Remix: Andy Clark's *Being There*

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Introduction

In 2005 I left a successful career as a consultant and designer in the children's new media industry to re-enter the academic world. I was interested in how and why different forms of new media might impact children's experiences and their cognitive development. So much of what I saw in industry was driven by market and business demands and by novelty – being first to market – rather than being grounded in rich understandings of how children develop intelligence and how this process could be supported through their interaction with new media. I had taken a turn away from screen-based products and found myself wanting to work on the kinds of hybrid physical-digital exhibits common in museums and science centres. It seemed to me at that time (before I had children of my own) that hybrids were better suited to the active, social, busy lives of children, than products aimed at single child sitting isolated in front of a computer screen. I had so many questions about how and why different forms of media might be beneficial to children that I decided to take an academic position and was hired at a new School called Interactive Arts and Technology at Simon Fraser University, Canada.

About the same time, I was introduced to Andy Clark's book, *Being There: Putting Brain, Body and World Together Again* [7]. It was this concise, readable book that introduced me to embodied cognition, although it was targeted philosophers of mind rather than interaction designers. In this book, Clark weaves together seemingly disparate fields in order to provide an alternative paradigm for understanding cognitive science. I'm glad I began with Clark's fascinating descriptions of Jakob Von Uexkull's Umwelt of a tick, Rodney Brook's autonomous agent research, Esther Thelen and Linda Smith's application of dynamical systems theory to research with infants learning to walk, Gibsonian psychology, and David Kirsh and Paul Maglio's exploration of epistemic actions and external scaffolding in the game Tetris. It was all here — all in one place! I was giddy with delight as I read about a theory of mind that involved an integrated account of how we sense, perceive, and think with and through our bodies in ways that are tightly coupled with the specifics of our environment.

This book forever changed how I thought about cognition and how I designed interactive systems to support cognition, and it shaped the course of my research career. I had struggled with representational theories of mind and Clark introduced me to another way of thinking that was not so much anti-representational but provided alternative explanations that left room for representational and action-based strategies depending on the context and demands on the agent. Clark's account provided a foundation from which I could explore the many questions I had about children, the development of intelligence, and new forms of child-computer interaction.

Implications

Embodiment matters because it changes how one thinks about children's cognitive and motor-cognitive development and how one designs to support children's learning and development. It changes what you need to know and how you use that information.

Piaget Revisited

An embodied approach to cognition has broad implications for theories about how children develop intelligence as they age. In genetic epistemology, Piaget proposed that intelligence develops as cognitive structures are formed from patterns of physical or mental action, and that the formation of cognitive structures proceed in stages. These stages are familiar to most interaction designers working with children: sensori-motor, preoperations, concrete operations, and formal operations. Development is conceptualized as a linear progression through discrete stages of reasoning that corresponds roughly with children's ages [11]. This approach assumes an end goal: the ability to reason with abstract representations. In the IDC community Piaget's ages and stages theory has been taken by many almost as a manifesto for designing for children. It provides a systematic way to determine age-appropriate design considerations.

However, this approach is problematic because it results in overly prescriptive design guidelines that pay little attention to the diverse ways in which intelligence emerges in the interactions of a child with an environment and as a result of activity. Embodied cognition challenges the notion that cognitive growth is a smooth linear or step-like progression from concrete to abstract thinking. A particular environment may provide opportunities that enable a child to perform coupled physical-mental operations beyond the stage predicted by their age. Keil provides many examples of this in his summaries of various researchers' work that has shown that children failed at Piagetian tasks for reasons other than basic competencies related to their ages [9]. So taking an embodied perspective on the development of intelligence tells us not to look at what most children can do at a particular age, but instead to see development as a trajectory where the environment (in this case the interactive product) can provide opportunities, like foot and handholds in rock climbing, for children to practice something that they are developing. The job of the designer is not to understand what a child can do and design to support that, but rather to understand what a child is able to practice doing or thinking about and to produce opportunities to practice those skills in a specific context with external aids. My recent publication with Tilde Bekker on Developmentally Situated Design discusses the idea of designing to support what children are practicing [5] but still relies on ages and stages to some degree. It has been a difficult legacy to let go of.

Bootstrapping Abstract Thinking through Movement
Clark introduced me to Mark Johnson's ideas about image schemas and metaphorical elaboration [8], and Giacomo Rizzoloti's work on mirror neurons and common coding theory [12]. A mirror neuron is a neuron that fires both when we act or when we observe the same action performed by another human. Common coding theory suggests that the mirror neuron system provides the physiological mechanism for perception-action coupling, which is fundamental to theories of embodied cognition. These ideas, taken together, change the roles of the body and the environment from input device and problem space respectively, to crucial parts of the cognitive system [6]. Image schema theory suggests that abstract thought utilizes neural patterns and cognitive structures (image schemas) that are formed from repeated patterns of physical experience. For example, repeated patterns of physically balancing the body (e.g. learning to walk, standing on one foot, balancing on a teeter-totter) give rise to neural patterns that provide the cognitive structure for a *balance* image schema. These same neural patterns are utilized when visually seeing balance (e.g. in a painting or photograph) and thinking about balance in abstract domains such as mathematics or justice (e.g. balancing an equation, balancing the punishment against crime).

Based on these ideas, I posited the notion that an input space where children could enact image schematic actions might bootstrap their perception of and thinking about digital representations of abstract concepts related to those image schemas. I conducted a series of studies that explored whether and when such input spaces improved children's performance and understandings. For example, in the SoundMaker audio environment pairs of children move near and far to change the pitch of the percussive sound from high to low [1]. Using MoSo tangibles, children move a tangible sound making object high or low to change the volume of the sounds [4]. Using Springboard interactive environment, adults move their bodies in and out of balance to explore images and sounds depicting balance and imbalance in issues related to social justice [2]. This area continues to be one of my major research directions, and its findings have broad implications for the design of new forms of user interfaces.

Providing Handholds for Problem Solving
Clark also introduced me to David Kirsh's work on complementary and epistemic actions (e.g. [10]). An embodied perspective on cognition posits problem solving as real time pattern completion utilizing resources in the environment rather than logical inference. One way we do this is through complementary actions, which are organizing activities

that recruit external elements to reduce cognitive loads. A subclass of complementary action is epistemic action. These are actions used to change the world in order to simplify the problem-solving task. These ideas led me to a research direction where I explored how to design tangible and multi-touch interfaces that provide opportunities for complementary and epistemic actions. For example, we conducted an experiment comparing children's performance using screen-based and tangible jigsaw puzzles. We found that spatial features of the tangible puzzle (e.g. 3D interaction space, table edges) provided opportunities for epistemic actions that resulted in better puzzle performance [3]. Currently we are comparing tangible and multi-touch puzzles to better understand the benefits of three dimensional interaction spaces versus their two dimensional counterparts. The results of this work have implications for many hands-on interactive products.

Summary

Clark's work introduced me to many of the main ideas in embodied cognition. It fundamentally changed how I thought about the trajectory of cognitive development and cast into doubt all (including my own) design work based on ages and stages guidelines. It impacted how I thought about designing interfaces in general, and specifically led me to two research directions: one about image schemas and abstract thinking, and another about epistemic actions and how we think with our hands. It remains to be seen how emerging forms of human computer interaction will compete with traditional interfaces. However, with the uptake of touch interfaces (e.g. iPhone), it seems likely that understanding the implications of embodied cognition for design will become increasingly relevant for all designers.

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