PHOEBE SENGERS

CHAPTER 2

THE ENGINEERING OF EXPERIENCE

A deep shift in Western culture has occurred in the last 200 years. We have moved from lifestyles in which work, play, and other forms of experience are inextricably intertwined, to one in which most people separate their work life from a private (and often less societally valued) life of fun and play. Engineering has played a central role in this bifurcation, fulfilling a cultural desire to engineer human experience for optimal functionality. The result has been a great increase in our material comforts, coupled with a harried, frenzied lifestyle for many. In this chapter, I will argue that designing systems to support rich, meaningful, and pleasurable human experiences requires moving away from the model of engineering experience and towards an interdisciplinary approach to computing, in which technology design is intertwined with philosophical and cultural analysis.

1. FUN IS THE DREGS OF ENGINEERING EXPERIENCE

The history of the industrial revolution is a story of the gradual optimisation and rationalization of work. Over the last two centuries, work has gone from an integral part of daily life, to something which is bought and sold per hour and engaged in standardized ways. Craftspeople were collected into factories, their work was split into pieces along a production line, some steps of the production line were taken over by machines, and gradually craftspeople became tenders of rote machinery, engaged in soulless work.

This shift is epitomized by the work of the efficiency expert Frederick Winslow Taylor, who in the early 20th century developed the system of scientific management or ‘Taylorism.’ Taylorist engineers maximize the efficiency of human labour by observing workers, analysing their movements, and developing a script for the ‘one best way’ to achieve their work tasks, in the process eliminating all unnecessary or wasteful motions. After the development of the assembly line, which rationalized and optimised machine labour in the production process, the last source of inefficiency in factories was human labour. Businessmen were naturally eager to find ways to reduce this inefficiency, a task which Taylorism solved.

After Taylorist analysis, a worker is told not only the steps to take in order to fulfil a task, but also what order to do those steps in and exactly how to move in order to minimize waste in their work. Because of the mindless, rote nature of Taylorized work, the quality of experience of work is reduced. Rote labour causes both repetitive stress injuries and rebellious, unhappy workers. Offsetting this

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Funology: From Usability to Enjoyment, 19-29.

reduction in experience is a drastic increase in its efficiency and productivity. Because of these great increases in efficiency, Taylorism took the business world by storm. The impact of Taylorism on Western, especially American, culture can hardly be underestimated. It is still felt through later, less extreme manifestations such as ergonomics and time management. Despite the problems of Taylorism, many of us have remained with a model of work in which experience is engineered for maximum efficiency and minimum pleasure. We have also imported these models to the home: to-do lists, appointment calendars, and a clutter of chores regiment our home lives and attempt to ensure that we are as efficient at home as we are at work.

Engineering work leads to a bifurcation of experience. As Blythe and Hassenzahl argue in this volume, if work, on the one hand, maximizes efficiency at the cost of pleasure, we balance out in our free time by engaging in fun: maximizing pleasure and minimizing task achievement. Many of us spend 8-10 hour days working efficiently and unhappily, then race home for a mindless evening in front of the TV or Playstation.. In the post-industrial West, and especially in America, we have split experience into two: whereas life could be a steady stream of work intermingled with pleasure, we have disengaged the two, often preferring to lavish 'serious' attention only on the first.

2. COMPUTER SCIENCE IS COMPUTATIONAL TAYLORISM (BUT DOESN'T NEED TO BE)

A similar split and imbalance has occurred in computer science. Taylorism is, at heart, simply engineering applied to human behaviour; hence it is no surprise that computer scientists tend to approach work processes the same way as a Taylorist. We break complex processes down into simple steps, we figure out optimal procedures for each work step, and we eliminate wasteful steps and problems.

This process is most clearly seen in Artificial Intelligence, in which both classical planning and the newer behaviour-based approaches attempt to engineer experience by increasing the efficiency and optimality of algorithms and to maximize their functionality (Sengers 1998, Sengers forthcoming). But we see similar emphases in human-computer interaction (HCI). On the one hand, it has a strong emphasis on work-related tasks and increasing the efficiency of their execution. On the other hand, it often focuses on rationalized and optimised techniques to understand and engineer human experience – even when the goal is fun.

Engineering is the correct approach to take when there is a well-defined task to be solved. But designing systems that open a space for new kinds of experience is not an engineering task per se. Instead, one must consider the technical challenges to be overcome in the context of the kinds of cultural and social meaning that the system may take on and the ways in which users may choose to interact with it. This necessitates a shift from a pure, task-oriented engineering approach to an interdisciplinary approach that combines socially-oriented approaches such as the social sciences or literary and cultural studies with more traditional human-computer interaction and computer science. Such hybrid approaches are becoming popular both within HCI and in the media art community (see e.g. Ehn 1998; Wilson 2002).

3. THINK BEYOND BOTH WORK AND FUN

The pendulum between work and play is beginning to swing in the other direction. The recent interest in ‘fun’ as manifested by this volume is important in opening up an understanding of some of the unstated work-related assumptions underlying HCI methods. Funology will necessitate fundamental rethinking of some HCI approaches and the development of new techniques that are less about efficiency and more about quality of experience.

Nevertheless, funology is not enough. Rather than continuing the bifurcation of experience into work vs. play (traditional HCI vs. funology), as a culture we need to consider systems that take a more integrative approach to experience. This may mean on the one hand systems like that of Hohl, Wissmann and Burger in this volume that combine work-related task achievement with pleasurable experience. More fundamentally, it also means that we need to explore the vast and utterly neglected territory of possible systems that are really *neither* work *nor* fun. Such systems may support reflection by users on their lives and activities; they may give users new ways to experience the world; they may make cultural comments in the form of interactive artworks. These systems are neither directly task-related, nor intended simply to entertain. They have a serious point, but they may bring their point across in a playful manner. Examples of such work include Bill Gaver and Heather Martin’s conceptual information appliances (Gaver and Martin 2000), which explore the role of technology in our everyday lives; Tony Dunne and Fiona Raby’s electronic furniture (Dunne and Raby 2001), which provide people with different ways to sense and respond to activity in the electromagnetic spectrum; and Simon Penny’s Petit Mal (Penny 2000), an artwork exploring the nature of artificial agents through a gangly and not very bright robot whose complex and graceful physical activity is almost entirely triggered by human bodily interaction. What these systems have in common is not a desire to engineer experience, but to build thoughtful artefacts that create opportunities for thinking about and engaging in new kinds of experiences. We need to shift from engineering experiences – whether work or fun – to designing them, using principles that draw on both technology design methods and social and cultural analysis.

4. SOME EXPERIENCES DESIGNING EXPERIENCES

In this section, I will describe some experiences in designing systems that are intended to support richer and more meaningful notions of human experience than those traditionally used in computer science by using a broader, interdisciplinary approach combining computer science with cultural analysis. My first work in this area was in designing Artificial Intelligence (AI) architectures for interactive computer characters. Traditionally, AI focuses on activity in the world as problemsolving rationality. The goal for autonomous agents is often to behave optimally rationally in approaching some goal. For interactive computer characters, this focus is problematic, since characters do not need to be particularly smart or rational, instead needing to project emotion and personality in a way that is understandable to users. In the Industrial Graveyard (Figure 1), I explored how to create agents, not as rational problem-solvers, but as experienced by human users (Sengers 1999). Users observe the antics of a discarded lamp in a junkyard, while controlling the behaviour of its unsympathetic overseer. The technology is based on narrative psychology, which argues that humans interpret activity by organizing it into narrative. I support human interpretation of character action by providing visible cues for narrative interpretation of agent behaviour, most notably through transitions between behaviours that connect them by expressing the reason for the behaviour change to the user.

Figure 1. *The hero of the Industrial Graveyard*

With the Industrial Graveyard, I started out being interested in how human experience was represented in agents; but in the course of building the system, I began to realize that what was central was the way in which the *user* experienced the system. The next system I worked on explored ways to generate engaging user experiences. With a team of 5 researchers led by Simon Penny, I explored the construction of physical experiences in virtual reality (Penny et al. 2001). In Traces, users' body movements generate 3-dimensional traces which share their physical space, and with which they can interact (Figure 2).

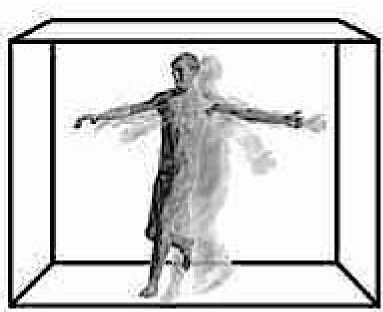

Figure 2. *Concept of Traces: user movement through space leaves behind 3-dimensional traces*

In traditional VR systems, the body is an afterthought, left behind when the headset is put on. The goal of Traces was to develop a kind of VR installation where it is possible instead to have strong bodily experiences. Traces is an installation for the CAVE VR display, a small room onto whose walls 3D images are projected. When users enter wearing 3D glasses, they have the illusion of being surrounded by virtual objects in real, physical space, while they can still look down and see their own bodies. In Traces, vision cameras detect the movement of users, allowing them to leave behind and interact with traces of physical movements that seem to surround them (*Figure* 3).

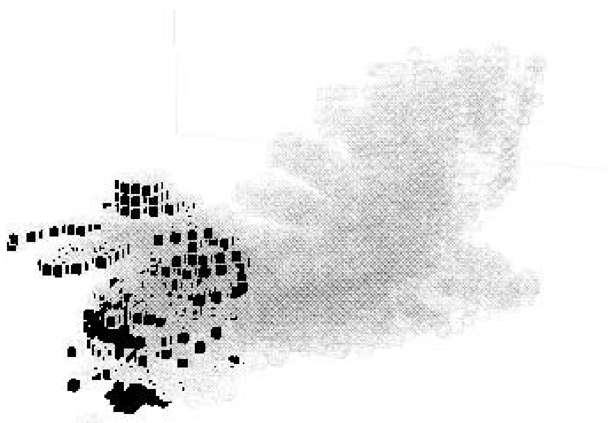

Figure 3. *A user (body model shown in black) moving through Traces leaves behind tracks of physical movement (grey). In the CAVE the voxel model is not shown; instead, the user's own body leaves behind colourful 3-dimensional traces in the space surrounding him or her. Users are surrounded by the trace they create*

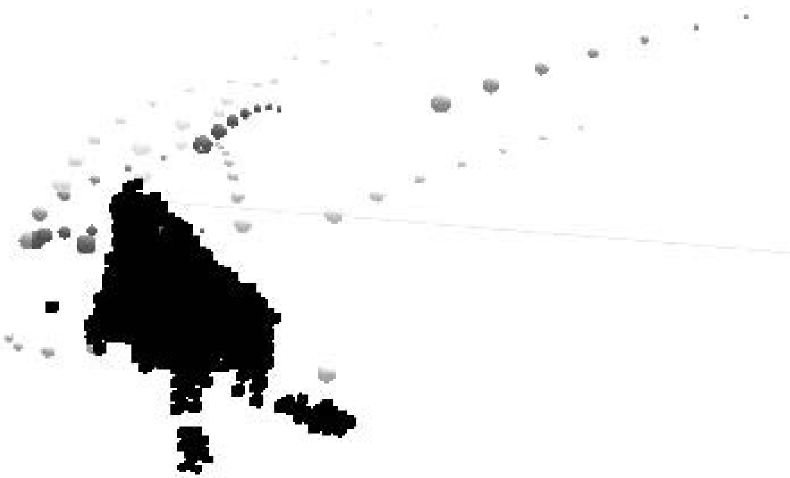

Figure 4. *A user (body model shown in black) being chased by a set of Chinese dragons (grey). In the actual experience in the CAVE, the user does not see their voxel model, but only sees Chinese dragons sharing their physical space and responding directly to their physical movemen.*

Gradually, the traces become more autonomous, turning into “Chinese dragons” which flock together and sense and react to users’ physical movements (Figure 4).

Traces was installed at Ars Electronica ’99, where users leapt, ran, skipped, did cartwheels, and came out of the CAVE sweating. Users had strong reactions to the Chinese dragons; though the dragons were not particularly intelligent, they seemed strongly alive and present to human users because they shared the same physical space. With Traces, it became clear that physical interaction and shared physical space with (embodied) users is a way to create meaningful, powerful experiences.

The Influencing Machine (Sengers et al. 2002) explores the human experience of affective computing, or computational systems that recognize, reason about, or can express emotions. It was developed by the author, Rainer Liesendahl, Werner Magar, and Christoph Seibert at the MARS Exploratory Media Lab as part of the EU SAFIRA project. In the Influencing Machine installation, users enter a small room, on one wall of which childlike drawings are being created in real-time, accompanied by an abstract soundscape. In the middle of the room, they discover a wooden mailbox, into which they can put art or coloured postcards. By choosing postcards, they can change the “mood” of the drawings and sounds as they are being created. Users explore the postcards, asking themselves what the picture means to them, and exploring what it means to the machine. With the Influencing Machine, we came up with ways to engineer *enigmatic* experience: the interaction is deliberately open-ended and open to interpretation, yet through the interaction of postcards, graphics, and sound, we can create experiences which have concrete meaning for many users. The Influencing Machine was formally evaluated by Gerd Andersson, Pia Mårtensson, and Kristina Höök, who developed new techniques for non-task-oriented evaluation for this project, most notably by using groups of users and recording their conversations in order to better understand the nature of user experience of the system.

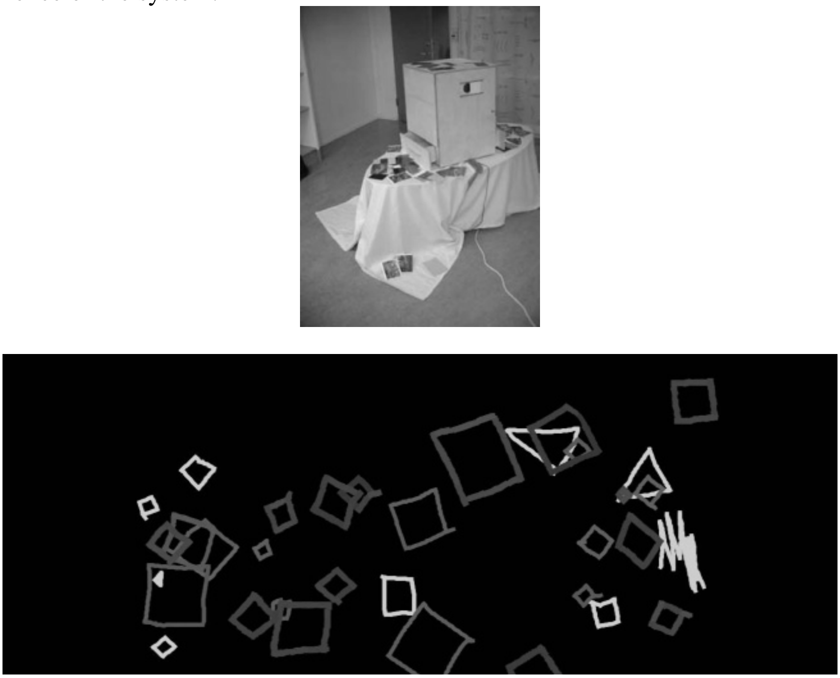

Figure 5. *Input and output of the Influencing Machine*

These three systems are all examples of critical technical practices (Agre 1997), or practices of technology development which incorporate a cultural, critical component. In all three cases, we built on an analysis of what was missing in the cultural assumptions about human experience that were unconsciously built into previous technology. The Industrial Graveyard twists the notions of optimality, correctness, and action-selection inherent in many algorithms for autonomous agents. Traces alters the assumption of bodilessness behind many VR applications. The Influencing Machine plays off of the assumption in many affective interfaces that "affect" is something to be extracted through surveillance or skin contact, and instead places the user's own choices at the centre of affective interaction. I believe building rich, meaningful experiences will require not just engineering competence but also cultural analysis, design, and art perspectives.

5. HOW TO DESIGN EXPERIENCE

A pure engineering approach suggests that one can understand human experience by building formal models of it – the traditional approach taken by computer science. In

AI, for example, we build conceptual models of people, implement these in code, and run them, in the hopes of better understanding what human experience is like. In HCI, we similarly often build cognitive models of users, allowing software to reason about what users may be experiencing by comparing their behaviour with expectations of human behaviour built into the cognitive models. In many ways these attempts to make human experience computational mimic the efforts of the Taylorists, as we try to clean up, formalize, and organize what is an inherently messy and perhaps fundamentally incomprehensible phenomenon. In my own work as an AI researcher, I became frustrated by the fact that my clean, beautiful models of behaviour always seem to miss the point – they can somehow never generate the complexity and richness of natural behaviour of humans or animals.

The perspectives of the arts and humanities also suggest the futility of trying to formally represent experience. Many humanists and artists feel that complexity, messiness, ill-definedness, and enigmatics are fundamental to the nature of human experience, and that therefore all clean and formal models fundamentally distort that nature. Winograd and Flores's rejection of AI (Winograd and Flores, 1986), for example, is fundamentally based on this point. If this is the case, then how can we design systems that can create rich, meaningful, and complex experience for users? I believe we must do so by realizing that we cannot fully represent experience within the software, and instead try to set up more nuanced relationships between (internal, formal, clean) code and (external, messy, complicated) experiences. More concretely, I suggest the following (nonexhaustive) set of heuristics:

– *Instead of representing complexity, trigger it in the mind of the user.*

Instead of trying to contain the complexity of user experience in formal structures such as user models, one should focus on shaping the *actual* (not modelled) experience of the user, which will hopefully be much more complex than its internal, logical representation. One way to do this is to focus on the user's strength: an ability to engage in complex interpretation using a vast amount of cultural background knowledge. By focusing on how users react, rather than on the internal content of the software, a simple computational artefact can be used to communicate a rich and complex idea. In the Industrial Graveyard, I take advantage of the user's 'narrative intelligence' by providing 'hooks' that support narrative understanding of agent behaviour. The agent architecture is structured to support symbolic, narrative interpretation, rather than internal optimality, efficiency, and completeness. Systems built using this heuristic have behaviour that is internally simple, but appears complex to users thanks to the complexity of human interpretation.

– *Instead of representing complexity, bootstrap off it.*

Human behaviour is rich, complex, messy, and hard to organize into rules and formal models. This insight can be used to create rich, complex, messy, and subtle *computational* behaviour with little computational cost simply by driving it directly from human behaviour. For example, in Traces the motion of the Chinese dragons is based on simple rules that respond to human movement. Because human movement is complex and the dragons are responding to it in real time, the movement of the dragons is similarly complex. Unlike the previous heuristic, systems built using this heuristic truly have complex behaviour – but only because they are driven by complex input.

– *Think of meaning, not information.* Computers care about information. Humans care less about raw data than they do about what information means to *them*. Focusing on meaning instead of information in the design of computational objects means that we adapt to user experience of information rather than to its internal representation. With the Influencing Machine, for example, we tried to move away from the standard affective computing model in which ‘emotion’ is fundamentally a unit of information to be extracted, manipulated, and communicated, to one in which user interpretation of emotionally valenced postcards, graphics, and sound is central, with the internal informational representation of emotion playing only a supporting role.

6. THE ENGINEERING OF EVERYDAY LIFE, OR WHERE’S THE FUN?

How do these heuristics extend to work outside of the museum and beyond AI? One domain in which non-engineering approaches are clearly needed is in everyday life in the home. In current discussions in HCI, the move of computation from desktops and factories into the home and everyday life is considered motivation to alter the efficiency- and task-oriented approaches on which HCI has largely concentrated in favour of fun- and pleasure-based approaches. Underlying this argument is an assumption that Taylorist models may be appropriate for work, but that they do not apply to the home. Yet the historical record makes clear that Taylorist models are central to current home life in the West, especially in America – to the detriment of our quality of life (Bell and Kaye, 2002).

Already at the turn of the century, the popularity of Taylorism and the model of factory production which was rapidly and fundamentally changing the American way of life led to attempts to adapt Taylorism to home life (Strasser 1982). Home economist Christine Frederick was perhaps its most ardent proponent; she proposed that housewives engage in motion studies to minimize the amount of movement they spent on household chores such as washing the dishes or doing the laundry. This attempt to adapt Taylorism to the home ran into resistance, for several reasons. First, many home tasks, such as minding children, are not amenable to being fully engineered and controlled. Second, there was no clear reason why housewives needed to be so efficient. Focusing purely on efficiency causes a great reduction in the experience of work, and many housewives saw no need to get more done at the cost of less pleasure and a more unnatural work process.

The situation today has changed. As Ralph Keyes notes,

> At one time the home was considered a refuge from work pressures. Now its inhabitants march to a businesslike beat. The pace at home has become little different from that at work. It calls for huge calendars on the kitchen wall, constant cross-checking of everyone’s schedules, and sophisticated use of complex telephone systems so everyone can stay coordinated…. The tempo of the office and much of its paraphernalia – datebooks, Rolodexes, phone systems, computers, even faxes – have invaded the home. (p. 141)

In fact, especially for two-career families, efficiency and engineering an optimal task schedule are as important at home as at work. What role will HCI play in this? Will we continue the engineering approach, building domestic technology that will allow harried families to cram yet one more activity into a busy schedule, alternating with stress reduction through mindless fun? Or will we design experiences for users that counteract these cultural forces, developing an alternative vision of what home life could be like?

7. DON'T JUST ENGINEER - LEARN TO LOVE COMPLEXITY AND SPEAK ITS LANGUAGE

Building computational artefacts that support rich and meaningful human experience requires a variety of perspectives to be combined. Engineering, including technology and algorithm design, is essential in order to be able to turn the vision of an interaction into a functioning system. Traditional and newly created human-computer interaction techniques are needed to support the fine-tuning of interaction and to evaluate the effect the system may have on users. But 'engineering' truly rich experiences requires more of system designers than just technical skills. System designers also need to understand and design for the ways in which user experience exceeds our abilities to formalize it. They can't just love their code; they must learn to love the complexity of user experience as well and be conversant in it. This suggests the incorporation of practices like cultural studies, anthropology, speculative design, surreal art, culture jamming, story-telling, cultural history, sociology, improvisation, and autobiographies, which have found ways to address and understand the complexity of human experience without needing to create complete and formal models of it. Most importantly, it means recognizing the role, not just of fun but of serious *play* as a form of opening the conceptual space for designing, building, and interacting with the new systems with which we will share our lives.

8. ACKNOWLEDGEMENTS

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9. REFERENCES

Agre, P. E. (1977) *Computation and Human Experience*. Cambridge: Cambridge UP.

Bell, G. and Kaye, J. (2002). Designing Technology for Domestic Spaces: A Kitchen Manifesto. *Gastronomica*, 2(2).

Dunne, A. and Raby, F. (2001) *Design Noir: The Secret Life of Electronic Objects*. Basel, Switzerland: August / Birkhaeuser.
Ehn, P. (1998) Manifesto for a Digital Bauhaus. *Digital Creativity*, *9* No 4:207-216.
Gaver, B.l and Martin, H. (2000) Alternatives: Exploring information appliances through conceptual design proposals. *Proceedings of the CHI 2000 conference on Human factors in computing systems*. pp 209-216. ACM Press.
Keyes, R. (1991) *Timelock*. HarperCollins.
Penny, S. (2000) Agents as Artworks and Agent Design as Artistic Practice. In Kerstin Dautenhahn, ed., *Human Cognition and Social Agent Technology*. Amsterdam: John Benjamins.
Penny, S., Smith, J. Sengers, P., Bernhardt, A. and Schulte, J. (2001) Traces: Embodied Immersive Interaction with Semi-Autonomous Avatars. Convergence. Vol 7, No 2, Summer.
Sengers, P. (1998). *Anti-Boxology: Agent Design in Cultural Context*. PhD Thesis, Carnegie Mellon Department of Computer Science.
Sengers, P. (1999). Designing Comprehensible Agents. 1999 International Joint Conference on Artificial Intelligence (IJCAI-99). Stockholm, Sweden.
Sengers, P. (forthcoming) The Agents of McDonaldization. In Sabine Payr, ed., *Agents and Culture*.
Sengers, P., Liesendahl, R., Magar, W., Seibert, C., Müller, B., Joachims, T., Geng, W., Mårtensson, P. and Höök, K. (2002) The Enigmatics of Affect. 2002 Conference on Designing Interactive Systems. ACM Press.
Strasser, S. (1982) *Never Done; A History of American Housework*. NY: Pantheon Books.
Wilson, S. (2002) *Information Arts: Intersections of Art, Science and Technology*. Cambridge, MA: MIT Press.
Winograd, T. and Flores, F. (1986) *Understanding Computers and Cognition*. Norwood, NJ: Ablex.