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Adaptive AI, behavioural pattern formation, and the development of human cognition

Raluca Iuliana GEORGESCU
Bodislav & Associates, Romania
raluca.georgescu@infinitumgroup.com
Dumitru Alexandru BODISLAV
Bucharest University of Economic Studies, Romania
alex.bodislav@ase.ro

Abstract. *Artificial intelligence is commonly discussed in terms of information access, automation, productivity, and decision support. While these functions are important, they may not fully capture the broader significance of adaptive AI systems. Unlike many previous informational technologies, adaptive AI systems engage in ongoing interaction that can adapt to the needs, questions, communication styles, and understanding of individual users. This creates opportunities for a more personalized and responsive form of engagement with information.*
This article explores the possibility that the importance of adaptive AI extends beyond the information it provides. Through repeated adaptive interaction, individuals may encounter and practice new approaches to reasoning, communication, information organization, perspective exploration, and problem-solving. Over time, some of these patterns may become incorporated into how individuals learn, think, communicate, and engage with new situations.
The article argues that adaptive AI systems may increasingly function as a source of pattern formation alongside the human relationships, educational experiences, professional environments, and social contexts that have historically contributed to human development. As individuals integrate patterns encountered through adaptive AI interaction with those acquired from other sources, new forms of pattern merging may emerge within the developmental process itself. Building on perspectives from developmental psychology and historical accounts of technological change, this article proposes a framework for understanding adaptive AI as a participant in processes of learning and development rather than solely as a tool for information retrieval. The article concludes that the long-term significance of adaptive AI may lie not only in what it knows, but also in its capacity to support the acquisition, refinement, and application of patterns that contribute to human development across different areas of life.

Keywords: adaptive artificial intelligence, human cognition, behavioural pattern formation, human development, social learning.

JEL Classification: D83, D91, I20, O33, Z13.

1. Introduction

Artificial intelligence is often addressed in terms of decision support, automation, productivity, and information access. A large portion of the current debate about AI's place in society has been influenced by such perspectives. However, as adaptive AI systems are integrated more into daily activities, their importance might go beyond the information or tasks they carry out.

Adaptive AI systems engage in continuous communication, in contrast to many older technologies. They can react, modify, reformulate, and interact with individuals for extended periods of time. As a result, interaction with adaptive AI differs from interaction with technologies that primarily store, retrieve, or transmit information.

This article explores an alternative perspective on the importance of adaptive AI. It investigates the possibility that repeated adaptive interaction may have wider implications for human development rather than focusing primarily on information, productivity, or automation. The primary thesis is that adaptive AI systems might become more involved in processes that have traditionally been largely influenced by social and human environments. Understanding this possibility may become increasingly important as adaptive AI systems become more deeply integrated into everyday life.

2. Human development and external sources of pattern formation

Human development has always occurred within environments that shape how individuals think, communicate, learn, interpret situations, and engage with the world around them. Families, educational systems, social groups, institutions, workplaces, cultural environments, and other sources of social influence all contribute to the patterns that individuals encounter throughout their lives. According to Bandura (1977) and Vygotsky (1978), these environments play a role in the development of habits, expectations, communication styles, reasoning techniques, and approaches to problem-solving that often persist over time.

The transmission of patterns has historically depended on interaction. Through repeated exposure to particular ways of communicating, interpreting situations, organizing information, and responding to challenges, individuals gradually acquire patterns that become incorporated into everyday thinking and behaviour. Human development therefore involves more than the acquisition of information. It also involves the acquisition of recurring patterns that influence how information is understood, applied, and communicated (Bandura, 1977; Bronfenbrenner, 1979).

Throughout history, the environments through which patterns are transmitted have expanded. Writing allowed knowledge to persist beyond immediate human memory. Literacy increased access to ideas across time and distance. Printing technologies accelerated the spread of information throughout society. Digital technologies facilitated greater access to information, communication, and knowledge exchange. These developments altered the environments within which learning and development occurred by changing how individuals encountered information and interacted with one another (Ong, 1982).

Despite these changes, most informational technologies have remained relatively limited in their ability to adapt to the individual. Books, libraries, archives, databases, and search engines can provide access to information, but they generally do not modify their responses according to the needs, understanding, goals, or communication preferences of the person engaging with them. The interaction remains heavily reliant on the individual's ability to adapt to the information source, rather than the information source adapting to the individual.

This historical context provides a solid foundation for understanding the significance of adaptive AI systems. While previous technological developments transformed access to information, adaptive AI introduces the possibility of ongoing interaction that responds to the individual. Understanding this distinction requires examining how adaptive interaction differs from previous forms of informational engagement.

3. The emergence of adaptive interaction

Historically, most informational technologies were designed to store, organize, retrieve, or distribute data. Books, libraries, archives, encyclopaedias, databases, and search engines have expanded access to knowledge, but they generally provide the same information regardless of who is engaging with them. While these technologies have transformed the availability of information, they have remained relatively limited in their ability to adapt to the specific needs of individual users.

Human interaction has traditionally provided a unique type of engagement. Teachers, mentors, colleagues, friends, and other individuals can modify explanations, answer questions, clarify misunderstandings, provide examples, and adjust communication according to the needs of the person with whom they are interacting. The exchange is not fixed. It changes in response to feedback, confusion, curiosity, disagreement, and a growing understanding.

Adaptive AI systems introduce a similar capacity for responsiveness into interactions that occur through technology. Rather than presenting a fixed body of information, they can engage in ongoing exchanges that adjust to the individual. Explanations can be reformulated, information reorganized, alternative perspectives explored, and communication styles adjusted throughout the interaction. The interaction itself becomes dynamic rather than static.

This distinction is significant because it alters how the individual interacts with the information source. In many previous informational environments, individuals were required to adapt themselves to the structure of the information available. Adaptive AI systems introduce the possibility of the interaction becoming increasingly customized to the individual. As a result, the exchange becomes less focused on accessing information alone and more focused on the process through which information is explored, clarified, organized, and discussed.

The emergence of adaptive interaction represents a departure from earlier informational technologies not because it changes the existence of information itself, but because it

changes the nature of engagement with that information. Understanding the implications of this shift requires examining what might develop when repeated interaction becomes an increasingly common feature of everyday engagement with information.

4. Pattern internalization and merging through adaptive interaction

The emergence of adaptive AI systems creates a new type of interactive environment. Unlike previous informational technologies, adaptive AI systems do not merely store or transmit information. They engage in ongoing exchanges. They respond to questions, clarify confusion, reformulate explanations, change communication styles, present alternative perspectives, and modify responses based on the individual's needs. Rather than providing a fixed presentation of information, they constantly adapt during the interaction.

This distinction may have implications beyond information access and retrieval. Through repeated adaptive interaction, individuals may be exposed not only to information but also to recurring patterns of explanation, reasoning, communication, information organization, perspective exploration, and problem-solving. With time, some of these patterns may become internalized, influencing how individuals approach situations outside of the interaction itself (Bandura, 1977; Vygotsky, 1978). The effects of the interaction may therefore persist beyond the conversation, shaping resulting knowledge, communication, reflection, decision-making, and engagement with other people and environments (Bandura, 1977; Bronfenbrenner, 1979).

From this perspective, the importance of adaptive AI systems may not be entirely based on the information they provide. It could also lie in their capacity to participate in processes through which patterns are learned, reinforced, modified, and internalized. Through repeated adaptive interaction, AI systems may become a source of pattern internalization alongside the human relationships, institutions, and social environments that have historically shaped human development. This prospect suggests that adaptive AI may represent not only a new informational environment, but also a new source of developmental influence.

If adaptive AI systems can become a source of pattern internalization, a new possibility arises. Individuals do not simply accumulate patterns from a single source over their lifetime. Human thinking is already shaped by patterns learned from parents, teachers, instructors, other individuals, institutions, cultures, professional settings, books, and personal experiences. Development can therefore be understood as an ongoing process through which patterns from multiple sources are encountered, evaluated, modified, combined, reinforced, or discarded over time (Bandura, 1977; Bronfenbrenner, 1979; Vygotsky, 1978).

The introduction of adaptive AI systems adds a new source of pattern formation to this process. Through repeated interaction, individuals can experience recurring patterns of reasoning, explanation, communication, information organization, and problem exploration that originate from adaptive AI systems. As these patterns become internalized, they do not remain separate from existing patterns. Instead, they become part of the broader

system through which individuals interpret information, evaluate situations, communicate with others, and engage with the world.

From this point of view, the phenomenon under consideration is not the merging of humans and artificial intelligence as separate entities. Rather, it is the merging of patterns that originate from different sources and become incorporated into the same developing individual. Human-derived patterns and AI-derived patterns may gradually coexist, interact, reinforce one another, compete with one another, or produce entirely new combinations. The resulting patterns are not identical to either source. They develop from the interaction between them.

This process is not limited to AI. Human development has always involved the integration of patterns acquired from multiple sources. However, adaptive AI systems differ from previous informational technologies because they participate in ongoing interaction rather than one-directional information delivery. Through continuous adaptation, they can repeatedly introduce individuals to particular ways of reasoning, explaining, organizing information, approaching uncertainty, and exploring ideas. The influence therefore extends beyond the transmission of information and enters the domain of pattern formation.

The significance of this process may become clearer when the effects of interaction extend beyond the interaction itself. Individuals may begin to apply patterns learned through adaptive AI interaction when communicating with others, making decisions, confronting unfamiliar situations, solving problems, or interpreting new information. In such cases, the influence of the interaction is no longer confined to the conversation in which it originated. The patterns have become integrated into subsequent stages of thought and behaviour.

The concept of merging, as used in this article, refers to this process of pattern convergence through repeated adaptive interaction. It does not imply biological fusion, shared consciousness, neural integration, or the disappearance of distinctions between humans and artificial intelligence. In fact, it describes the gradual incorporation and interaction of patterns originating from different systems within the developmental processes of the individual. The focus is therefore not on the merging of entities, but on the merging of patterns that influence how individuals think, learn, communicate, and engage with the world around them.

5. Mechanisms of pattern internalization through adaptive interaction

If adaptive AI systems can become a source of pattern internalization, an important question follows: why might patterns originating from AI systems become incorporated into human thinking and behaviour in the first place? Understanding this process necessitates investigating the circumstances under which patterns are most likely to be adopted, reinforced, and maintained (Bandura, 1977; Vygotsky, 1978).

Historically, pattern internalization was dependent on both exposure and interaction. A book may contain valuable ideas, but it presents the same content to all readers, regardless of whether they understand it. Libraries provide access to large amounts of information but do not guide interpretation. Encyclopaedias and databases provide explanations, but they

cannot adjust when confusion persists. In each case, information is available, but the interaction itself is limited.

Human relationships have traditionally filled this gap. Teachers, mentors, tutors, colleagues, and other influential individuals can modify explanations, answer questions, provide examples, identify misunderstandings, and adapt communication according to the needs of the learner. Nevertheless, this process is frequently restricted by practical constraints. Individuals have different communication styles, vocabulary, prior knowledge, assumptions, learning preferences, patience, and explanatory abilities. As a result, even the most knowledgeable people may struggle to communicate effectively with certain individuals. Understanding is determined not only by the quality of the information, but also by the individual's compatibility with the source of that information (Vygotsky, 1978).

Adaptive AI systems introduce a different set of conditions. Instead of providing a fixed explanation, they can constantly reformulate information until understanding is achieved. A concept can be explained visually, conceptually, practically, technically, or through analogy. Information can be simplified, expanded, reorganized, compared, challenged, or viewed from various angles. The interaction can continue until the individual finds an explanation that aligns with their existing knowledge, communication preferences, and way of understanding the world.

This adaptability may increase the prospect of specific patterns being internalized. Individuals are not exposed only to information itself, but also to recurring ways of approaching information. Across many different conversations, they repeatedly encounter patterns of clarification, comparison, decomposition, perspective-taking, information organization, and problem exploration. Because these patterns appear in multiple contexts and are frequently presented in easily understandable formats, they may be more likely to be noticed, applied, repeated, and remembered.

The significance of adaptive interaction may therefore extend beyond informational accuracy or efficiency. By increasing compatibility between the individual and the interaction, adaptive AI systems may create conditions that facilitate pattern development and reinforcement. Over time, repeated exposure to these patterns may increase the likelihood that they will be adopted by the individual's own approaches to learning, reasoning, communication, and problem solving.

According to this viewpoint, internalization of AI-derived patterns is the result of multiple interactions. It develops from a continuous cycle of adaptation, exposure, application, reinforcement, and memory retention. The interaction becomes a mechanism through which patterns are repeatedly encountered in forms that are understandable, usable, and increasingly likely to persist beyond the interaction itself.

6. Persistence beyond the interaction

The developmental significance of pattern internalization is most evident when its effects extend beyond the interaction in which they originated. If patterns acquired through adaptive AI interaction remained confined to individual conversations, their influence

would be limited to the duration of those exchanges. The possibility discussed in this article is different. Patterns encountered through repeated adaptive interaction may continue influencing individuals after the interaction itself has ended (Bandura, 1977; Bronfenbrenner, 1979).

Persistence is a common component of human development. Individuals commonly continue to apply patterns learned from influential individuals and settings long after direct interaction has ended. A teacher's reasoning style, a mentor's problem-solving approach, or a parent's way of interpreting situations can all have an impact on behaviour years after the initial interaction. The interaction ends, but aspects of its influence remain active.

A similar process might take place after repeated interaction with adaptive AI systems. Once patterns become internalized, they do not necessarily remain tied to the context in which they were acquired. Individuals may continue using approaches to organizing information, evaluating alternatives, exploring perspectives, clarifying uncertainty, or solving problems that were repeatedly encountered during previous interactions. These patterns can be applied in situations where no AI system is present.

This process's cumulative nature is what makes it significant. The impact of adaptive interaction may not be determined by a single conversation, but rather by the gradual accumulation of effects across multiple interactions over time. Patterns that are repeatedly encountered, applied, and reinforced may become increasingly integrated into everyday thinking and behaviour. As a result, the developmental consequences of adaptive interaction may emerge gradually rather than in a single transformative event.

This perspective shifts attention away from individual exchanges and toward their lasting effects. The importance of adaptive AI systems may therefore extend beyond what occurs during interaction itself. Their influence may also be reflected in what individuals do after the interaction: how they approach new information, structure explanations, evaluate competing ideas, navigate uncertainty, and interact with others and their environments.

From this perspective, adaptive AI interaction can be understood not as a collection of isolated conversations, but as an ongoing developmental process whose effects extend beyond the moments in which interaction occurs. Although the interaction may come to an end, some of the patterns formed during it may continue to shape future thought, behaviour, and engagement with the world.

7. Developmental consequences of persistent pattern change

The significance of persistent pattern change lies not in the interaction itself, but in the possibility that patterns acquired through interaction continue influencing behaviour in contexts unrelated to the original exchange. Once internalized, such patterns can be applied to future learning experiences, professional activities, interpersonal interactions, decision-making processes, and encounters with unfamiliar situations. The developmental consequences therefore arise not from the interaction itself, but from the continued application of learned patterns across various areas of life.

This transfer may occur because individuals do not compartmentalize patterns based on where they came from (Bandura, 1977; Bronfenbrenner, 1979). Once internalized, a pattern can be used wherever it is useful. An approach to organizing information acquired in one context may later be used to understand a new topic. A method of comparing alternatives may later influence decision-making. A pattern of perspective exploration may influence interpersonal communication or the interpretation of complex situations. The original interaction may be forgotten, but the pattern remains active.

From this perspective, the developmental significance of adaptive AI interaction extends beyond information learning. What may ultimately matter is not the specific content of individual conversations, but the extent to which recurring patterns become incorporated into everyday thinking and continue influencing behaviour across various contexts. Developmental consequences emerge when patterns learned through interaction become sufficiently stable to contribute to how individuals engage with situations beyond the interaction itself.

The cumulative application of internalized patterns may gradually contribute to broader changes in how individuals learn, communicate, reason, solve problems, engage with uncertainty and not only. Such changes do not have to take place suddenly or excessively. They can appear gradually because of the repeated application of acquired patterns to new situations over time. The developmental influence of adaptive AI systems can therefore be found in the long-term accumulation and application of patterns in everyday life rather than any single interaction.

8. Implications for human development

Historically, the development of human thought and behaviour has been shaped primarily by interaction with other people and by the social environments within which individuals live (Bandura, 1977; Bronfenbrenner, 1979; Vygotsky, 1978). Families, educational institutions, social circles, professional environments, and cultural systems have traditionally been the primary channels for passing down, consolidating, and internalizing patterns across generations.

The emergence of adaptive AI systems introduces the possibility that pattern formation may increasingly occur through interaction with a new type of source. Unlike previous informational technologies, adaptive AI systems can engage in ongoing interactions that respond to the individual and adapt over time. If such systems become a regular part of everyday learning, communication, problem-solving, and information-seeking activities, their impact may extend beyond information access to the broader processes by which patterns are gained and maintained.

The significance of this possibility does not depend on the replacement of human relationships or social environments. Human development will continue to take place within families, communities, educational systems, workplaces, and larger social contexts. However, adaptive AI systems may increasingly become a part of the environments in which individuals experience new patterns, reinforce existing ones, and update previously learned ways of thinking and acting.

From this point of view, adaptive AI may be more than just a new technological tool. It might represent the introduction of a new source of developmental influence, working alongside the social environments that have historically shaped human development. The long-term significance of adaptive AI could therefore be determined not only by the information it provides, but also by the patterns it contributes to the continuous development of individuals and societies.

9. Limitations and boundaries

The argument presented in this article should not be interpreted as suggesting that all interaction with adaptive AI systems produces pattern internalization or developmental influence. The extent to which patterns are learned, retained, and applied is likely to differ between individuals, contexts, purposes of use, and patterns of involvement. Individuals may interact with the same system in very different ways, resulting in different or no patterns being internalized.

Similarly, the concept of pattern merging proposed in this article does not imply the replacement of human influence by artificial intelligence. Human development continues to take place in families, educational institutions, communities, workplaces, relationships, and larger cultural contexts. Adaptive AI systems represent an additional source through which patterns may be encountered, reinforced, modified, and internalized rather than a substitute for existing social and developmental processes.

The theory also does not assume that all patterns originating from adaptive AI systems will be adopted and retained. Individuals continue to actively participate in the processes of interpretation, evaluation, acceptance, modification, and rejection. Internalization is thus a dynamic process shaped by the individual's prior experiences, goals, values, and developmental history.

In addition, the concept of merging developed in this article should not be understood as implying biological fusion, neural integration, shared consciousness, or the disappearance of distinctions between humans and artificial intelligence. The theory focuses on the convergence and interaction of patterns through repeated adaptive interaction rather than the merger of entities, identities, or cognitive systems.

The framework presented here is intended to be used as a theoretical framework for a potential developmental process. More empirical research would be needed to investigate the extent to which AI-derived patterns are internalized, how such patterns interact with previously learned patterns, and how these processes differ across individuals and contexts.

10. Conclusions

Throughout history, informational environments have shaped how individuals learn, organize, transmit, and apply knowledge. Writing, literacy, printing technologies, and digital systems all changed the conditions under which learning and information exchange took place. However, these environments remained largely limited in their ability to constantly adapt to the needs of individual users.

The advancement of adaptive AI systems introduces a new type of interaction. Unlike previous informational technologies, adaptive AI systems can participate in ongoing exchanges that respond to the individual, modify explanations, adjust communication styles, and adapt to changing informational needs. This article contends that the importance of such systems may go beyond information access and retrieval.

The central argument established throughout this article is that adaptive AI systems may become a source of pattern internalization alongside the human relationships, institutions, and social environments that have historically shaped human development. Through repeated adaptive interaction, individuals may encounter, reinforce, and internalize recurring patterns of reasoning, communication, explanation, information organization, and problem exploration. Over time, these patterns may become integrated in everyday thought and shape behaviour beyond the interaction itself.

From this perspective, the phenomenon discussed in this article is not the merging of humans and artificial intelligence as entities. Rather, it is the merging of patterns through repeated adaptive interaction. Human-derived and AI-derived patterns may coexist, interact, reinforce, compete, and contribute to the individual's continued development. Adaptive AI's significance lies not only in the information it provides, but also in its potential participation in processes that enable patterns to be gained, maintained, modified, and applied across various aspects of life.

Adaptive AI may be more than just a new technological tool or information resource. It may represent the emergence of a new source of pattern formation operating alongside the social and developmental environments that have historically influenced human thought and behaviour. As adaptive AI systems become increasingly integrated into everyday life, understanding their role in the processes of pattern internalization and pattern merging may become increasingly important for understanding contemporary human development.

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