Tools for Thought: Research and Design for Understanding, Protecting, and Augmenting Human Cognition with Generative AI

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Abstract

We invite researchers, designers, practitioners, and provocateurs to explore what it means to understand and shape the impact of Generative AI (GenAI) on human cognition. GenAI radically widens the scope and capability of automation for work, learning, and creativity. While impactful, it also changes workflows and the quality of thinking involved, raising questions about its effects on cognition, including critical thinking and learning. Yet, GenAI also offers opportunities for designing tools for thought that *protect* and *augment* cognition. Such systems provoke critical thinking, provide personalized tutoring, or enable novel ways of sensemaking, among other approaches. How does GenAI change workflows and human cognition? What are opportunities and challenges for designing GenAI systems that protect and augment human cognition? Which theories, perspectives, and methods are relevant? This workshop aims to develop a multidisciplinary community interested in exploring these questions to protect against the erosion, and fuel the augmentation, of human cognition using GenAI.

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CCS Concepts

• **Human-centered computing** → **Human computer interaction (HCI)**; • **Computing methodologies** → **Artificial intelligence**.

Keywords

generative AI, artificial intelligence, critical thinking, reasoning, cognition, metacognition, learning, diversity, creativity, sensemaking, autonomy, augmentation, intentionality, reflection, social science, research, design, workshop

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1 Motivation

"Not another Generative AI workshop!", you might think to yourself—yet, although Generative AI (GenAI) is an essential aspect of the workshop, our distinctive concern is *human cognition*. This workshop aims to bridge (a) an emerging science of how the use of GenAI affects human thought, from metacognition, to critical thinking, to memory, to creativity (Section 1.1), with (b) an emerging design practice for building GenAI tools that not only *protect* human thought, but also *augment* it (Section 1.2). We aim to gather a multidisciplinary community set on protecting and augmenting human

cognition with Generative AI, and kickstart an enduring conversation by mapping the space of opportunities in this area (Section 2).

1.1 How will people learn and think in the future, as Generative AI is embedded into our work and lives?

The Generative AI shift [12, 64] is upon us. Society is undergoing a radical widening in the scope and capability of automation for work, learning, and creativity. While powerful, there are risks that such automation may bring to human cognition. GenAI systems are commonly deployed as replacements for tools and processes [69]—such as writing and research—through which people think and, therefore, learn, build skills, and grow expertise. GenAI systems also shift workflows from production to 'critical integration' [62] of material, involving decisions about when and how to use GenAI, framing tasks, and assessing outputs [35, 55, 63, 72, 76]. Thus, the quality and nature of thinking—where thinking is applied, what kind of thinking is applied—all change when knowledge workflows reorient themselves around GenAI.

GenAI systems therefore act as functional extensions of human cognition, as suggested by the 'extended mind thesis' [6].[1] Indeed, GenAI systems and users may form cognitively coupled systems, defined by an interaction between users' inputs (e.g., fine-tuning, prompting), and systems' short- and long- term impact on users' task performance and cognition, with these two components "continuously co-affecting one another in a self-reinforcing cognitive loop" [68]. What changes in human cognition occur within this cognitive loop?

There is evidence that recent technologies are reshaping human cognition. For example, reliance on GPS may negatively impact people's sense of direction and navigational knowledge [27, 54], and internet use may change the way we process information [52], recall information [70], or assess our confidence in our own knowledge or abilities [24, 52, 61, 71]. Emerging evidence suggests that GenAI may have analogous impacts on cognition. For instance, in education, students with unregulated access to GenAI perform worse when AI is taken away, as they become over-reliant and fail to develop essential independent problem-solving skills [11]. Although directly analogous findings in knowledge work are scant, studies suggest that workers over-rely on these systems in a similar way, at least in the short term, particularly when using GenAI to automate rather than augment tasks [8, 17, 21]. Understanding the nature of this change is vital for making well-informed decisions about protecting aspects of human cognition in light of the GenAI shift, and for designing systems that do so.

Yet the impact we propose to understand is not all negative—well-designed GenAI systems can improve learning [11, 38, 46, 47, 84], writing [87], creativity [7], sensemaking [22, 73], and various forms of knowledge work productivity [15, 20, 21]. Understanding the cognitive underpinnings of this positive impact can help build better AI models and design better systems (e.g., [40]). More broadly, we emphasize that seeking to understand the impact on cognition is complementary to the work on improving AI models or automating tasks. By understanding where, how, and why any impact on our cognition occurs, we can deploy GenAI systems intentionally, maximizing benefits while mitigating harms. Moreover, by understanding the interplay between GenAI and human cognition, we can design systems that ultimately *augment* it, leading to better short- and long-term outcomes for people.

[1] Popper's 'three worlds' theory provides a complementary perspective, in which GenAI systems, as products and physical instantiations of 'World 2' human cognition and 'World 3' ideas, continue to shape our cognition and ideas in both of these worlds [14].

1.2 What opportunities are there for GenAI to augment, or even transform thinking, much as older tools such as writing have done?

While the unconsidered use of GenAI can pose risks to human cognition, GenAI also offers opportunities beyond 'mere' task automation—it can help build *tools for thought*, as envisioned by Engelbart [60], Kay [42], and others since then [53, 79]. Alongside automating tasks and generating content, it can help us better understand tasks and think more critically about our work. In addition to increasing the *quantity* of our outputs, it can improve their *quality* by helping us ask better questions, as explored in recent work [16, 19, 36, 65, 67, 74, 86, 87].

One line of work suggests that GenAI systems can support thinking by acting 'antagonistically' [16], as 'provocateurs' [65], as 'coaches' [36], or otherwise prompting 'metacognitive' reflection [74], and thereby challenging users' thinking. Empirical work has begun to explore this direction in individual [32, 57, 58, 83] and collaborative contexts [18, 56]. Relatedly, research is also exploring GenAI as an explicitly educational technology, offering personalized and dynamic tutoring to students [40, 46, 47, 49, 80]. Finally, other work is exploring GenAI as a medium for dynamically representing information at different abstractions [4]. Rather than directly probing users' thinking, this approach supports cognition by adapting informational representations to the task at hand or encouraging different ways of sensemaking [39, 41, 51, 73, 77, 87] and verification [45, 82]. In sum, this work aims to protect cognition by engaging people in meaningful and beneficial forms of thinking, and moreover, to augment it by challenging or reframing perceptions, assumptions, and understanding. Together with research on understanding the impact of GenAI on cognition, this work offers a pathway for GenAI that not only improves productivity (on top of that afforded by automation), but also leads to improved decision-making, learning, creativity, and understanding.

2 Workshop Aims

With GenAI's rapid real-world adoption and the proliferation of GenAI-driven systems, now is the time to initiate a dedicated effort in understanding what this means for human cognition, and how we can shape this technology for our wide-ranging benefit. The CHI community has both the duty and the means to explore this. As alluded to above, this effort requires multi-disciplinary collaboration. CHI is a unique venue that brings together not only HCI technical system designers, developers, and engineers, but also those from psychology, linguistics, anthropology, sociology, learning science, communications, management, science studies, history, and policy, among others. Similar efforts have arisen in the past, with areas such as Explainable AI [25] and Responsible AI [1, 10] developing strong communities of interest and numerous

resources [2, 5, 13, 37]. Cognitive concepts have been alluded to in these contexts, but have not been their core focus—in contrast, our effort is distinctly concerned with the impacts of GenAI on human cognition and the implications for the way people learn, build skills, and grow expertise. Thus, this workshop has two aims:

(1) As the initial instance of an anticipated series, we want to **identify and coalesce a multidisciplinary community** interested in understanding and shaping the impact of GenAI on human cognition.
(2) We want to **map the space of opportunities** in this area, in terms of the following high-level questions:
   - How do GenAI systems change workflows? What activities become more or less important? What activities are eliminated and created?
   - What is the impact of current GenAI paradigms on human cognition, such as our ability to learn, think critically and creatively, reason, remember, and do sensemaking in contexts from creative art to programming or scientific research? How can we better understand and mitigate potential negative impacts, and maximize positive impacts?
   - What does it mean to protect and augment human cognition?
   - What are opportunities and challenges for designing GenAI systems that protect and augment human cognition? How do we develop principles or guidelines for doing so?
   - Which contemporary and historical theories and perspectives—from across disciplines—are relevant for understanding the impact of GenAI on cognition and workflows, and for designing GenAI systems that protect and augment human cognition?
   - How do we study the impact of current GenAI paradigms and novel GenAI systems for protecting and augmenting human cognition?

Given the breadth and complexity of these questions, we do not expect this initial workshop to provide definitive answers to the above, but rather to initiate focused conversations that lay the groundwork for addressing these questions as a community.

An underlying aim of this workshop and its community is to strengthen the link between *understanding* the impact of GenAI on cognition and *designing* new systems that protect and augment cognition. For example, exploring foundational theories and approaches to studying impact from across relevant disciplines is not only useful for its own sake, but will provide principled grounds for designing novel GenAI systems and evaluating their afforded experiences and effectiveness. The connection between descriptive theories and prescriptive design is illustrated in recent studies on AI-enabled tutoring systems [11, 47], which examine the impact of current GenAI systems on learning, harness pedagogical principles to inform the design of new systems, and conduct comparative evaluations. There are similar opportunities for designing GenAI systems that support critical thinking [65, 76] or sensemaking [19, 73] in knowledge work. CHI's multidisciplinary community, its focus on contextual understanding of technologies, and its strength in designing real-world systems, therefore make it the ideal venue for this workshop.

3 Organizers

Lev Tankelevitch is a Senior Researcher in Microsoft Research, within the *Tools for Thought* group. His research explores how to augment human agency in collaborative knowledge work, including using metacognition as a lens to understand and improve human-AI interaction, and to design GenAI systems that improve intentionality in collaboration. He has a background in applied behavioural science, having previously worked at the Behavioural Insights Team, and in cognitive psychology and neuroscience. Find more about his work here: https://aka.ms/levt.

Elena Glassman is an Assistant Professor at Harvard University's Paulson School Of Engineering and Applied Sciences. Her research focuses on building AI-resilient interfaces [29] that support meta-cognition through a variety of novel interface features and affordances that enhance user's reading, writing, and sensemaking abilities. These features include constructive antagonism [16] and reifying (1) multiple recursive levels of detail [33], (2) natural language commands as dynamically generated UI widgets [78], and (3) pre-computed similarities and distinctions across many items in a corpus at both the literal and analogical levels, e.g., OverCode [30], Examplore [31], ParaLib [85], and Positional Diction Clustering [28]. Her group specializes in leveraging theories of human cognition about how humans form mental models from varying concrete examples.

Aniket Kittur is a Professor in the Human-Computer Interaction Institute in Carnegie Mellon's School of Computer Science. His research explores combining human and machine intelligence to scale up sensemaking and innovation in domains including scientific literature, decision making, productivity, and analogical design.

Mina Lee is an Assistant Professor in Computer Science, Data Science Institute, and Cognitive Science (affiliated) at the University of Chicago. Her research centers around Writing with AI, especially how AI is transforming our writing process, the content we produce, and our identities as writers. She was named one of MIT Technology Review's Korean Innovators under 35 in 2022. She has co-founded and organized workshops on Intelligent and Interactive Writing Assistants (In2Writing) and Human-centered Evaluation and Auditing of Language Models (HEAL) at ACL 2022, CHI 2023, and CHI 2024.

Srishti Palani is a Senior Researcher at Tableau Research. She researches at the intersection of Cognitive Science, Human-Centered AI and Human-Computer Interaction. Her research investigates how people think and behave while exploring, sensemaking and being creative and with Generative AI and information on the Web. Based on this understanding of user behaviors and cognition, she builds interactive intelligent systems that augment these human cognitive abilities. She earned her doctorate and master's from the University of California, San Diego. Before PhD, she graduated *summa cum laude* double majoring in Computer Science and Psychology (specializing in Cognitive Neuroscience) from Mount Holyoke College.

Majeed Kazemitabaar is a PhD candidate at University of Toronto, where he is researching on and developing tools that balance productivity and cognitive engagement in AI-assisted programming. He has studied the impact of learning to code with AI on subsequent performance without AI, to measure the effects of

overreliance on AI [43, 44]. He has developed and evaluated programming tools based on the concept of "*Friction-Induced AI*" to achieve two goals: enhancing short-term productivity by improving verification through added intervention points [45], and preventing long-term productivity loss by requiring user engagement with AI-generated code [46].

Jessica He is a UX Designer at IBM Research, where she is a member of the Human-AI Collaboration team. Her work focuses on leveraging design to bridge the gap between user expectations and emerging AI technologies, encompassing topics including AI attribution, risk mitigation, and enhancing knowledge work [34]. By applying user-centered methods, she strives to create - and guide other practitioners in creating - trustworthy generative AI applications that augment rather than replace human capabilities and collaboration [81].

Gonzalo Ramos is a Principal Researcher at Microsoft Research at Redmond. He is part of the Human Centered AI and Experiences Group at Microsoft Research at Redmond, where he works at the intersection of HCI, Design, and AI to augment people's agencies and capabilities. He is a graduate from the University of Toronto's DGP lab, as well as the Universidad de Buenos Aires. Prior to his position at Microsoft Research, he worked as a Senior Design Technologist and later UX Scientist at Amazon, and as a Scientist at Microsoft. You can find more information on his work here: https://www.microsoft.com/en-us/research/people/goramos/.

Advait Sarkar is a researcher at Microsoft, affiliated lecturer at the University of Cambridge, and honorary lecturer at University College London. He studies the effects of Generative AI on knowledge work [62, 75], programming [48, 64], and data analysis [23, 26, 45, 50]. He is part of the *Tools for Thought* group at Microsoft [59], where he leads a research agenda aimed at enhancing critical thinking with Generative AI [66, 67]. His article *"AI Should Challenge, Not Obey"* appears in the October 2024 issue of Communications of the ACM [65].

Yvonne Rogers is a Professor of Interaction Design at University College London. A central theme of her work is concerned with designing AI that augments human cognition. She have given many keynotes and invited talks on how HCI can meet AI in the I.

Hari Subramonyam is an Assistant Professor (Research) at Stanford Graduate School of Education and Computer Science (by courtesy). He is also the Ram and Vijay Sriram Faculty Fellow at the Stanford Institute for Human-Centered AI. Subramonyam studies ways to augment human learning using AI by (1) engaging in cognitively informed design practices, (2) co-designing with learners and educators, and (3) developing transformative AI-enabled learning experiences. Through his research, he also contributes tools and methodologies that prioritize ethical considerations, responsible design practices, and human values when creating AI experiences.

4 Workshop Organisation: In Person

The workshop will be in-person only to facilitate in-depth discussion among all participants, and to avoid challenges in ensuring equitable opportunities for participation between in-person and remote attendees. While we acknowledge that this decision would unfortunately exclude those who cannot travel to attend in person, we believe that this trade-off would result in a superior experience for those who do attend, and is better aligned with the primary community-building aim of the workshop. Alongside synchronous in-person engagement, we will use Discord for asynchronous discussions before, during, and after the workshop. To facilitate in-depth discussion and community-building, we are designing the workshop for 30 participants. Presentations and other media will be shown on the provided projector and also shared on the asynchronous platform. The workshop is planned as a 1-day event, 9:00AM to 5:30PM, with breaks.

4.1 Accessibility

Authors will be encouraged to submit position papers or other media in accessible versions. We will use a platform that enables captions for speech. We will also determine participants' accessibility needs in advance and will liaise with the CHI Accessibility Chair if further support is needed.

4.2 Asynchronous Materials

We plan to use a dedicated website (https://ai-tools-for-thought.github.io/workshop/) to promote and distribute workshop information, including the call for proposals, publish workshop submissions in advance of the workshop, and publish a summary of activities after the workshop. We will create a Discord channel for asynchronous communication and media sharing before, during, and after the workshop.

5 Workshop Activities

5.1 Before the Workshop

We aim to build a multidisciplinary community and therefore hope to attract participants not only from HCI, including researchers, designers, technologists, and industry professionals, but also those studying and working in related fields such as psychology, education, data science, anthropology, sociology, philosophy, and others. We will advertise the workshop through its website, social media (e.g., X/Twitter, LinkedIn), email distribution lists from relevant conferences (including CHI, CSCW, IUI, ACL) and research and industry institutions, and direct communication with colleagues. The diversity of organisers' institutions should facilitate this dissemination.

Those wishing to participate will be asked to submit either a position paper (of *up to* 2,000 words) or other portfolio of work (e.g., a system or set of design explorations) accompanied by a description of its relevance. We particularly welcome submissions that offer novel perspectives, critical reflections, and/or preliminary results on the topic of GenAI's potential to impact cognition or enable the design of tools for thought (see call for proposals in Section 7). Submissions will be reviewed by at least two members of the workshop's organizing committee (corresponding to ACM's 'Reviewed' level of prepublication evaluation [9]). To help increase the diversity of perspectives at the workshop, structure the workshop activities, and facilitate community-building, we will also ask participants to submit a short personal statement of up to 150 words describing their relevant background, their motivation for attending, and specific areas of interest. This will be considered holistically with the submitted work.

Accepted submissions will be posted on the workshop's website in advance of CHI2025, to encourage participants to gain familiarity with each other's work. We will also explore using GenAI to creatively synthesize and communicate submitted information to provide an overview of the incoming participant community in advance of the workshop, and potentially support workshop activities.

5.2 During the Workshop

We will start the workshop with a welcome session outlining the main themes and upcoming sessions. We will also engage participants in an ice-breaker activity: the 'human spectrogram' [3], where participants indicate their opinion about provocative questions central to the workshop by physically moving along an imagined spectrum covering the response extremes (e.g., 'strongly agree' to 'strongly disagree'). This will introduce the range of questions central to the workshop, help participants discover similarities and differences in their opinions, and stimulate discussions.

The workshop will then be divided into four sessions, each lasting 75 minutes, and focusing on different themes (exact themes will be finalized based on the submissions and participants; tentative schedule in Table 1):

- **Session 1 (talks and discussion): Impact of GenAI on Cognition and Workflows.** What is known about the positive and negative impact of GenAI on cognition and workflows? What important perspectives (e.g., historical, cultural, etc.) on these impacts do we need to be aware of?
- **Session 2 (talks and discussion): Methods and Theories.** What are existing (and novel) methods and theories from across disciplines relevant for studying the impact of GenAI on cognition and workflows, and designing and evaluating new GenAI systems? How is HCI research well-positioned (or ill-positioned) to apply these methods and theories?
- **Session 3 (talks and discussion): Designing for Cognitive Protection and Augmentation.** What does it mean to protect and augment cognition? What are promising prototypes, frameworks, design approaches, guidelines, or perspectives for designing GenAI systems that protect and augment cognition?
- **Session 4 (co-ideation): Mapping opportunities**. A co-ideation activity with all attendees in groups, with each group focusing on:
  - Key research questions for understanding the impact of GenAI on cognition and workflows
  - Specific areas of cognition and aspects of workflows that may be impacted by GenAI
  - Opportunities for designing GenAI systems that protect and augment cognition
  - Challenges for designing GenAI systems that protect and augment cognition
  - Potential principles and guidelines for designing GenAI systems that protect and augment cognition

The first three sessions will feature 5-6 lightning talks (each presentation approximately 5 minutes), followed by a panel discussion with all presenters together with audience Q&A (approximately 45 minutes). These sessions will be moderated by a member of the organizing committee. Alongside the live questions, we will encourage participants to submit thoughts, ideas, and questions to Discord. Presenters will be a subset of all participants, selected by the organizing committee to ensure a diversity of perspectives, approaches, and types of contributions. As our workshop aims to facilitate community-building and mapping of opportunities for the future, this format will ensure ample time for questions and discussion in a way that is accessible to all attendees, while balancing the need to provide presentation opportunities for as many participants as possible.

The fourth session will consist of a co-ideation activity with all attendees, split into groups of 5-6, and allocated based on their indicated interests and submissions. The co-ideation activity will be 50 minutes, followed by 25 minutes of group share-outs. Each group will be provided with discussion prompts, and moderated by at least one workshop organizer.

Coffee breaks will be used to informally showcase any demos or related work that participants have submitted; interested participants will be instructed in advance to prepare their demos. We will organize an informal outing for lunch to facilitate further networking and discussion. We will encourage the use of the asynchronous platform throughout the workshop to facilitate ideation, information exchange, and networking.

The workshop will conclude by summarizing the day's insights, eliciting participants' opinions on next steps for the community, and suggesting future action items.

6 Publishing Workshop Proceedings and Post-Workshop Plans

We will publish a collection of the submitted papers as workshop proceedings via CEUR-WS. We will use the workshop website to create a permanent record that links to these archival versions of all position papers, as well as any portfolios, and recordings of all talks and panel sessions.

During the closing segment of the workshop, we will discuss and gather feedback about strategies for disseminating the materials covered during the workshop, such as research questions, positions, and design principles. We anticipate that the discussions from this workshop will inspire an expanded position paper, a collection of articles for special issues of peer-reviewed journals like TOCHI, or a series of articles on platforms like Medium. All output will be posted on the workshop website, and shared via social media.

Furthermore, we will deliberate on methods to cultivate the Tools for Thought community through social media and/or a special interest group (SIG). We will also consider organizing follow-up events in HCI, design, and ML venues to expand the size and visibility of the research community.

7 Call for Participation

We invite researchers, designers, and provocateurs to explore what it means to understand and shape the impact of Generative AI (GenAI) on human cognition. GenAI radically widens the scope and capability of automation for work, learning, and creativity. However, it also changes workflows and the quality of thinking involved, raising questions about its impact on human cognition.

Table 1: Proposed Workshop Schedule

Slot	Activity
09:00 - 09:30 (30min)	Welcome, ice-breaker, and coffee
09:30 - 10:45 (75min)	Lightning talks + panel discussion: *Impact of GenAI on Cognition and Workflows*
10:45 - 11:15 (30min)	Coffee break and informal demos
11:15 - 12:30 (75min)	Lightning talks + panel discussion: *Methods and Theories*
12:30 - 14:00 (90min)	Lunch break (informal networking and discussion)
14:00 - 15:15 (75min)	Lightning talks + panel discussion: *Designing for Cognitive Protection and Augmentation*
15:15 - 15:45 (30min)	Coffee break and informal demos
15:45 - 17:00 (75min)	Co-ideation session: *Mapping Opportunities*
17:00 - 17:30 (30min)	Next steps and closing

Nonetheless, GenAI offers opportunities for designing tools for thought—systems that *protect*, and moreover *augment* cognition.

How does GenAI change workflows and impact human cognition, such as our ability to learn, think critically and creatively, reason, remember, and carry out sensemaking? What are opportunities and challenges for designing GenAI systems that protect and augment human cognition? Which theories, perspectives, and methods are relevant? Through lightning talks, panel discussions, and co-ideation sessions, **this workshop aims to build a multidisciplinary community interested in these questions** and in mapping the opportunities for addressing them.

We invite position papers (up to 2,000 words) or portfolios of work (accompanied by description of relevance) addressing the above or related questions. We particularly welcome submissions that offer **novel perspectives, critical reflections, revisitations of older yet relevant work, and/or preliminary findings**. Submissions should be in CHI Extended Abstract format, submitted through the workshop website: https://ai-tools-for-thought.github.io/workshop/, and will be reviewed by the organizing committee. Accepted submissions will be published as workshop proceedings, posted on the workshop website, and shared on social media, with a subset also selected for a lightning talk and panel discussion. Participants are also asked to submit a short personal statement of relevant background and interests for the workshop (up to 150 words). Submitted work and statements will be considered holistically to increase the diversity of perspectives, structure workshop activities, and facilitate community-building. At least one author of each accepted submission must attend the workshop and all participants must register for both the workshop and at least one day of the conference.

8 Expected size of attendance

We plan for 30 in-person attendees only.

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