The Next Leap Forward in Human Intelligence: Expanding & Exploring Complex Spaces of Thought

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ABSTRACT

This position article explores how artificial intelligence can act as a cognitive amplifier by expanding and supporting the exploration of complex spaces of thought. Grounded in historical reflections on tools that have extended human cognition, I outline a conceptual model of human-AI partnership that emphasizes mutual contributions to thought: AI expands conceptual spaces, and humans explore them through reflective and creative engagement. I then share a set of exploratory systems—each engaging a different domain such as knowledge, representation, information, or design—as concrete illustrations of this model. These systems inform a set of preliminary design guidelines for building tools that encourage generative, flexible, and serendipitous thinking. Together, this framing aims to contribute to ongoing discussions in the tools for thought community about designing AI systems that enhance rather than diminish human cognitive capacities.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; **Interactive systems and tools**.

KEYWORDS

tools for thought; intelligence; complex spaces of thought

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1 INTRODUCTION

Artificial intelligence (AI) presents an unprecedented opportunity to shape tools for thought in new ways. However, without thoughtful design, AI can have negative effects on our ability to think effectively [2, 3, 8]. As Edsger W. Dijkstra noted, "The tools we use have a profound and devious influence on our thinking habits, and, therefore, on our thinking abilities" [1]. Similarly, Marshall McLuhan observed that "First we shape tools, and thereafter, they shape us" [4]. These insights highlight the critical importance of intentionally designing AI systems that enhance rather than diminish human cognitive capacities.

How should we design tools for thought so they enhance our ability to think? To answer this question, I first examine the historical trajectory of tools that have pushed the boundaries of human intelligence, identifying the patterns of how these tools expanded our cognitive capabilities. I then propose a conceptual model of human-AI partnership focused on the expansion and exploration of complex spaces of thought, followed by a review of exploratory systems I have developed that illustrate aspects of this model.

2 LEARNING FROM HISTORY: PREVIOUS GENERATION OF TOOLS THAT ADVANCED HUMAN INTELLIGENCE

Throughout history, humanity has developed tools that have progressively expanded the boundaries of human intelligence. By reviewing how these tools transformed cognition, we may glean insights into how to continue this trajectory—guiding the design of future tools that further augment our capacity to think, create, and understand.

- **Knowledge Space**: The development of writing systems and printing presses transformed knowledge preservation and dissemination, making vast amounts of information accessible across generations.
- **Representation Space**: The invention of new representations such as mathematical notations, visual languages, mapping systems, scientific modeling approaches, and diagramming techniques provided structured ways to represent abstract concepts, spatial relationships, and complex phenomena, leading to new ways of thinking and discoveries that pushed our intelligence further.
- **Information Space**: The rise of digital computing and the internet expanded how information is stored, retrieved, and synthesized, allowing individuals to explore vast data landscapes with unprecedented ease.
- **Design Space**: The evolution of design tools from physical models to digital environments, generative algorithms, parametric design platforms, and collaborative creative systems have reshaped creative and engineering disciplines, enabling rapid iteration and exploration of design possibilities.

These historical advancements demonstrate a recurring theme: tools that enable new ways of representing, organizing, and exploring knowledge and ideas fundamentally shift our cognitive and creative capabilities.

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3 A CONCEPTUAL MODEL FOR THE NEXT GENERATION OF TOOLS FOR THOUGHT

Building on the historical trajectory outlined in Section 2, we see a pattern in how tools have consistently acted as enablers of expanded cognition—by reshaping the spaces in which thought occurs.

This reshaping happens through the introduction of new structures, representations, and interaction modalities that expand both the scope (what can be thought) and the range (how far one can think) of cognitive activity. For example, writing allowed thoughts to persist beyond the moment, maps enabled spatial reasoning over large terrains, and digital computing opened new possibilities for modeling complex systems.

Each of these tools extended the conceptual boundaries within which humans operate, effectively enlarging the canvas for human thought. AI, as a computational tool, continues this tradition but with significantly more generative and adaptive potential. Based on these observations, I propose a conceptual model of human-AI partnership that emphasizes bidirectional expansion and exploration:

- **AI expands** complex spaces of thought with its computational capabilities
- **Humans expand** these spaces with creativity, critical thinking, and contextual understanding
- **Together, they explore** these co-created spaces through thoughtfully designed interfaces and interactions

The metaphor of a cognitive telescope illustrates this relationship. Just as telescopes extend vision into previously unreachable realms, AI expands the cognitive space available to humans. Yet, this extension alone isn't sufficient—just as astronomers must skillfully operate telescopes, humans must thoughtfully navigate and interpret AI-augmented thought spaces.

Complex Spaces of Thought. I define these complex spaces of thought as multidimensional conceptual environments that span knowledge, representations, information, design possibilities, problems, and solutions—among other dimensions yet to be fully explored. These are often beyond what any one person can access unaided, but AI's generative and computational capabilities allow for their expansion. But how can we turn the potential overwhelm into discovery and advanced intelligence? I explore this more concretely in the next section with examples of systems that tackle this challenge by making these expanded spaces accessible, navigable, and conducive to human exploration.

4 DESIGN GUIDELINES FOR THE NEXT GENERATION OF TOOLS FOR THOUGHT

The following systems illustrate different ways to support exploration within complex cognitive spaces, each targeting a distinct domain of thought:

Luminate (Design Space) [5]: Encourages exploration across a generated space of ideas, offering an alternative technique to single-output prompting (prompt engineering) that helps reduce early fixation and promote divergent thinking. It supports exploratory engagement by inviting users to consider multiple creative directions.

Sensecape (Information Space) [6] (Information Space): Supports multilevel abstraction and seamless transitions across views, while demonstrating how interfaces can be designed to encourage exploratory sensemaking as users move between multiple levels of abstraction.

CodeToon (Representation Space) [7]: Translates Python code into comics, illustrating how transformable representations can support understanding.

KnowledgeTrail (Knowledge Space): Enables creative exploration of dynamically generated timelines, providing an interface that supports serendipitous discovery and flexible navigation of knowledge. The system's dynamic and exploratory interface invites users to uncover relationships across events that would not be apparent in traditional timelines.

StoryEnsemble (Persona-Problem-Solution Spaces): Facilitates flexible iteration across persona-problem-solution spaces in the design process, offering a continuous, extensible, and dynamic workflow. Its interface supports exploratory movement between stages, allowing users to evolve and adapt ideas fluidly.

From these systems, I derive and propose the following guidelines for interfaces and interactions for supporting effective exploration of AI-augmented cognitive spaces:

Interfaces should be:

- **Dynamic**: Responsive to user input and adaptable to changing contexts.
- **Generative**: Capable of exposing unseen possibilities.
- **Transformable**: Modifiable and reconfigurable to match users' evolving needs.
- **Extensible**: Possible to extend beyond the original scope.

Interactions should be:

- **Exploratory**: Inviting users to navigate and make sense of complex space.
- **Continuous**: Preserving flow across changes in abstraction or representation.
- **Serendipity-supporting**: Enabling chance encounters with valuable ideas.

I present these preliminary guidelines along with the human-AI partnership model in Section 3 to push us to design tools that serve as active mediums for cognition—tools that might guide users in discovering new connections, generating ideas, and expanding their capacity to think—echoing Dijkstra's observation that the tools we use profoundly shape our thinking habits.

5 CONCLUSION

As we design tools for thought in the age of AI, we must remain attentive to how these tools influence our thinking habits, both subtly and profoundly. I contribute a conceptual model and a set of preliminary design guidelines—grounded in reflections on historical tools and illustrated by exploratory systems—that aim to inspire new possibilities for human-AI partnerships.

Rather than prescribing fixed solutions, I hope this framing encourages ongoing inquiry into how AI systems might serve as cognitive amplifiers, helping us navigate and make sense of increasingly complex conceptual terrains. The challenge ahead lies in crafting interactions that genuinely support our capacity to explore, reflect, and think more deeply—pushing the boundaries of what we can know, imagine, and understand.

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