ARTIFICIAL INTELLIGENCE AND COGNITIVE BOUNDARIES: A CRITICAL EXAMINATION OF INTELLIGENCE, UNDERSTANDING, AND CONSCIOUSNESS

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Abstract: This paper critically examines the cognitive limitations of artificial intelligence (AI) by juxtaposing its operational capacities and conceptual understanding with human cognition. While AI has demonstrated remarkable advancements in data processing, pattern recognition, and task automation, it remains fundamentally constrained in its ability to achieve higher-order cognitive functions such as abstract reasoning, contextual comprehension, and self-awareness. By drawing upon multidisciplinary perspectives from cognitive science, psychology, philosophy, and computer science, this study systematically explores the key areas in which AI exhibits significant cognitive deficits in comparison to human intelligence. The paper engages with critical discussions advanced by scholars such as Nicholas Carr and Ramon López de Mántaras, scrutinizing AI's purported intelligence and its limitations in attaining genuine "understanding" beyond syntactic processing. Central to this examination is the question of whether AI can truly possess semantic comprehension or whether it merely simulates intelligence through statistical correlations and probabilistic models. Furthermore, the study addresses philosophical inquiries regarding the nature of consciousness, intentionality, and the potential for machine self-awareness, analyzing whether AI can ever transcend its current status as an advanced tool and evolve toward autonomous cognition. Through a synthesis of contemporary literature and theoretical frameworks, this analysis elucidates the inherent "glass ceiling" of AI evolution—the boundary beyond which artificial systems, constrained by their algorithmic foundations and lack of experiential embodiment, struggle to achieve human-like cognitive flexibility and adaptive learning. The discussion highlights the implications of these limitations for AI ethics, decision-making, and its integration into critical societal domains such as healthcare, education, and governance. The paper advocates for a measured and cautious approach to AI development and deployment, emphasizing the necessity of recognizing and critically addressing its cognitive constraints. By fostering a nuanced understanding of AI's strengths and weaknesses, the study underscores the importance of maintaining human oversight in AI applications, ensuring that artificial systems complement rather than replace human judgment in complex and ethically significant contexts. In doing so, this research contributes to ongoing debates on the role of AI in shaping the future of intelligence, creativity, and decision-making in an increasingly digital world.
Keywords: Artificial Intelligence, Cognitive Limitations, Machine Consciousness, Human Cognition, Computational Understanding

1. INTRODUCTION

In the contemporary digital age, artificial intelligence (AI) has emerged as a transformative force profoundly reshaping human activities across diverse sectors including healthcare, education, industry, and governance. The exponential growth in AI capabilities, particularly within domains such as machine learning, deep neural networks, and natural language processing, has elicited widespread discourse on the implications of delegating human cognitive tasks to computational systems. However, despite rapid technological advancements, fundamental cognitive barriers continue to delineate clear distinctions between artificial intelligence and human cognition (Marcus & Davis, 2019). Central to these distinctions are higher-order cognitive faculties—abstract reasoning, semantic comprehension, intentionality, contextual adaptation, and self-awareness—which remain notably elusive for AI systems (Carr, 2021). Historically, the conceptual understanding of artificial intelligence has evolved significantly. Early AI systems were narrowly focused, algorithmically rigid, and inherently limited to precise computational instructions. Contemporary iterations, such as OpenAI's GPT-4 and DeepMind's AlphaGo, showcase remarkable advancements in autonomous decision-making, pattern recognition, and predictive analytics. These advances suggest a sophisticated imitation of human cognitive processes. Nonetheless, scholars have argued that AI's apparent intelligence is fundamentally superficial, driven largely by statistical correlations, probabilistic models, and syntactic manipulations rather than genuine semantic understanding (López de Mántaras, 2016; Searle, 1980). This ongoing scholarly discourse raises significant epistemological and ethical questions concerning the limits of AI and its prospective role within complex societal frameworks. The philosophical inquiries concerning AI cognition are particularly profound, as they interrogate the very nature of intelligence, understanding, and consciousness. The philosopher John Searle (1980) prominently challenged AI's claim to understanding through his

Chinese Room thought experiment, asserting that computational manipulation of symbols does not equate to genuine semantic comprehension. Similarly, David Chalmers (1995) articulated what he termed the "hard problem" of consciousness, highlighting that subjective experiences—qualia—remain inherently inaccessible to computational models. Such arguments underscore the persistent philosophical contention regarding AI's capability for authentic cognition beyond algorithmic performance. Moreover, AI's deficiency in intentionality—the quality of cognitive states to be directed towards objects or states of affairs—has been a longstanding critique by philosophers like Franz Brentano (1995, originally 1874) and Daniel Dennett (1991). Intentionality requires an experiential and embodied foundation, often linked to evolutionary processes, that purely computational systems fundamentally lack (Dennett, 1991). Embodied cognition theorists further suggest that genuine cognitive processes cannot exist in isolation from sensory and environmental interactions, a critical limitation within current AI paradigms (Pfeifer & Bongard, 2006; Hoffman & Pfeifer, 2018). These theoretical perspectives collectively delineate an intrinsic "glass ceiling" in AI's cognitive potential—a boundary defined by its reliance upon statistical algorithms devoid of experiential grounding or subjective awareness (Tononi & Koch, 2015). Such limitations have profound practical and ethical implications, especially given AI's integration into critical societal sectors. For example, the European Commission's recent AI Act explicitly addresses AI's cognitive limitations and mandates robust human oversight, precisely because AI lacks authentic ethical judgment and adaptive flexibility (European Commission, 2021). Consequently, recognizing AI's inherent cognitive constraints is crucial to framing its ethical use and societal deployment. Scholars emphasize a cautious and balanced approach toward AI development, promoting technologies that complement rather than supplant human cognition and ethical judgment (Bostrom & Yudkowsky, 2014; Floridi, 2023). This careful positioning ensures AI's strengths—such as rapid data processing, automation, and scalability—are leveraged responsibly, while its weaknesses are explicitly acknowledged and mitigated. This paper critically examines these cognitive boundaries, juxtaposing AI's operational capabilities against human cognitive faculties through multidisciplinary perspectives drawn from philosophy, cognitive science, psychology, and computer science. It engages deeply with critical insights from scholars including Nicholas Carr and Ramon López de Mántaras, systematically analyzing whether AI systems can ever genuinely surpass their current state of advanced statistical simulation toward authentic understanding, consciousness, and intentionality. Through this nuanced discourse, the paper contributes to ongoing scholarly debates surrounding the ethical deployment and cognitive limits of artificial intelligence, offering both theoretical clarity and practical guidance for future developments in AI technologies.

2. MAIN DISCUSSION: AI'S COMPUTATIONAL BOUNDARIES AND HUMAN COGNITION

Central to examining artificial intelligence's cognitive limitations is the distinction between semantic understanding and syntactic processing. Current AI systems, including advanced natural language models like GPT-4, exhibit substantial proficiency in processing and generating human-like linguistic outputs. These models utilize complex statistical correlations and probabilistic inference methods to achieve seemingly sophisticated communicative abilities. However, the philosophical critique first articulated by John Searle (1980) remains pertinent; computational systems, regardless of their apparent proficiency, do not genuinely comprehend semantics or meaning. Searle's Chinese Room argument asserts clearly that: "Syntax by itself is neither constitutive nor sufficient for semantics" (Searle, 1980, p. 423). AI systems fundamentally process symbols without intrinsic understanding of meaning. The outputs of AI, therefore, represent syntactic manipulations rather than true semantic comprehension. This critical distinction remains relevant today, as noted by contemporary scholars such as Marcus and Davis (2019), who assert that genuine understanding necessitates a cognitive substrate grounded in experiential reality—something beyond the reach of current computational architectures. Nicholas Carr (2021) further emphasizes AI's semantic limitations by describing the qualitative difference between human thought processes and AI-generated outputs. Carr notes that AI systems simulate cognition superficially, but without understanding context, metaphor, irony, or the subtleties of cultural meaning. Humans naturally integrate context, embodied experiences, and emotional intelligence, enabling abstract reasoning and creative problem-solving. By contrast, AI struggles with contextual comprehension, as evidenced by its notorious difficulties in interpreting nuanced human communication (Carr, 2021; Mitchell, 2021). Empirical research by Lake et al. (2017) supports these theoretical critiques, highlighting AI's significant limitations in abstract reasoning. Humans can generalize abstract concepts from minimal examples, transferring knowledge across contexts seamlessly. AI, however, typically requires extensive training data and structured learning environments, resulting in considerable rigidity. The absence of true abstraction and generalized reasoning significantly restricts AI's cognitive flexibility, particularly evident in unstructured or novel scenarios requiring genuine adaptive thinking (Lake et al., 2017; López de Mántaras, 2022). Furthermore, AI's shortcomings in abstract reasoning present critical limitations for real-world applications. For instance, algorithmic biases and contextual errors in facial recognition technology, extensively documented by Buolamwini and Gebru (2018), highlight the practical consequences of AI's semantic inadequacies. Their study illustrates AI's tendency to perpetuate biases and make errors when contextual nuances—such as cultural and intersectional identity factors—are overlooked or misunderstood due to purely computational logic (Buolamwini & Gebru, 2018). Thus, the persistent limitation of AI systems in semantic comprehension and abstract reasoning underscores a fundamental cognitive boundary delineating human intelligence from computational simulation. While AI excels at tasks characterized by clear algorithms, extensive datasets, and structured environments, it remains profoundly limited in handling complexities requiring true semantic and abstract cognition.

Philosophical challenges to artificial intelligence

Beyond semantic and abstract limitations, philosophical discourse intensifies when addressing consciousness, intentionality, and self-awareness within AI systems. These cognitive dimensions represent foundational aspects of human cognition and remain profoundly elusive for artificial computational systems. Philosophers and cognitive scientists emphasize the qualitative aspects of consciousness—often referred to as qualia—as inherently inaccessible to computational processes. David Chalmers (1995) famously delineated the “hard problem” of consciousness, distinguishing it sharply from computational or neurological explanations of cognitive functions: “The really hard problem of consciousness is the problem of experience… even when we have explained the performance of all cognitive and behavioral functions, we still may not have explained why there is subjective experience” (Chalmers, 1995, p. 201). Chalmers' analysis underscores the qualitative gap between artificial cognition, grounded in algorithms, and human consciousness, inherently subjective and experiential. Similarly, philosopher Thomas Nagel (1974) reinforced this idea, famously exploring the subjective character of consciousness in his seminal essay, "What is it like to be a bat?". Nagel argued that subjective experience is irreducible to purely physical or computational explanations, emphasizing the uniqueness and irreproducibility of subjective states through computational methods: “If physicalism is to be defended, the phenomenological features must themselves be given a physical account. But when we examine their subjective character, it seems that such a result is impossible” (Nagel, 1974, p. 437). These philosophical arguments present substantial theoretical barriers for AI achieving genuine consciousness or self-awareness. Artificial systems inherently lack subjective experience and, as a result, intentionality—the quality of mental states being directed toward objects or external states of affairs. Franz Brentano (1874/1995) notably argued that intentionality fundamentally distinguishes mental phenomena from purely physical or computational ones. Brentano’s influential assertion maintains that cognitive processes must inherently be about something external to themselves, an experiential and embodied quality computationally inaccessible to artificial systems. Daniel Dennett (1991) further explores intentionality and consciousness by emphasizing their evolutionary and embodied foundations. Dennett argues that intentional states and consciousness evolved as adaptive traits linked to survival and environmental interaction. He asserts that: “Intentionality is grounded in the biological processes that evolved naturally. Artificial computational processes inherently lack these evolutionary and embodied foundations” (Dennett, 1991, p. 45). From this perspective, artificial intelligence, constructed through algorithmic and syntactic manipulations, inherently lacks authentic intentionality and consciousness due to its lack of biological and evolutionary grounding. The Integrated Information Theory (IIT), developed by Giulio Tononi and Christof Koch (2015), further supports philosophical skepticism regarding AI consciousness. IIT asserts that consciousness emerges from complex, highly integrated information-processing systems inherently linked to biological substrates. According to Tononi and Koch (2015), consciousness necessitates both informational complexity and integration, features structurally inaccessible to current computational architectures. These philosophical perspectives collectively indicate a robust theoretical boundary preventing artificial intelligence from attaining genuine consciousness, intentionality, or self-awareness. Consequently, AI remains confined within algorithmic operations devoid of subjective experience, genuine intentionality, and qualitative self-awareness. An essential cognitive boundary separating artificial intelligence from human intelligence resides in the concept of embodied cognition—the principle that cognition inherently emerges from bodily interactions with the physical and social environment (Pfeifer & Bongard, 2006). Embodied cognition suggests that intelligence cannot exist in isolation as mere symbolic processing; rather, it is deeply grounded in sensory-motor experiences, physical interactions, and dynamic environmental exchanges (Hoffman & Pfeifer, 2018). While current AI systems, including sophisticated robotics, partially simulate sensory-motor functions, their interactions remain fundamentally algorithmic, devoid of genuine embodied experiences. Rodney Brooks (1991), a foundational figure in robotics, has notably argued that intelligence is intrinsically linked to the agent’s capacity for real-world interaction rather than solely abstract computation. Brooks critiques traditional AI approaches, which rely heavily on representation and symbol manipulation, asserting that genuine cognition emerges through direct physical interaction with the environment. He proposes the paradigm of "intelligence without representation," emphasizing real-world embodiment as central to authentic intelligence (Brooks, 1991). This critique directly implicates current AI methodologies, highlighting their significant shortcomings due to reliance on algorithmic abstraction rather than genuine embodied interaction. Empirical studies further underscore AI's limitations in embodied learning. Hoffman and Pfeifer (2018) demonstrate that robotic systems lacking authentic sensory-motor grounding encounter substantial difficulties performing even basic adaptive tasks when confronted with unpredictable physical environments. In contrast, human cognition effortlessly integrates sensory input, motor responses, and environmental context, adapting dynamically to changing conditions. This adaptability remains notably absent in computational simulations due to their inherently non-embodied architecture (Lake et al., 2017). Embodied cognition also implies social and emotional intelligence—capacities dependent on experiencing meaningful social interactions. Recent studies, such as those reviewed by Lamb et al. (2020), emphasize AI's persistent difficulty simulating authentic social cognition due to the fundamental lack of genuine embodied social experiences. While algorithms can approximate certain emotional expressions, their lack of authentic social embodiment severely restricts meaningful interpersonal interactions. This limitation particularly impacts AI's integration into domains such as healthcare, education, and caregiving, where nuanced social understanding and genuine empathy are critical (Floridi, 2019). Thus, embodied cognition establishes a significant conceptual and practical limitation for artificial intelligence. Without authentic embodied experiences and real-world environmental interaction, AI remains confined within superficial, algorithmically driven simulations, incapable of achieving human-level cognitive flexibility, adaptability, or social-emotional intelligence. AI's inherent cognitive constraints—particularly limitations regarding semantic understanding, consciousness, intentionality, and embodied cognition—carry profound ethical and societal implications. Misjudging AI's capacities can lead to severe real-world consequences, especially when AI systems are deployed in critical domains such as healthcare, criminal justice, education, and governance (European Commission, 2021). Ethical concerns primarily arise from AI's inability to comprehend moral contexts genuinely, recognize biases autonomously, or adapt ethically to complex situations requiring nuanced judgment and sensitivity (Mittelstadt et al., 2016). Bostrom and Yudkowsky (2014) argue that ethical vigilance must accompany AI development precisely because AI systems lack intrinsic moral intentionality and autonomous ethical discernment. AI, they assert, remains fundamentally amoral—algorithmically driven and devoid of genuine ethical comprehension—thus necessitating rigorous human oversight to ensure ethically sound deployment. This is echoed by Floridi (2019), who emphasizes that the moral agency required for authentic ethical decision-making remains fundamentally absent from artificial computational frameworks. Floridi argues explicitly for strong regulatory measures and continual human oversight to safeguard ethical standards and human values in AI-driven processes. Practical examples of AI's ethical failures illustrate these concerns vividly. Buolamwini and Gebru's (2018) research on racial and gender biases within facial recognition algorithms highlights the real-world impact of AI's contextual inadequacies. Their findings indicate that algorithmic biases disproportionately affect marginalized groups due to AI's intrinsic incapacity to perceive nuanced social, cultural, and ethical contexts autonomously. Such systemic ethical oversights underline AI's persistent cognitive limitations and their substantial ethical ramifications.

Further, the recent European Commission's Artificial Intelligence Act (2021) directly addresses these cognitive and ethical limitations, recognizing explicitly that AI systems require comprehensive oversight, transparency, and accountability. The regulation underscores the imperative of maintaining human oversight precisely because AI's cognitive limitations preclude genuine ethical autonomy or reliable moral judgment. Thus, ethical frameworks must explicitly acknowledge AI's inherent cognitive constraints, emphasizing stringent regulations, transparency requirements, and persistent human involvement in ethically sensitive applications. This cautious and ethically informed stance promotes AI as a supportive tool rather than an autonomous ethical agent, ensuring its responsible and beneficial societal integration.

3. CONCLUSIONS

The critical examination presented in this study reveals substantial and inherent cognitive limitations within contemporary artificial intelligence systems, explicitly delineating the boundaries separating AI from genuine human cognition. While recent advances have undeniably enhanced AI's capabilities in areas such as pattern recognition, natural language processing, and predictive analytics, deeper philosophical and cognitive-scientific analyses illustrate fundamental barriers that persistently limit AI's capacities. These barriers specifically involve semantic comprehension, abstract reasoning, contextual adaptation, intentionality, consciousness, and embodied interaction—faculties central to human cognition yet elusive to computational frameworks. At its core, the persistent semantic gap identified by scholars such as John Searle (1980), Nicholas Carr (2021), and Ramón López de Mántaras (2022) underscores AI's inherent inability to transition from mere syntactic manipulation to authentic semantic understanding. AI systems excel at processing language and information algorithmically, yet fundamentally lack genuine comprehension of context, nuance, metaphor, irony, or intentionality. This limitation significantly restricts AI's cognitive adaptability and underscores its intrinsic reliance on extensive training datasets and algorithmic specificity, preventing meaningful generalization beyond familiar scenarios. Philosophical inquiries further solidify these cognitive boundaries. David Chalmers's (1995) conceptualization of the "hard problem" of consciousness clearly differentiates between computational explanation and the qualitative aspects of subjective experience (qualia). Thomas Nagel (1974), similarly, argues convincingly for the irreducibility of subjective experience to purely computational or physical explanations, emphasizing the inherent qualitative uniqueness of human consciousness. From an intentional standpoint, philosophers including Franz Brentano (1874/1995) and Daniel Dennett (1991) argue decisively that intentional states are fundamentally embodied, evolutionary products inaccessible to purely algorithmic entities. These philosophical arguments are reinforced by contemporary cognitive-scientific frameworks such as Tononi and Koch's (2015) Integrated Information Theory, which stipulates specific informational and biological conditions for consciousness that current artificial architectures inherently fail to meet. Additionally, theories of embodied cognition, as articulated by Pfeifer and Bongard (2006) and Rodney Brooks (1991), establish that genuine cognition necessitates physical embodiment and real-world interaction—conditions fundamentally absent from computational simulations. These cognitive limitations are not merely theoretical but carry significant practical and ethical implications. AI's inability to genuinely comprehend context or ethical nuance has led to serious issues in societal integration, particularly exemplified by algorithmic biases documented by Buolamwini and Gebru (2018). Ethical scholars such as Floridi (2019), Mittelstadt et al. (2016), and Bostrom and Yudkowsky (2014) emphasize the essential requirement for robust regulatory frameworks, comprehensive human oversight, and transparency, precisely because AI systems lack authentic ethical judgment and moral intentionality. These concerns have prompted concrete policy responses, such as the European Commission's AI Act (2021), which explicitly mandates continued human oversight and accountability mechanisms. Future developments in AI, such as neuro-symbolic and embodied robotic approaches (Lamb et al., 2020; Hoffman & Pfeifer, 2018), offer incremental progress but do not fundamentally circumvent these deep philosophical and cognitive constraints. Incremental improvements may narrow the gap superficially, but genuine semantic comprehension, intentionality, self-awareness, and true abstract reasoning are predicted to remain beyond algorithmic reach due to AI's inherent structural and experiential deficiencies. This research, therefore, advocates for cautious and informed optimism regarding artificial intelligence. Recognition and explicit acknowledgment of AI's intrinsic cognitive limitations must inform future development strategies, deployment decisions, and ethical frameworks. Rather than positioning AI as a replacement for human cognitive functions, stakeholders must strategically leverage AI's strengths—such as its computational speed, consistency, and scalability—to complement and augment human cognition, particularly within ethically sensitive societal contexts. Such complementary roles for AI require ongoing human oversight, careful ethical guidance, and clear regulatory frameworks to ensure beneficial outcomes. In conclusion, by critically delineating AI's cognitive boundaries and advocating for a measured and responsible approach, this study contributes meaningfully to ongoing scholarly debates and practical discussions on the future of artificial intelligence in contemporary society. Clearly understanding these boundaries ensures that AI is developed and integrated ethically and effectively, ultimately complementing rather than replacing genuine human insight, judgment, and consciousness.

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