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Embodied Cognition And Its Relevance On Human-Computer Interaction

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Abstract

This paper discusses embodied cognition as an importance albeit newer facet of cognitive studies, and human-computer interaction as a growing new field aimed at understanding the relationship between machine and user. Existing literature documents the various approaches within the field of embodied cognition. The paper progresses on to its links with HCI, and how two main domains, that of education and interface design, emerge as areas with maximum research, indicating that the need for this amalgamation exists most urgently in those areas. The author also pointed out the gap in the research with the lack of material about children with learning disabilities and the scope of these concepts for their betterment. Further, on the subject of user interface, a fairly old idea of intuitive ubiquitous computing technology translates and finds its way to newer technology such as current research in artificial intelligence (AI) as well. Lastly, there are examples of situated cognition in organisations, that help us understand that this unique combination could support many fields and many disciplines improve functioning.

Introduction

Embodied Cognition

The APA online dictionary defines 'embodied cognition' as the theory that the human mind is largely determined by the structures of the human body (morphology, sensory and motor systems) and its interactions with the physical environment.

Antle (2012) describes embodiment as how the nature of a living entity's cognition is shaped by the form of its physical manifestation in the world. In other words, embodied cognition is the idea that human cognition is linked to sensory and motor processes. According to Antle, embodied theories of cognition explicate different mechanisms or processes by which aspects of perceptual and motor processes are tightly coupled to each other as well as to higher cognitive processes including languages and mathematics.

Dackermann, Fischer, Nuerk, Cress, and Moeller (2017) discuss the fundamental tenet of embodied cognition as thinking being an activity that s strongly influenced by body and the brain interaction with the environment, instead of it being something that is divorced from physical experiences.

Human-Computer Interaction

Human-Computer Interaction or HCI is a multidisciplinary field of study focusing on the design of computer technology and specifically the interactions between the machine and its users. Dourish (1999) speaks of HCI as an ongoing attempt to capitalise on the full range of human skills and abilities- not the ones that are acquired as a result of training, but rather abilities that come naturally and inherently that most people take for granted. The author also discusses the history of computers as machines that evolved from being capable of performing a singular task after a lot of manual programming, to its genesis into intelligent interface and more complex functions with minimal effort put in by the user.

Embodied Cognition

Cognitive science emerged as a field with the advent of computers, where the mind itself was also believed for a while to be an information-processing machine. Embodied cognition is an even newer subdomain under cognitive studies, with a focus on a holistic understanding of the processes that underlie cognition. The theory states that cognition is not dependent on the mind in isolation; instead, the body and its experiences play a role in the cognition of the individual. This means that the sensory and motor processes of the human body actually aid learning and thinking.

Needless to say, the implications of such a theory are vast. Multiple studies have attempted to understand the potential applications of such a concept. In a paper titled Four Applications of Embodied Cognition(2012), researchers came together to highlight how embodied cognition can be applied to various fields, namely law, literature and visual art, built environment, and music cognition. Benforado explains the possible uses of embodied cognition in law, by stating that the sensorimotor experiences of legal actors are linked intimately to their abstract thinking. The author then highlights how bodily experiences at key moments could bias or influence the decisions made by judges and juries, or impact an interrogation being conducted. Esrock talks about how body-driven research into literature and art is emerging, with some theorists positing that the reader's/viewer's bodily processes (such as breathing, muscular tensions, etc.) serve as non-imitative substitutes for components of the visual/verbal world. The author also quotes Lakoff and Johnson in stating that our bodily experiences in the world are reflected in metaphors that govern language use and concept in all domains. This kind of research in linguistics could prove useful since it would give a deeper insight intohuman thought. Turner and Dalton focused on embodiment in architecture and other special constructions, proposing the hypothesis that cognition of complex spatial environments occurs when an individual physically moves through them. Noorden and Leman believe that the way in which music is understood and used can be changed by viewing music as experience based on perception and action. They refer to people's movements while listening to music, pointing out that a lot of cultures do not have a distinction between music and dance. This could be applied to other roles for music, such as using it for spatial cognition. Further, it could also help in understanding the role of music in social interactions.

In Six Views of Embodied Cognition (2002), Wilson describes 6 distinct claims about embodied cognition. First, that cognition is situated, meaning it takes place in real-world settings. Second, that cognition is time-pressured, meaning it must be studied in the context of experiencing things in real-time. Next, that individuals off-load cognitive work onto the environment, meaning we make the environment hold or manipulate information for us so as to avoid an overload. Fourth, that the surrounding environment is a part of the cognitive system, and that the mind studied in isolation is not enough. Fifth, that cognition is for action, since the function of the mind is to guide action- cognitive processes must thus be understood in the context of their end-goal. Finally, that off-line cognition is body-based, meaning sensorimotor processes play a large role in cognition. The author substantiates these claims and makes distinctions between them using multiple detailed sources. In conclusion, the author writes that embodied cognition should be treated in reference to its specific viewpoints instead of studying it as singular viewpoint, so as to gain from the specificity of the distinctions. These viewpoints show that there are multiple approaches even to embodied cognition, even though it would seem like a singular idea. This would also mean that the different approaches view individuals differently. One approach, in line with the 'cognition is body-based' thought, has been outlined in Constraining Theories of Embodied Cognition (2005) by Markman and Brendl. Many studies in the embodied cognition model have demonstrated the link between perception, and sensory and motor processes. This paper quotes a study by Strack, Martin, and Stepper, wherein participants were asked to hold a pen in their mouths using either their lips (leading to a frowning posture) or their teeth (leading to a smiling posture). The participants were asked to evaluate cartoons while holding this posture. Smile-posture participants rated the cartoons funnier than frown-posture participants did. For their own study, the researchers were interested in examining the influence of evaluation on speed of motor movements. They quoted studies which talk about the movement of arms and their connection to people's evaluation. For example, Chen and Bargh's 1999 study demonstrated that participants would allot pulling arm movements for desirable words and pushing arm movements for undesirable or less desirable words. According to the authors, most theories of cognition do not assume direct connections between perception and motor action and are but rather assume that all cognitive representations are kinked to perceptual or motor modalities. The researchers' study is based on two assumptions- first, that the self is located in one's body and second, that evaluative movements therefore involve moving objects either toward or away from one's body, or self. The researchers constructed a variant of a task used in a previous study by researchers Chen and Bargh in which participants' representations of themselves were separated from their representations of their bodies.

Linkages To Human-Computer Interaction

As mentioned earlier, HCI is the multidisciplinary field of study focusing on the design of computer technology and specifically the interactions between the machine and its users. While cognitive science itself developed with the development of information processing technology, since HCI deals specifically with the relationship between user and machine, it makes sense for embodied cognition to be deeply linked to it. One would make the assumption that user

experiences can be studied in the context of the machine for multiple things, chief among them being the utility of the machine, and foundations for new designs based on how its users respond to the technology.

This interplay between HCI and embodiment has been noted in many fields. The most common ones are the field of education and the field of technology, specifically in dealing with user interface.

Education

Bodily experiences play a major role in embodied cognition. This idea lines up with the idea of alternative, application-based teaching methods that are designed to help students visualise concepts in their minds in order to better understand them. This could be a major factor in the number of studies conducted to help facilitate learning through embodiment.

The study of child-computer interaction has been taking more and more of an embodied cognition approach in recent times. Antle (2012) discusses this in detail in Research Opportunities: Embodied Child-Computer Interaction, with a focus on understanding how this study influences the ways in which interactive technologies for children are designed. Further, Antle introduces three groups of theories with their foundations, the current ongoing work, as well as ideas for future work in the field. First, that children follow a dynamic trajectory of development. The author quotes Piaget to make an argument about the development of intelligence being a result of the creation of physical or mental patterns. Second, that children offload cognition on the world. This means that children may be able to use their environment to facilitate their thinking. Finally, the author puts forward the theory that movement helps children think. Under this, the author talks about how simulations help strengthen neural patterns created by experience. The working of mirror neurons is also highlighted as being part of this. A related theory that has been applied to child-computer interaction is that when individuals (children and adults) learn or reason with abstract concepts, they end up utilising mental stimulations based on concrete motor-perceptual experiences. Once again, this highlights the foundation of embodied cognition, which is of the belief that physical and material experiences play a huge role in the way cognitive processes work.The author concludes by making some suggestions for future research. First, that there is a need to delve into how to design to better support the aforementioned dynamic trajectory of development. Next, that there is a need to understand how to develop products that can aid the process of unloading cognition so that children are better equipped to deal with the more important tasks of choice. Lastly, that there is a need for research that can give insight into designing products that can support movement-based simulations or re-enactments of motor-perceptual states that aid children's thinking. To sum up, the article details the major pillars of the idea of embodied cognition, aimed specifically at understanding how it can be used to create interactive digital tools to boost the way in which children think and learn.

In a more discipline-specific and issue-specific study, Dackermann, Fischer, Nuerk, Cress, and Moeller (2017) in Applying Embodied Cognition: From Useful Interventions and

Their Theoretical Underpinnings to Practical Applicationsdiscuss the practical applications of embodied numerical trainings. The authors define embodied trainings as trainings that allow for embodied experience of a specific numerical concept. They base their study on the theory that spatial-numerical associations develop early in life (de Hevia et. al 2012, 2014) and become culturally shaped through various experiences as children grow. Training success was assessed using children's performances in a number line estimation task, where the children had to estimate the spatial position of numbers on an empty number line with labelled endpoints. The researchers conducted 5 different studies to evaluate how far embodied trainings work in teaching the students numerical concepts, across different media. Essentially, the researchers argue that the role of the body in numerical learning should find its way into practice. Finally, they conclude that embodied trainings are successful in aiding students across age groups (kindergarten to second grade), and across different digital media (eg. Interactive whiteboard, Kinect sensor, etc.) This study shows that different media aid in different methods of embodied training, and work across age groups for children with different skill-levels. The findings of this study are useful to multiple stakeholders, such as educators, parents, developmental psychologists. From an HCI perspective, it would also be useful for computer scientists who could help develop teaching aids for newer, alternative methods of teaching to be adopted.

As is evident, a lot of research is done in the field of education for children. While we know based on these studies what might work effectively for children, there is another group of individuals who also engage in some form of learning at some point- adults. In The Promise of Situated Cognition(1993), Wilson discusses education for adults, and asks whether learning transfers across contexts. Focusing primarily on adult learning and decision-making, the author argues that thinking is interwoven with the context of the problem to be solved. This is a counter to the dominant view of cognition, which assumes cognition as independent of context. The practice of adult learning would thus have to be situated in a real-world setting. The aim of the article is to discuss the implications of situated cognition for adult education. The author argues that once the situation of learning is given significance, the role of tools, social interaction, and activities become more important.

Not much data could be found on how embodied cognition specifically works for adult students. However, based on some of these studies as foundations, a future course of research could be to look at the differences in the working and efficacy of an embodied cognition approach for students from a wider range of age groups (e.g. toddlers to adults). Further, not much research seems to have been conducted on the scope of embodiment for the betterment or easier learning for students with learning disabilities. This could be another avenue, since education through embodied cognition makes use of tools and methods that use various senses and are not restricted to traditional teaching methods. Since alternative teaching methods already make up a large part of teaching processes for students with learning disabilities, this kind of research would neither be far-fetched, nor impossible to conduct.

Interface Design

A lot of research on embodied cognition is linked to interface design and the way in which users react or respond to the interface provided by a particular software or technology. The scope of technology is vast, and it encompasses everything from different kinds of learning software and heavy machinery in factories to appliances at home.

In Embodied Interactions: Exploring the Foundations of a New Approach to Human-Computer Interaction,Dourish (1999) aims to uncover the foundations of an embodied approach to interaction. The paper focuses on the theoretical and foundational underpinnings of interactive system design and development, proposing an embodiment as the new foundational approach to HCI. The author describes embodiment as both a physical presence in the world and social embedding in a web of practices and purposes. Further, the author discusses the influence of psychology and sociology on HCI, in explaining the activity of users using their machines as something that is defined by a web of surrounding relationships, activities, and practices. Specifically, the author discusses Computer-Supported Cooperative Work, used to study collaborative and organisational work. Sociology has also contributed to the use of HCI in analysis of data collected from ethnographic studies. Dourish refers to Weiser's (1989) ideas of 'ubiquitous computing' or tangible computing, involving embedding computerised processes into other devices and objects. This was used as a research agenda by Weiser when he set up the Computer Science Lab at PARC. In citing other examples of work in the field of HCI and embodied cognition, the author brings up the idea of the invisible user interface, and highlights the arguments made against such a concept. He predicts that the focus in the future will be based more on drawing attention to the presence of the UI, instead of making it disappear. The idea of ubiquitous computing remains significant since it involves most devices we use in the present day. Antle, Corness, and Droumeva(Human-Computer-Intuition? Exploring the Cognitive Basis for Intuition in Embodied Cognition, 2009)discuss embodied interaction as an intuitive form of human-computer interaction. The authors conduct an exploratory study comparing interaction models based on embodied metaphors and non-embodied metaphors. They performed this for the same system, to test the theory that including an embodied metaphor would make an interaction more intuitive. Through this study, the researchers aimed to contribute to the effort of understanding the potential role and benefits of incorporating embodied metaphors into designs for ubiquitous computing systems relying on direct physical interactions with computation. This idea of intuitive interface has fascinated users and makers alike for a while now, with the current trend in Artificial Intelligence also leaning towards intuitive software and interface.

In Embodied Cognition, Human-Computer Interaction, and Application Areas (2012) Garg discusses the two main approaches (symbolic and connectionist) to study cognition and argues that this thinking leads to theories of embodied and situated cognition. The author discusses the application areas of an interaction between embodied cognition and HCI. First, there are web-based educational systems under development that adapt to satisfy the learner's state of understanding. There is also research underway in the field of robotics, to tailor

different design interfaces for differences in cognitive style, etc. Another major step has been in the field of interfaces, where cognitive work analysis is conducted to help improve the design of user interfaces. The paper significantly points out that it is important to design machines such that they help humans in every aspect, acting as efficient and effective assistants to work. Further, the understanding of interaction, especially between humans and objects (artefacts) help in enhancing the knowledge base about objects, properties, and their relations between themselves and with the world.

In Embodied Cognition and the Magical Future of Interactive Design, Kirsch (2013) provides a detailed argument about how embodied cognition can provide HCI practitioners and theorists with new ideas and principles about interaction and design. This is done on the basis of 4 ideas about cognition. First, interaction with tools changes the way in which individuals think and perceive. Second, that humans think with their bodies as well as their brains (a fundamental tenet of the concept of embodied cognition). Next, that individuals know more by doing than by seeing; this once again highlights the emphasis laid on bodily experience by embodied cognition. Finally, that there are instances where people think with things. Here, the author talks about how physical thinking is an external version of the idea in embodied cognition that much of our cognitive life depends on internal simulation of things. In the body of literature surrounding embodied cognition, simulation is internal. The author posits that this can be expanded, to include external simulation as a means of thinking. Lastly, the author concludes by highlighting the importance of studying the coordination between internal and external simulation, in order to reach new heights in design, and to create better tools for physical-digital coordination.

Hurtienne (2009) begins Cognition in HCI: An Ongoing Story by drawing a comparison between traditional theories of cognition and embodied cognition. The author details a history of cognitive psychology as a field that emerged alongside computers, where the mind began to be looked at as an information processing device. However, this idea garnered criticism within a few years, thereby opening up avenues for new ways of understanding cognition. The paper then proceeds to outline how the image schema theory is useful in the context of interface design. Image schemas as defined as abstract representations of recurring sensorimotor patterns of experience (Johnson, 1987). These schemas are formed by and also directly play a role in structuring our experience with the world. There have been more than 40 image schemas discussed so far. To link this idea to HCI, the author states that the image schema theory would need to fulfil two requirements. First, that it would allow for making valid predictions in a context of user interface design. Second, that it would prove useful in practice. The researcher found that although this idea originates from research in cognitive linguistics, many image schemas would prove useful for interface design. In gauging the practicability of the theory, the author found that image schemas facilitate the transfer from requirements to design solutions by providing the structure of the prospective user interface. The study also showed that cognition will not remain the only discipline which can contribute to HCI. The author concludes by pointing out that new theories of cognition can help enliven the field of HCI and make it more productive.

Some very specific studies discuss more niche topics to do with interface. For example, Jetter, Reiterer, and Geyer in Blended Interaction: Understanding Human-Computer Interaction in post-WIMP Interactive Spaces (2013)write an extremely specific paper introducing the concept of blended interaction, as a framework that will help explain whether users perceive UI as natural or not. They introduce the notion of conceptual blends, making the claim that individuals use familiar and real-world concepts when learning new digital technologies. The authors specifically apply this concept to the Windows Icons Menu Pointer interactive spaces, which are ubiquitous computing environments for collaborative work by multiple users.

Kieras and Meyer (1997)in An Overview of the EPIC Architecture for Cognition and Performance e With Application to Human-Computer Interaction speak about a cognitive architecture called Executive Process-Interactive Control or EPIC, as being suited for modelling human multimodal and multiple-task performance. The authors use some of these studies to demonstrate how EPIC classifies basic properties of human performance and provides usefully precise accounts of performance speed.

Some studies also display a link in the two domains already discussed, i.e. education and interface design, by highlighting the need for paying close attention to the designing of software, teaching aids, and other tools to be used specifically by children. These designs should keep in mind how children process information and undergo the process of learning.

More

Some other uses for embodied cognition do come up. One particularly interesting study aimed to assess situated cognition, i.e. a type of embodied cognition where cognition is contextualised with spatial relations, in workplaces. Elsbach, Barr, and Hargadon begin their study (Identifying Situated Cognition in Organisations, 2005) based on the theory that individuals and groups in organisations use identifiable and stable cognitive templates (schemas) for understanding and engaging in cognitive activity. The employ the concept of situation, arguing that cognition occurs interaction of the perceivers' mind (schemas) and their environment i.e. cognition that is embedded in the context in which it occurs. The authors go on to present a framework of common situated cognitions described in empirical case study research in the 15 years before the article was written. Careful reading of the case studies led the authors to identify 4 common factors of interaction between cognitive schemas and organisational contexts that lead to situated cognition. Broadly, they reached the following conclusions. First, that interactions between event schemas and institutional or cultural contexts give rise to the momentary situated cognition of perceived option attractiveness (the desirability of a given choice). Next, it appears that individuals' understandings about the relationships between key variables or constructs relevant to solving a problem (rule schema) interact with dimensions of the physical context of problem solving (e.g. the functional layout of work area, spatial arrangements of workers, etc.) to give rise to transitory understandings of the problem to be solved. Third, they found that an individual's self-perceptions of distinctive traits become salient when pre-existing self-schemas are brought to mind in the presence of personally

meaningful physical artefacts during the sensemaking process. Finally, the researchers also found that interactions between rule schemas and socio-dynamic contexts give rise to collectivist mindsets. While these findings are not a result of rigorous statistical analysis of data from the empirical studies used, the researchers hope that their close reading and analysis will open up new avenues for studies on situated cognition in organisational settings. Particularly for spaces like corporate organisations or government institutions, such studies could help frame policies and rules so as to ensure maximum productivity and help in the welfare of the employees.

Conclusion

To summarise, the author of this paper began by discussing embodied cognition as an importance albeit newer facet of cognitive studies, and human-computer interaction as a growing new field aimed at understanding the relationship between machine and user. We looked at the existing literature documenting the various approaches within the field of embodied cognition itself. The paper progressed on to its links with HCI, and how two main domains, that of education and interface design, emerge as areas with maximum research, indicating that the need for this amalgamation exists most urgently in those areas. The author also pointed out the gap in the research with the lack of material about children with learning disabilities and the scope of these concepts for their betterment. Further, on the subject of user interface, the author pointed out that a fairly old idea of intuitive ubiquitous computing technology translates and finds its way to newer technology such as current research in artificial intelligence (AI) as well. Lastly, there was the example of situated cognition in organisations, that helped us understand that this kind of a unique combination could help many fields and many disciplines make changes in the way they function, for the better.

References

1. Antle, A. N., Corness, G., &Droumeva, M. (2009). Human–computer-intuition? Exploring the cognitive basis for intuition in embodied interaction . International Journal of Arts and Technology, 2(3). Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.655.2079&rep=rep1&type=pdf
2. Antle, A. N. (2012). Research opportunities: Embodied child–computer interaction. International Journal of Child-Computer Interaction, 1.
3. APA Dictionary of Psychology. (n.d.). Retrieved from https://dictionary.apa.org/embodied-cognition
4. Dackermann, T., Fischer, U., Nuerk, H.-C., Cress, U., & Moeller, K. (2017). Applying embodied cognition: from useful interventions and their theoretical underpinnings to practical applications. ZDM Mathematics Education.
5. Davis, J. I., Benforado, A., Esrock, E., Turner, A., Dalton, R. C., Noorden, L. V., & Leman, M. (2012). Four Applications of Embodied Cognition. Topics in Cognitive Science, 4(4), 786–793. doi: 10.1111/j.1756-8765.2012.01225.x

6. Dourish, P. (1999). Embodied interaction: Exploring the foundations of a new approach to HC. Retrieved from https://www.researchgate.net/publication/228934732_Embodied_interaction_Exploring_the_foundations_of_a_new_approach_to_HCI
7. Elsbach, K. D., Barr, P. S., & Hargadon, A. B. (2005). Identifying Situated Cognition in Organizations. Organization Science, 16(4), 422–433. doi: 10.1287/orsc.1050.0138
8. Garg, A. B. (n.d.). Embodied Cognition, Human Computer Interaction, and Application Areas .
9. Hurtienne, J. (2009). Cognition in HCI: An Ongoing Story. Human Technology, 5(1), 12–28. Retrieved from https://jyx.jyu.fi/bitstream/handle/123456789/20231/HT_2009_v05_n01_p_12-28.pdf?sequence=1&isAllowed=y
10. Jetter, H.-C., Reiterer, H., & Greyer, F. (2013). Blended Interaction: understanding natural human-computer interaction in post-WIMP interactive spaces. Personal and Ubiquitous Computing, 18(5).
11. Kieras , D. E., & Meyer, D. E. (1997). An Overview of the EPIC Architecture for Cognition and Performance With Application to Human-Computer Interaction. Human-Computer Interaction, 12, 391–498.
12. Kirsh, D. (2013). Embodied cognition and the magical future of interaction design. ACM Transactions on Computer-Human Interaction, 20(1), 1–30. doi: 10.1145/2442106.2442109
13. Markman, A. B., &Brendl, C. M. (2005). Constraining Theories of Embodied Cognition. Psychological Science, 16, 6–10. Retrieved from https://www.jstor.org/stable/pdf/40064064.pdf?ab_segments=0%2Fbasic_SYC-5055%2Ftest&refreqid=excelsior:be79a496df5813f5c227624d0551b2b6
14. Wilson, A. L. (1993). The promise of situated cognition. New Directions for Adult and Continuing Education, 1993(57), 71–79. doi: 10.1002/ace.36719935709
15. Wilson, M. (2009). Six Views of Embodied Cognition. Psychonomic Bulletin and Review, 9(4), 625–636. Retrieved from https://link.springer.com/content/pdf/10.3758/BF03196322.pdf