Designing Metacognitive Support Interactions to Augment People's Thinking in Complex (Co-)Creative Tasks

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Abstract

Generative AI (GenAI) holds promise for supporting complex creative workflows but often remains difficult for users to leverage effectively. Core challenges include misalignment of AI-generated content with user intentions, uncertainty about the AI system's capabilities, and difficulty effectively communicating intentions to the system. Additionally, users often experience reduced cognitive involvement in GenAI-assisted processes due to cognitive offloading. This can result in insufficient exploration and specification of design problems, and a limited ability to evaluate generated outcomes. This portfolio presents a multi-year research program investigating how metacognitive support—such as open-ended questioning, externalization through sketching and planning, and guided intent elicitation—can enhance human thinking during GenAI-assisted tasks. Through empirical studies, system prototyping, and Wizard-of-Oz evaluations, we explore voice- and GUI-based interaction techniques that scaffold users' reasoning and problem formulation. Our findings demonstrate how thoughtfully designed support interactions can mitigate cognitive disengagement and promote effective co-creation with AI. We conclude by identifying directions for cross-domain comparative research to develop generalizable principles for AI systems that augment, rather than diminish, human cognitive processes.

CCS Concepts

• **Human-centered computing** → **Empirical studies in HCI**; *Interaction design*; • **Computing methodologies** → **Artificial intelligence**.

Keywords

generative AI, human-AI interaction, computational design tools, support interfaces, metacognition, think-aloud, wizard of oz study

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1 Research Portfolio Overview

Despite generative AI (GenAI) systems' potential for supporting complex creative tasks, such as design or writing activities, professionals often struggle to integrate GenAI into their workflows effectively. Three core challenges include:

(1) Misalignment of AI-generated content with user intentions (intent elicitation and alignment) [1, 9], which can lead to a perceived disconnect between user input and the AI system's interpretation,
(2) user uncertainty around the AI system's capabilities and how to best communicate their intents to the AI system (prompt formulation) [6, 7, 10], which can lead to trial-and-error interactions and
(3) users' reduced cognitive involvement in the GenAI-assisted processes due to cognitive offloading, which can lead to insufficient problem exploration and specification and limited ability to evaluate generated outcomes [4, 5, 8, 11].

Such fundamental cognitive and interaction issues impede effective human-AI collaboration. We argue that in order to utilize GenAI's potential more effectively in assisting people with complex, cognitively demanding, co-creative tasks, it is essential to design interactions and interfaces that align with and enhance human thought processes. Over the past years, our work has explored how we can design interaction techniques and systems to assist people in thinking through and formulating complex problems while enabling more effective human-AI co-creation workflows. Following a user-centered design process, we gained insights into this question through observational user studies, novel prototyping methods, and system-building activities. We studied how mechanical and architectural designers use AI-based CAD tools in multi-objective manufacturing tasks to understand their concrete challenges better [4]. Through this study, we identified several promising strategies, including metacognitive support (e.g., reflective questioning, providing planning and sketching support) that enhanced designers' cognitive engagement and interactions with GenAI tools.

Based on these findings, we explored how personal voice agents can facilitate metacognitive support strategies, such as reflective questioning, to enhance designers' critical thinking and effectiveness in working with GenAI [2]. A Wizard-of-Oz study with mechanical designers showed that metacognitive support positively influenced their design process and outcomes.

From these insights, we built *SocraBot*, a voice-based multimodal support agent that helps designers think through GenAI-based mechanical and manufacturing design tasks by providing metacognitive support through reflective prompts and diagram sketching.

To extend the exploration of metacognitive support interactions to other task domains and non-voice modalities, we then developed *Intent Tags* [3], a novel interaction technique for AI-assisted rich content creation that allows users to articulate and refine their intent through granular, adaptive UI elements. An evaluative study of IntentTagger, an Intent Tag-based GenAI-driven slide creation system we built, showed that users felt more in control and satisfied than chat-based GenAI interactions.

2 Future Work

Going further, we aim to systematically apply and compare previously identified metacognitive support interactions across different communication modalities (e.g., voice, text, GUI), task domains (e.g., 3D character design, academic writing), and software tools (feature-rich 3D model editor, text processing suite) to further stress-test these principles and derive generalizable insights on how to design effective future metacognitive support systems.

3 Advancing Tools for Thought

Our work directly contributes to the design and study of "tools for thought" by advancing a perspective on how metacognitive support interactions can be operationalized in GenAI-assisted design workflows. By scaffolding intent articulation, critical reflection, and planning through SocraBot and Intent Tags, we explore how AI systems might not only generate content, but actively augment users' reasoning processes. This portfolio provides empirical and design-based evidence for how such systems can be integrated into cognitively demanding creative tasks, offering concrete interaction paradigms for protecting and enhancing human cognition in the age of GenAI. We aim to share these interaction paradigms and empirical insights at the *Tools for Thought* workshop at CHI'25 and contribute to ongoing discussions on augmenting human cognition with GenAI—collaboratively shaping future directions for designing systems that actively support—rather than supplant—human thought and creativity.

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