Advancing Physiological Methods for Human-Information Interaction

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ABSTRACT

With the advancement of pervasive technology, information interaction has become increasingly ubiquitous. In these diverse information access devices and interfaces, it is crucial to understand and improve the user experience during human-information interaction. In recent years, we have seen a rapid uptake of physiological sensors used to estimate the cognitive aspect of the interaction. However, several challenges remain from a ubiquitous computing perspective, such as the definitions discrepancy of cognitive activities (e.g., cognitive bias or information need) and the lack of standard practice for collecting and processing physiological data in information interaction. In this workshop, we bring together researchers from different disciplines to form a common understanding of cognitive activities, discuss best practices to quantify the cognitive aspects of human-information interaction, and reflect on potential applications and ethical issues arising from physiological sensing methods.

CCS CONCEPTS

• **Human-centered computing** → **Ubiquitous and mobile computing**.

KEYWORDS

information interaction; user experience; cognitive activity; physiological sensors

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1 MOTIVATION

In recent years, **Human-Information Interaction (HII)** has become increasingly ubiquitous due to the prevalence of information access devices and user interfaces. People can readily access information through smart and pervasive devices. While it is crucial to understand and improve the user experience in HII [16], evaluating user experience in HII remains a challenge, mainly due to many **cognitive activities** involved in information interaction [20]. Across different scenarios, various cognitive activities operate around HII, for example, how users perceive the relevant information provided (relevance judgment) [28], how satisfied the user feels with the information collected so far (information satisfaction) [20], the rising concerns of misinformation [25], and cognitive biases when consuming information [2, 4].

So far, researchers have employed self-report and behavioral measures [1, 20], for example, web-logging data, to quantify user experience in HII. However, these methods do not directly uncover the cognitive activities and underlying psychological factors during information interaction [12, 20]. More recently, the advancement in wearable physiological sensing technology, such as Electroencephalogram (EEG) and Electrodermal Activity (EDA), has opened novel approaches to quantify users' physiological responses implicitly [8]. Particularly for scenarios like information seeking, physiological measures have shown their capacity to understand the users' behaviors during information access [11, 13], web search [30], video browsing [9], and used as implicit feedback to improve the interaction [27, 28]. Besides, physiological measures have also been applied to detecting more intricate cognitive activities [18, 23], such as cognitive biases [4, 19] or various needs of information [17].

However, quantifying user experience in HII still poses several significant challenges. First of all, **the criteria and definitions of user experience in HII are complex and abstract**, thus open to subjective interpretations. For example, information relevance and satisfaction involve various affective and cognitive activities [29]. Moreover, their definitions can vary based on the application scenarios. For example, information relevance is investigated and defined differently from the user's and system's view [10]. In addition, given the complex nature of user experience in HII, **measuring the user experience can contain confounds**. Unlike affect with clear orienting physiological responses, cognitive activities lack a direct association and, thus, are challenging to explain and validate [22]. For example, one can directly correspond happiness (*i.e.*, affective valence) with physiological arousal (e.g., an increase in phasic EDA response) [22]. Meanwhile, for high-level cognitive activities, it is difficult to ascertain that the detected response is exclusively a result of the experimental manipulation. As a result, the reliability and potential of existing physiological methods require further verification and exploration. Lastly, **there is a lack of common practice for designing experimental tasks and measuring cognitive activities**. Research on confirmation bias suggested that different task designs can induce different outcomes [14, 24]. Recently, researchers in HCI and Ubiquitous Computing have begun to consolidate community standards for measuring cognitive activities. Kosch et al. [15] surveyed how HCI researchers measure cognitive load. Recent research has also suggested guidelines for collecting and processing physiological data, such as EDA [3] and brain signals [21].

The role of cognition in information interaction has become a growing discourse in the Ubicomp/ISWC and broader HCI communities as well as in the Information Retrieval domain. Multiple research initiatives address how we can understand and improve HII. Recent workshops such as *PhysioCHI: Towards Best Practices for Integrating Physiological Signals in HCI* [6] at CHI 2024 and *The Future of Cognitive Personal Informatics* at MobileHCI 2023 have explored related topics around the use of physiological signals in HCI. A workshop series at Ubicomp from 2016 to 2020 – *UbiTension:Workshop on Smart & Ambient Notification and Attention Management* [26] – has focused on tracking the user's attention with pervasive devices. *Workshop on Understanding and Mitigating Cognitive Biases in Human-AI Collaboration* [5] at CSCW 2023 has investigated the notion of cognitive biases in HCI. In the domain of Information Retrieval, a SIGIR 2015 workshop *NeuroIR: Neuro-Physiological Methods in IR* [7] at SIGIR 2015 has showcased the potential of physiological methods in HII. Given the complexity of information-related activities, bridging insights from different disciplines and creating a common ground for future research in understanding information interaction is important.

2 OUR WORKSHOP

This workshop aims to bring together researchers and practitioners who use physiological sensors to measure user experience in information interaction. We invite people from different disciplines, such as HCI, Ubiquitous Computing, Information Retrieval, and Cognitive Psychology. Our main objective is to form a common understanding and community standards of **quantifying the cognitive aspect of user experience in HII**. We expect participants to share their research ideas, questions, and opinions with respect to the following themes:

- **Exploring and Defining Cognitive Activities in HII.** What cognitive activities impact the interaction between humans and information? We aim to uncover cognitive activities involved in HII and build a common understanding among cross-disciplinary researchers. Previous research has investigated a diverse set of cognitive activities, *e.g.*, relevance judgment [28], information satisfaction [20], and cognitive biases [4].
- **Methods to Quantify Cognitive Activities.** What tools and modalities can quantify cognitive activities in HII? What are the ground truths, and do we need them? How can we ensure that the collected data are ecologically valid? What are the considerations for using physiological sensors in HII settings?
- **Application Scenarios and Impacts.** We seek to explore how cognitive activity quantification can impact human-information interaction. What kind of applications would cognitive activity quantification enable and benefit users of information systems? At the same time, what are ethical, legal, and privacy considerations arising from using physiological sensors in HII?
- **Case Studies.** We would like to see realistic cases where the utilization of physiological signals has been adopted into research related to human-information interaction.

Relevance and Timeliness

The emergence of information access devices and interfaces renders the ubiquity of HII. Thus, understanding and improving information interaction lies in the intersection of HCI, Information Retrieval, and, more recently, Ubiquitous Computing. Moreover, physiological sensors have become an emerging tool in the Ubicomp/ISWC community. In line with this trend, in this workshop, we emphasize the usage of physiological sensors in understanding information interaction.

3 PRE-WORKSHOP PLANS

Before the workshop, we will advertize our CFP message through existing research connections, mailing lists, and social media. We expect each submission to be a short research summary or a position paper (4 pages excluding references) discussing one or more workshop themes. All submissions will be peer-reviewed by the workshop organizers and (if possible) external reviewers. Our acceptance criteria comprise the quality of the submission, the potential to generate meaningful discussions during the workshop, and the diversity of the perspectives. We expect to have a selection of 10-15 submissions accepted at our workshop. We will request at least one author of each selected submission to register for the workshop upon acceptance. We also encourage authors to create a short video (3–5 minutes) summarizing their submissions. We will feature accepted papers and video previews on our workshop website[1].

[1] https://hii-biosignal.github.io/ubi24/

4 WORKSHOP STRUCTURE

We propose a full-day workshop with in-person participation. With an open workshop setting, we expect the attendance to be around 20–30 participants. To enhance research sharing and facilitate discussions, we divide the workshop activities into three components: paper presentations, keynote talks, and two-round group discussions. To distribute passive and active participation, we plan to have paper presentations and the first-round group activity in the morning, followed by a keynote speech and the second-round group activity in the afternoon. Table 1 summarizes a tentative schedule for our workshop.

- **Introduction** (10–20 minutes): We will welcome participants to this workshop and provide an outline of planned activities, goals, and themes. We will also include a quick ice-breaking activity for participants to get to know each other.
- **Interactive Paper Presentations** (60 minutes): Authors will share their paper submissions. We plan on allocating time for selected presentations under their relevance to the workshop themes. Each submission will have 5 minutes to briefly discuss their work and 3 minutes for Q&A. We aim for this session to be an opportunity for authors to introduce their research and gain feedback from the audience.
- **Group Discussion Round I** (60 minutes): We will divide participants into small groups (4–5 people) where each group's theme will associate with concrete scenarios from the submitted position papers, for example, search engines, social media, or conversational agents. Participants can join a group they are most interested in. The scenarios and the number of groups will be determined according to the submissions and attendance number.
  - **Brainstorming** (30–40 minutes). Participants will receive a brainstorming task and discuss solutions within their group. There will be at least one organizer facilitating discussion in each group. Brainstorming tasks will be sourced from open questions in the workshop's themes, *e.g.*, *definitions* (*e.g.*, What does quantifying user experience in HII matter?), *methods* (*e.g.*, what are considerations when using peripheral signals to measure user experience in HII?), and *applications* (*e.g.*, how can we leverage physiological sensors to improve user experience in HII?). We plan to distribute a feature board, sticky notes, and marker pens to each group, in which participants can write down and post on their ideas.
  - **Knowledge Synthesis** (20 minutes): All groups will reconvene and nominate a representative to share what they have discussed in their group, including key ideas, challenges, and opportunities. One organizer will moderate the discussion.
- **Discussion Lunch** (90 minutes): Depending on food options close to the conference venue, we plan to continue group discussions during lunch break. We will ask each group to return for the afternoon session with more refined solutions regarding to the prior brainstorming task.
- **Keynote Talk** (60 minutes): We will invite one prominent researcher in the area of Ubiquitous Computing to give a keynote talk as a kick-start for our afternoon session. The talk is aimed to complement the topical gaps and augment and stimulate group discussions in the morning session. We plan to spend approximately one hour, including Q&A.
- **Group Discussion Round II** (60 minutes): We will send participants back to their discussion groups and give them the second brainstorming task: each group will discuss for *actionable* solutions for an open question, for example, *What do we need to make reproducible and transparent research using physiological sensors in the context of HII?*, *How would information interaction look like with better physiological sensing?*. Questions for the second-round discussion will be based on the workshop themes, keynote talk, and existing discussions in the workshop. Similar to the first round, we plan to spend 40 minutes for group discussion and 20 minutes for knowledge synthesis.
- **Closing Remarks** (30–40 minutes): We will synthesize key takeaways from the discussion and identify the next steps for building a research community around HII. We will also facilitate follow-up conversations and networking after concluding the workshop.

Table 1: The tentative one-day workshop program comprising of paper presentations, keynote talk, and two rounds of group discussions.

Time	Program
9:00–9:20	Introduction
9:20–10:20	Paper Presentations
10:20–10:30	Coffee/tea Break
10:30–11:30	Group Discussion Round I
11:30–13:00	Lunch Break
13:00–14:00	Keynote Talk
14:10–14:20	Coffee/tea Break
14:20–15:20	Group Discussion Round II
15:20–15:40	Closing Remarks and Networking

5 ORGANIZERS

- **Nattapat Boonprakong** is a PhD candidate at the School of Computing and Information Systems, the University of Melbourne, Australia. His research is specifically focused on the quantification and mitigation of cognitive biases in the context of information consumption and misinformation. He employed a range of physiological sensors (for example, fNIRS and EDA) to measure the occurrences of confirmation bias. Nattapat has previously organized a workshop on cognitive bias quantification [5].
- **Kaixin Ji** is a PhD candidate at the School of Computing Technologies, RMIT University, Australia. Her research is about quantifying and measuring cognitive bias with multimodal physiological sensing, including EEG, EDA, PPG, and eye-tracking. She specifically focuses on the occurrences of cognitive bias as a sequence of decisions made during interactive information-seeking processes.

- **Ziyi Ye** is a PhD candidate at Tsinghua University, China. His research interest is using brain signals to improve search evaluation and performance. Recently, he has focused on investigating the potential relationship between large language models (LLMs) and the brain model.
- **Tuukka Ruotsalo** is an Associate Professor of Computer Science at the University of Copenhagen, Denmark, and LUT University, Finland. His research is in machine learning for physiological and cognitive computing, information retrieval, and human-computer interaction.
- **Benjamin Tag** is a Lecturer in the Embodied Visualisation Group at Monash University, Australia. He is researching ways to quantify and understand human emotions and cognition by combining methods from cognitive psychology and ubiquitous computing. He is interested in deploying commodity devices (*e.g.*, smartphones) in everyday settings to enable comprehensive long-term mental state assessments.
- **Damiano Spina** is a Senior Lecturer at the School of Computing Technologies, RMIT University, Australia. His research focuses on interactive information retrieval – including conversational agents – and evaluation of information access systems in terms of effectiveness and fairness. He has co-organized workshops in international conferences (including WWW, SIGIR, ICWSM, and CHIIR) and shared tasks for evaluation campaigns at CLEF and IberLEF.
- **Flora D. Salim** is a Professor of AI and Ubiquitous Computing and a Cisco Chair at the School of Computer Science and Engineering (CSE), UNSW, Australia. Her research is on machine learning for multimodal sensor data and on trustworthy AI.

6 CALL FOR PAPERS

We invite researchers and practitioners who use physiological data to measure user experience in information interaction to submit their contributions as a short research summary or position paper *(4 pages in the SIGCONF one-column format, excluding references)* discussing one or more of the workshop themes. Each submission will be reviewed by the program committee and accepted based on the quality of the submission, the potential to generate fruitful discussions, and the diversity of perspectives. Accepted submissions will be invited to give a talk at our workshop and encouraged to record a short 3-5 minutes video summarizing their work.

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