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Review

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Entangled Cognition: Exploring the Links Between Mind, Body, and Environment in the Era of AIeD

Hsu, Liwei*

Graduate Institute of Hospitality Management, National Kaohsiung University of Hospitality and Tourism, Kaohsiung City, Taiwan, China.

***Correspondence to:** Hsu Liwei, Institute of Hospitality Management, National Kaohsiung University of Hospitality and Tourism, Kaohsiung City, Taiwan, China. Email: liweihsu@mail.nkuht.edu.tw

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Abstract: This article analyzes embodied and entangled cognition models, which assert that cognitive processes are rooted in the body and influenced by environmental factors, including artificial intelligence (AI). These models challenge the traditional notion of cognition as solely mental, arguing that thought, emotion, and action arise from bodily interactions and environmental connections. The article examines the implications of these views, urging a reevaluation of cognitive models to reflect the interplay between mind, body, and environment. It discusses how embodied cognition draws from phenomenology, neuroscience, and psychology to show how sensorimotor experiences affect cognitive function. Entangled cognition proposes that cognition is shared across social and material contexts, calling for novel approaches to collective cognition studies. Furthermore, the article addresses the practical implications of these models. Embodied and entangled cognition in education offer frameworks for creating engaging learning environments that promote physical interaction and collaboration. Regarding AI, these concepts guide the design of systems that can adapt to human contexts by simulating embodied experiences. Lastly, the article suggests future research directions, emphasizing interdisciplinary studies that connect theory to practice, ultimately fostering a comprehensive understanding of cognition as embodied and interconnected.

Keywords: Artificial intelligence in education (AIeD); Embodied cognition; Entangled cognition

1. Introduction

Traditionally, cognition has been viewed as a solitary mental process, akin to a computer's central processing unit operating independently of its hardware. This classical cognitive science perspective, rooted in abstract information processing, portrays the brain as a self-contained system that manipulates symbols and representations, detached from the physical world (Shapiro, 2012; Tanton, 2023). However, emerging theories of embodied and entangled

cognition challenge this isolated understanding of the mind, emphasizing the role of sensory experiences, emotional states, and environmental contexts.

In contrast, emerging embodied and entangled cognition theories challenge this segmented understanding of the mind. Embodied cognition asserts that cognitive processes are fundamentally linked to the body's engagement with its surroundings. It posits that physical experiences significantly shape our thoughts, emotions, and actions. This implies that cognition transcends mere mental activity; it is fundamentally rooted in our sensory and motor systems in the brain (Clark, 2011; Gallagher, 2006). For example, our perception of objects, language comprehension, and problem-solving capabilities are profoundly influenced by our body's configuration and environmental movement (Barsalou, 2008).

Entangled cognition further expands this concept by suggesting that cognition is embodied, distributed, and interconnected among individuals and their environments (Aguayo et al., 2023; Jacob et al., 2023; Wilson & Golonka, 2013). This viewpoint underscores the intricate interactions between mind, body, and social and material context, suggesting that cognitive processes extend beyond individual boundaries. They are co-constructed through interactions with others and our surroundings (Varela et al., 2017). This interconnected perspective emphasizes the significance of shared experiences, cultural practices, and technological artifacts in shaping cognitive abilities.

This article intends to synthesize ongoing research on these interconnected cognitive frameworks, emphasizing their practical implications. By analyzing the theoretical foundations, empirical support, and practical implications, we aim to excite our audience about the potential applications in their respective fields. Investigating the dynamic interplay between mind, body, and environment, this review aims to provide new insights into our understanding of cognition, challenging established divisions and advocating for more integrated models that reflect the intricacies of human thought and behavior.

2. Theoretical Foundations

Embodied cognition posits that cognitive functions extend beyond the brain, incorporating the entire body. This perspective establishes a "body-cognition-situation" framework. It helps us understand how the interactions of these elements influence perception and memory (Huang et al., 2024). The synergy of action, emotion, and perception systems (Dove, 2022) demonstrates that bodily sensations and motor movements significantly shape thoughts and feelings, coalescing into human experience (Sullivan, 2018). In Wilson's view (2002), cognition is "grounded in sensory and motor processes," necessitating a comprehensive approach that includes bodily involvement.

Furthering this discussion, entangled cognition highlights the ongoing relationship between mind, body, and environment (Pessoa, 2023). Researchers like Barsalou (2015) and Glenberg et al. (2013) assert that cognitive processes are embodied and deeply rooted in environmental contexts. External factors substantially affect internal states, including values, experiences, and aspirations for growth (Whisler et al., 2019). Clark (2011) encapsulates this concept with "the extended mind," wherein tools, social interactions, and cultural settings altogether play crucial roles in our cognitive activities.

This review invites a reevaluation of traditional cognitive frameworks, suggesting that understanding human thought requires consideration of the broader ecological contexts in which individuals operate. We can better grasp the complexity of mental processes by emphasizing the significance of interactions between cognitive agents and their environments. Integrating these insights, the notion of "situated cognition" (Suchman, 1987) becomes critical; it posits that knowledge formation occurs within specific contexts influenced by social, cultural, and physical elements. This approach aligns with recent findings indicating that cognitive flexibility and adaptability are paramount in navigating real-world challenges (Adams et al., 2020). The implications extend to educational practices, where fostering environments encouraging embodied learning and multimodal engagement could enhance cognitive development.

Moreover, as we continue to dissect the intricate dynamics between cognition, emotion, and the physical world, current research must consider the implications of digital environments. The rise of technology reshapes how we think and interact and how we experience the world, making this an exciting front for future inquiry (Kirk et al., 2022). This evolving landscape demands

a reconsideration of methodologies and frameworks in cognitive science, aiming to integrate advancements in neuroscience with psychological and sociocultural perspectives.

3. Empirical Evidence

Cognitive science research often analyzes how physical conditions impact cognitive activities (Aitken & MacMahon, 2019; Zhang, 2024). Notably, studies by Beilock and Holt (2007) reveal that athletes excel in cognitive tasks related to their sport, underscoring the profound connection between physical experience and cognitive skills. In a related context, research by Kekäläinen et al. (2023) emphasizes the beneficial effects of physical activity on students' cognitive performance. These advantages extend to various aspects of learning, including attention, executive functions, memory, creativity, stress resilience, and mental health (Chen et al., 2024). From the biological point of view, recent research shows that physical activity enhances cognitive functions in older adults. It mitigates age-related cognitive decline by engaging various genetic and epigenetic pathways (Zhang et al., 2024).

Furthermore, neuroscientific investigations (Kiverstein & Miller, 2015; Tran et al., 2017) support the concept of embodied cognition, demonstrating that sensorimotor brain regions activate during abstract reasoning. For example, Gallese and Lakoff (2005) discovered that reading action-related words triggers the same neural pathways as executing those actions. Psychophysiological assessments highlight the strong ties among emotional, cognitive, and physical states. Damasio (1999) illustrated that bodily states significantly influence decision-making, reinforcing emotions' embodied perspective. These findings hold practical implications across numerous domains. In education, integrating physical activity into learning has been shown to improve memory and comprehension, as evidenced by kinesthetic learning research (Shapiro & Stolz, 2019). In artificial intelligence, designing systems that emulate human cognitive processes—including sensory and emotional aspects—aims to create machines that are more intuitive and responsive (Pfeifer & Bongard, 2006). In therapeutic practices, acknowledging the body's and environment's influence on mental health has sparked more holistic treatment methods, utilizing techniques like mindfulness and somatic therapy that engage the body to affect mental well-being (Fuchs & Koch, 2014).

Moreover, this integrative approach broadens our understanding of the mind-body connection and encourages interdisciplinary collaboration. Fields such as neuropsychology, affective computing, and human-computer interaction are increasingly intersecting, leading to innovations that enhance user experience and therapeutic efficacy. For instance, the development of wearable technologies that monitor physiological indicators of stress and anxiety presents new avenues for real-time interventions, allowing individuals to manage their emotional states actively (Holt-Lunstad et al., 2010). Such advancements underscore the necessity of a comprehensive framework that respects the intricacies of human behavior, prompting researchers and practitioners alike to consider the multifaceted nature of human experience when addressing both cognitive and emotional challenges. Consequently, fostering environments—whether educational, technological, or therapeutic—that prioritize this interconnectedness stands to yield a more profound impact on individual and collective well-being.

4. Future Directions

Future studies should blend embodied and entangled cognition concepts. Researchers must explore their interactions with cultural and technological influences. Human environments grow more complex, merging digital and physical realities. Thus, understanding these interactions is crucial for cognitive processes. For example, studies can investigate how technologies like AI and virtual settings affect embodied cognition. Also, they should assess whether these tools change how cognition distributes across the body and environment.

Additionally, examining cultural practices in shaping embodied cognition reveals differences in cognitive processes among societies. This can enhance our understanding of these cognitive phenomena' universal or specific. Longitudinal studies can track the evolution of embodied and entangled cognition, especially amid changing cultural and technological contexts. Such research should address how ongoing exposure to AI or immersive tools affects cognitive growth, decision-making, and problem-solving abilities. Cross-cultural analyses can shed light on how diverse contexts

influence the integration of bodily and environmental factors in cognition. These investigations may highlight how cultural norms and AI technologies shape cognitive processes. The results could inform tailored educational and therapeutic strategies.

Finally, future explorations are advised to examine the ethical consequences of merging embodied and entangled cognition into technology designs, especially in AI and human-computer interaction. As AI advances, replicating or supporting human cognitive processing—like emotions and sensory experiences—will be essential for creating compelling, ethical technologies aligned with human values. By tackling these directions, researchers can foster a more nuanced understanding of cognition that considers the intricate interplay between mind, body, environment, culture, and technology. Examining these interactions requires a multi-disciplinary approach, integrating insights from psychology, neuroscience, and anthropological studies. This comprehensive lens will enable researchers to understand how different cultural backgrounds shape individuals' interactions with AI and other immersive technologies. Furthermore, longitudinal studies could provide invaluable data on how continuous engagement with these tools evolves, influencing cognitive functions and adaptability.

Moreover, assessing the potential disparities in access to advanced technologies across various demographics is crucial. Understanding these dynamics will aid in identifying barriers that may hinder specific groups from reaping the cognitive benefits of innovation. Consequently, strategies must be developed to ensure equitable access and foster an environment where technology serves as an enhancer of cognitive capabilities rather than a source of division.

Ultimately, as we advance into an era where AI becomes increasingly prevalent, the ethical frameworks guiding our research and applications must be rigorously scrutinized. By prioritizing human-centric design principles that respect and amplify our cognitive strengths, we can strive towards a future where technology and humanity would go hand in hand, creating a symbiotic relationship that enhances our shared experiences and societal progress.

5. Conclusion

Embodied and entangled cognition theories reveal crucial insights about links between the mind, body, and environment. These connections provide a deeper understanding of human experience. Unlike traditional cognitive models that compartmentalize mental functions, these theories highlight the interactive nature of cognition, physical well-being, social engagement, and cultural factors. This review emphasizes the need to apply these insights in theory and practice, spanning education, artificial intelligence, and therapeutic strategies. Understanding the intertwined aspects of cognition sheds light on how individuals think, learn, and interact with their surroundings. This understanding should guide the creation of more comprehensive and practical methodologies across disciplines. As we progress in this area, blending embodied and entangled cognition within interdisciplinary studies becomes essential for fostering innovations that reflect the intricacies of human thought.

Putting together these perspectives can accelerate the development of educational frameworks that are not only effective but also responsive to the diverse needs of learners. Educators can create curricula that resonate more profoundly with students by recognizing that cognition is situated within a dynamic interplay of bodily states, environmental contexts, and social interactions. Furthermore, advancing AI will benefit from these insights, as designing systems that mimic human thought processes requires understanding how cognition is grounded in both physical and contextual realities. Similarly, therapeutic approaches can be enhanced by integrating these cognitive theories, enabling practitioners to address psychological issues by considering the all-inclusive experience of individuals. Thus, forward moving the dialogue around embodied and entangled cognition is vital for paving the way toward a richer, more inclusive comprehension of human behavior and interaction with the world. This convergence of ideas will enhance theoretical discourse and translate into practical applications that promote well-being and innovative problem-solving in diverse fields.

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