitive activity is conceptualised and understood by people.
- Research focused on the ethical, legal, and regulatory aspects of CPI.

We consider work on physiologically-driven interaction and cognitive state classification out of scope. We invite 1) Short research summaries (4-6 pages), 2) Perspectives papers (e.g. essay, design fiction) (4-6 pages), or 3) Attendee abstracts (1 page) that describe a perspective you can contribute. Submissions should be in single-column ACM format. Authors of research summaries and perspectives papers will be asked to record a 5-min video presenting their submission.

ACKNOWLEDGMENTS

Francesco Chiossi was supported by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), Project ID 251654672 TRR 161 and Horia A. Maior was supported by the UKRI EPSRC Trusted Data-Driven Products EP/T022493/1.

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