The Three Paradigms of HCI

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ABSTRACT

Informal histories of HCI commonly document two major intellectual waves that have formed the field: the first orienting from engineering/human factors with its focus on optimizing man-machine fit, and the second stemming from cognitive science, with an increased emphasis on theory and on what is happening not only in the computer but, simultaneously, in the human mind. In this paper, we document underlying forces that constitute a third wave in HCI and suggest systemic consequences for the CHI community. We provisionally name this the 'phenomenological matrix'. In the course of creating technologies such as ubiquitous computing, visualization, affective and educational technology, a variety of approaches are addressing issues that are bad fits to prior paradigms, ranging from embodiment to situated meaning to values and social issues. We demonstrate the underlying unity of these approaches, and document how they suggest the centrality of currently marginal criteria for design, evaluation, appreciation, and developmental methodology in CHI work.

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INTRODUCTION

Over the last few years, the authors of this paper have become increasingly aware that the third paradigm has been discussed in corners and cafes with much head nodding at the CHI conference, but has not been introduced as a legitimate frame or lens through which to view contributions. This paper is an attempt to give wider voice to the idea, first named by Malcolm McCullough's book, Digital Ground*, and discussed but not named in Paul Dourish's* Where the Action Is [22, 8] *Our name for this is the "Phenomenological Matrix."*

Looking back over the history of CHI publications, we can see how our community has broadened intellectually from its original roots in engineering research and, later, cognitive science. The official title of our central conference is "Conference on *Human Factors* in Computing Systems" even though we usually call it "CHI". Human factors[1] for interaction originated in the desire to evaluate whether pilots could make error-free use of the increasingly complex control systems of their planes under normal conditions and under conditions of stress. It was, in origin, a-theoretic and entirely pragmatic. The conference and field still reflects these roots in the occasional use of simple performance metrics.

However, as Grudin documents [17], CHI is more dominated by a second wave brought by the cognitive revolution. HCI adopted its own amalgam of cognitive science ideas centrally captured in Card, Moran & Newell [5], oriented around the idea that human information processing is deeply analogous to computational signal processing, and that the primary computer-human interaction task is enabling communication between the machine and the person. This cognitive-revolution-influenced approach to humans and technology is what we usually think of when we refer to the HCI field, and particularly that represented at the CHI conference. As we will argue below, this central idea has deeply informed the ways our field conceives of design and evaluation.

The value of the space opened up by these two paradigms is undeniable. Yet one consequence of the dominance of these two paradigms is the difficulty of addressing the phenomena that these paradigms mark as marginal. Over the last twenty years a wide variety of critiques and approaches have been emerging that appear to fit poorly the models and methods emerging from the cognitive revolution. These include participatory design, value-sensitive design, user experience design, ethnomethodology, embodied interaction, interaction analysis, and critical design. On the surface, these critiques appear to involve a disparate array of issues and approaches; yet we will argue that many of these approaches can be usefully seen as elements of a third ("3rd") paradigm, which treats interaction not as a form of information processing but as a form of meaning making in which the artifact and its context at all levels are mutually defining and subject to multiple interpretations. Meaning making is entailed by the analytic frame employed by the designers and analysts, and also by the users and other stakeholders in the situation of use.

[1] Coming originally from "scientific management" (i.e. Taylorism) in the early 20th Century, human factors began as an attempt to increase production and reduce injury. By the time of computers, it had moved on to concerns with "critical incidents".

These critiques and approaches not only focus on different topics and questions, they also suggest alternative metrics and methods for design and evaluation that can be difficult to reconcile with ones emerging from the first two paradigms. Their clash with some of the central assumptions and understandings of CHI as constituted so far had led to a variety of fates. Some approaches, such as affective computing, have found ways to back-fit new phenomena under study to the information-processing model common in CHI. Some, such as ethnographic approaches, have been amalgamated to CHI in an uneasy marriage. Some, such as ethnomethodological concerns about the centrality of practices outside those formalized in CHI, have been heard but not fully worked through, spawning alternative fields such as CSCW outside of CHI. In all these cases, when force-fitting new insights to old paradigms CHI fails to capitalize on the full value of these approaches.

We will use the rest of this paper to argue that (1) the commonly acknowledged waves of influence into HCI can be usefully seen in terms of paradigm shift, (2) the elements of a 3rd paradigm, that of the *phenomenological matrix*, are in place, (3) the lack of clarity about the epistemological distinctions between paradigms is a limiting factor in the development of the field, and (4) CHI can and should make a concerted effort to incorporate the third paradigm in explicit and programmatic ways. In order to make this argument, we first need to define what paradigms mean in the context of HCI.

Understanding Paradigms

The term 'paradigm' as a way to describe waves of research in a field derives from Thomas Kuhn's theory of the structure of scientific revolutions [20]. Kuhn describes not an accretive model of scientific knowledge, but one of successive and overlapping waves in which ideas are fundamentally re-framed. Canonical examples of such paradigm shifts include the acceptance of continental drift by earth scientists and the shift from a mechanically elegant Newtonian physics to the messy and, at times, counter-intuitive relativistic physics. In many cases, including that of HCI, new paradigms do not disprove the old paradigms, but instead provide alternative ways of thinking. They often co-exist.

Following Kuhnian lines, a scientific paradigm in HCI would contain the following elements:

- a common understanding of the salient properties of interaction
- types of questions that appear to be both interesting and answerable about those properties of interaction
- a set of broad procedures which can be used to provide warrantable answers to those questions
- a common understanding of how to interpret the results of these procedures

These four elements are interdependent and grounded in a deeper common conceptualization. For Kuhn, who derived his theory from analyzing physics, the deeper common conceptualization is embodied in the paradigmatic examples that are used in schools to teach the field. A paradigm shift, then, is accompanied by a shift in the examples which are considered to be central to the field. Because of the enormous range of topics taught as "HCI" and the dearth of classical reproducible experiments and demonstrations in our field, paradigm shifts must be tracked in another way; following Agre's theory of generative metaphors in technical work [1, pp. 33-48], we argue that paradigm shifts can be

traced in HCI by tracing shifts in the underlying metaphor of interaction.

In particular, Agre argues, following a long line of research in scientific metaphor, that technical fields tend to be structured around particular metaphors which suggest the questions that are interesting to ask and methods for arriving at answers to them. So, for example, the metaphor underlying cognitive science – that human minds are like information processors – suggests questions it could be interesting to ask - how humans process their input, how they represent information internally, how they access memory, etc. - and also suggests methods for finding answers to those questions, for example that we can effectively model human mental activity using computational code and validate these models by comparing computational and human input and output. An important attribute of these metaphors is that while they by no means strictly dictate what is done in a field, they do bring certain phenomena into the center of investigation, while marginalizing others. In cognitive science, for example, it is relatively straightforward to analyze intellectual, abstract skills, but it has been more difficult for the field to model embodied skills.

Following Agre, we argue that central to each paradigm in HCI is a different metaphor of interaction. Each such metaphor introduces 'centers' and 'margins' that drive choices about what methods are appropriate for studying and designing interaction and for how knowledge claims about interaction can be validated. A paradigm shift, then, could be said to occur when a new generative metaphor is driving new choices of what to research and how, and can be identified when problems and issues that used to be marginalized have moved to the center.

The First and Second Paradigms

Using this model, we can now characterize the first two waves of research in HCI. The 1st paradigm, an amalgam of engineering and human factors, saw interaction as a form of man-machine coupling in ways inspired by industrial engineering and ergonomics. The goal of work in this paradigm, then, is to optimize the fit between humans and machines; the questions to be answered focus on identifying problems in coupling and developing pragmatic solutions to them.

The 2nd paradigm, in contrast, is organized around a central metaphor of mind and computer as symmetric, coupled information processors. At the center is a set of information processing phenomena or issues in computers and users such as 'how does information get in', 'what transformations does it undergo', 'how does it go out again,' 'how can it be communicated efficiently' etc. To appropriate Flyvbjerg's characterization of the state of modern social sciences, it raises "rationality and rational analysis to the most important mode of operation for human activity" [11, p. 23]. Left at the margin are phenomena that are difficult to assimilate to information processing, such as how people feel about interaction, the place of a particular interaction in larger systems of use, and elusive and enigmatic aspects of everyday life such as "what is fun?". The point is not that the margins can't be talked about - you can make an information-processing model of any phenomenon - but that things at the margin are likely to be underrecognized and, when recognized, are likely to pose persistent problems that are difficult to solve.

This description of the two paradigms that have been dominant in HCI is not intended to imply that all research projects or researchers fit neatly into one of these two categories. For one thing, alternative constructions of paradigms are certainly possible. Our goal here is primarily to argue for the existence of a specific, additional paradigm for the purposes and goals of understanding HCI.

Neither do the paradigms necessarily contradict one another. Work may be done that cuts across the paradigms or that exists outside of them entirely. Rather, the paradigms provide broad perspectives that are useful for sorting out what problems are interesting and likely to be solved, and to suggest success criteria for finding their solution.

Of course, when paradigms clash, problems may arise. An example of such a clash is the 'Damaged Merchandise' controversy in the mid-'90's, in which Gray and Salzman argued not only that pragmatically-oriented approaches to usability evaluation are invalid, but also that usability can only be validated through the scientifically and theoretically grounded methods of the second paradigm [15,16]. Similar clashes, we would argue, are appearing now. In the next section, we describe emerging strands of research that poorly fit to the two dominant paradigms at CHI and suggest that a 3rd paradigm is at hand.

Evidence of An Emerging Paradigm

Following our definition of paradigms, a paradigm shift can be tracked by noticing when phenomena that used to be at the margin have moved to the center of attention. In this section, we describe some of the contemporary strands of research that suggest limits to the information-processing metaphor and the need to develop alternatives.

One set of issues arises out of work in ubiquitous computing which suggests a renewed centrality for the use-context of computing. While context could be sidelined to some extent in looking at the desktop interface, the appearance of computing embedded everywhere in both work and personal life has raised the context of computing to a central problem for ubicomp design. Some methods of dealing with this context follow directly from the 1st and 2nd paradigms, notably ones that attempt to identify and optimize information flow between mobile and ubiquitous devices and their context. These approaches model use-context as yet another source of information which can be formalized and transmitted to machines. But approaches to ubicomp that derive from disciplines such as ethnography, design, and the arts are based on the idea that use-context is, in the end, fundamentally unspecifiable and must be dealt with by other means [e.g. 9].

Another set of issues arises out of workplace studies, which focus on the social situation of interaction. These perspectives have often been hard to reconcile with CHI, leading to their parallel exploration in CSCW. In particular, the centrality of social, situated actions in explaining the meaning of interaction is at odds with the an information-theoretic view of social interaction that is the core of the 2nd paradigm. [27] Activity theory, for example, is incorporated to the extent that it is used to create accounts of an existing situation, but not in discussions of design or evaluation.

A third set of issues is represented by the situation of learning environments and the politics of their evalua-

tion. K-12 learning goals are quite specified, but metrics such as user satisfaction and even performance are only partial indicators of the phenomenon of central interest, learning. Tutorial programs that supplant the classroom are quite consistent with the 2nd paradigm, tying learning tightly to information transfer. However, classroom level interventions that utilize sophisticated, interdependent claims about fit have by-and-large moved to ICLS which allows discussion of broader contexts and goals.

A fourth set of issues arises out of the domain of non-task-oriented computing. These approaches tend to be bad fits to the 1st and 2nd paradigms, whose methods tend to require problems to be formalized and expressed in terms of tasks, goals and efficiency - precisely what non-task-oriented approaches are intended to question. It is difficult, for example, to apply usability studies to ambient interfaces, since standard evaluation techniques are 'task-focused' in the sense of asking users to pay attention to and evaluate the interface, precisely what the system is devised to avoid.

Last, yet another set of issues arise out of the marginalization of emotion in classic cognitive work. A wide range of approaches to emotion, notably those of Picard [25] and Norman [24], has been inspired by more recent cognitive psychology, which argues that emotion plays a central role in cognition and models emotion as a type of information flow. But other approaches to affective computing reject the equation of emotion with information and focus instead on the interpretation and co-construction of emotion in action in ways analogous to situated action approaches in workplace studies [e.g. 4].

While each of these issues – and probably quite a few more - can be seen as a separate critique of what is marginalized in the prior paradigms, in this paper we will argue that, taken as a whole, many of these forms of refocusing HCI form a coherent 3rd paradigm based on several core principles. Next, we delineate those principles and the ways in which they drive research questions and methods for arriving at their answers in different ways from the first two paradigms.

Describing The 3rd Paradigm

We begin with the recognition that one of the themes that underlies the 3rd paradigm is a focus on embodied interaction. Embodiment, of course, also plays a role in the 1st and 2nd paradigms. In human factors, attention is paid to such factors as the fit of a mouse to the human hand or the amenability of particular font sizes to be easily read. Cognitively based work in HCI has laid out physical constraints that usefully inform interface design such as the speed at which humans are able to react in various situations. Embodiment in the 3rd paradigm is based on a different, central stance drawing on phenomenology: that the way in which we come to understand the world, ourselves, and interaction derives crucially from our location in a physical and social world as embodied actors.

Many in HCI have been introduced to aspects of embodiment with Paul Dourish's book, *Where the Action Is* [8] It emphasizes the concept of 'engaged action' as critical to the enterprise: "*Embodiment is not a property of systems, technologies, or artifacts; it is a property of interaction…. In contrast to Cartesian approaches that separate mind from body and thought from action, embodied interaction emphasizes their duality.*"

Focusing on embodied interaction substantially changes what we take as central to interaction. Klemmer, Hartmann, & Takayama [19], for example, in a review of the literature on embodiment, highlight five central implications an embodied stance has for the way we think about interfaces. A focus on embodied interaction moves from the 2nd paradigm idea that thinking is cognitive, abstract, and information-based to one where thinking is also achieved through doing things in the world, for example expression through gestures, learning through manipulation, or thinking through building prototypes. It suggests that our GUI interfaces place too little emphasis on the differential abilities of the human body, overemphasizing seeing, hearing, and motor control of our hands, while under-supporting other senses and our physical abilities such as action-centered skills and motor memory. It refocuses attention from the single-user / single-computer paradigm that has dominated the 1st and 2nd paradigms towards collaboration and communication through physically shared objects. It highlights the importance of risk as a positive aspect of embodied practice; there is no undo button in the real world. Finally, it reminds us that while, under the 1st and 2nd paradigms we have tended to focus on aspects of activity that are easily automated, real-world practice is complex and rich, interleaving physical activity and awareness with abstract thoughts, rituals, and social interaction in ways that defy a purely informational approach.

The Essence of the Third Paradigm

Despite the centrality of embodied interaction to the 3rd paradigm, it would be a mistake to take physical embodiment – i.e. having a body - as its central, defining characteristic. Rather, what is central is a phenomenological viewpoint, in which all action, interaction, and knowledge is seen as embodied in situated human actors. This position leads to a number of intellectual commitments that contrast with those taken by the first two paradigms.

The Construction Of Meaning

The 1st paradigm tends to take a pragmatic approach to meaning, ignoring it unless it causes a problem, while the 2nd interprets meaning in terms of information flows. The 3rd paradigm, in contrast, sees meaning and meaning construction as a central focus. It adopts the stance that meaning is constructed on the fly, often collaboratively, by people in specific contexts and situations, and therefore that interaction itself is an essential element in meaning construction. Meaning derives from information, of course, but in this perspective cannot be summed up by mapping information flow; it is, instead, irreducibly connected to the viewpoints, interactions, histories, and local resources available to those making sense of the interface and therefore to some extent beyond the reach of formalization. Thus, for example, we see research on the value of ambiguity, notably the heavily cited work of Gaver, Beaver, & Benford [13].

Putting Users in Their Place

If meaning is in some ways irreducibly local, then knowledge is strongly situated as well. Following Haraway's definition [18], situated knowledge refers to the idea that people's understanding of the world, themselves, and, in the case of HCI, interaction is strongly influenced or perhaps even constructed by their varying physical and social situations. The move to embodiment is consequently a shift to recognizing a plurality of perspectives. Designing interaction, in turn, moves from attempting to establish one correct under-

standing and set of metrics of interaction to studying the local, situated practices of users, taking into account but not adjudicating the varying and perhaps conflicting perspectives of users. Aoki & Woodruff, for example, argue for the value of CMC systems accommodating multiple understandings of what is happening in a relationship [2].

Putting Interfaces in Their Place

One result of a viewpoint that takes situated embodiment as crucial is a renewed emphasis on the importance of place in computing. For example, McCullough's *Digital Ground* [22], which treats ubicomp from an architectural perspective, analyzes the significance of technologies becoming designed for or designed to adapt to specific locations, times, social situations, and surrounding systems. Broadly, 'putting interfaces in their place' is grounded in the recognition that the specifics of particular contexts greatly define the meaning and the nature of an interaction. Since all possibilities cannot necessarily be designed for, one design strategy is to make the computation and the interface embodied. By designing the externalities of the interface in much the way that robotics has embraced the idea (and of course, drawing on the ideas of the embodied human mind), the device or system does not have to model every contingency. Other strategies include location awareness or situation awareness, for example cell phones knowing if they are in a movie theater or if their owner is in the middle of non-phone conversation.

Putting Researchers in Their Place

If users' knowledge is situated, so is that of the researchers studying them. Compared to the 2nd paradigm, at least, the range of disciplines and perspectives constituting the 3rd paradigm is remarkably catholic, ranging from the arts to sociology to policy. The goal does not appear to be to establish one of these disciplines as the gold standard. Indeed, one characteristic of the 3rd paradigm is a preference for multiple interpretations that give a rich sense of the site of interaction over a single, objective description of it [26].

Explicit Focus On Values In Design

Given that the phenomenological perspective highlights the variety of potentially valid viewpoints, evaluation of what makes a system a success can no longer be rooted *a priori* in measures said to be universally valid. Instead, we must ask questions about what it means for a system to be 'good' in a particular context – a question that quickly brings us to issues of values. Value-based approaches to HCI such as participatory design and value-sensitive design have come into use to establish new criteria of success - and therefore of decision-making - in system design and evaluation. [12] All call for some form of explication and explicit negotiation. Instead of being marginalized, the context of design is brought back as central and filled with questions such as "Who is making the design decision?", "Who is paying for it?", "What is this saying about the user?" and so on. Likewise, in aesthetic evaluation of interfaces, "elegance" is no longer exclusively premiated; it is just as likely that "appropriate" or "appropriable" are central aesthetic requirements.

The centrality of context

The 1st and 2nd paradigms acknowledge context primarily as "those non-technological factors that affect the use of the technology." Under the 3rd paradigm, we ask not "how does context give our design meaning?" but instead "how does our design accommodate the con-

text?" This latter question includes what we do not put into our design, our restraint, or "zensign." It also encompasses the possibility that the technological system is reported not because it is particularly unique or attractive, but because of how it fits into the particulars of a complex situation. A consequence of this is that context is a central component not only to the problem (if any) but also to design and evaluation.

The 3rd Paradigm, Defined

We are now in a position to define the 3rd paradigm more precisely. It contains a variety of perspectives and approaches whose central metaphor is interaction as phenomenologically situated. The goal for interaction is to support situated action in the world, and the questions that arise revolve around how to complement formalized, computational representations and actions with the rich, complex, and messy situations at hand around them. The three paradigms are compared in Table 1.

Because of its emphasis on multiple perspectives, the 3rd paradigm does not espouse a single, correct set of methods or approaches. Instead, as discussed previously, we see a variety of approaches that are embedded in a similar epistemological substrate, like a biological matrix. For this reason, we suggest the term the, *phenomenological matrix*, a multidimensional characterization of concerns in which relationships and sequences can be defined as a name for the 3rd paradigm[2]. It fulfills Kurt Lewin's demand that we "draw on the totality of coexisting facts which are conceived of as mutually interdependent" [21, p.240] to explain, predict, and influence human behavior and experience. In a curious way, the 3rd paradigm resembles the 1st in its ability to recognize issues phenomenologically. However, rather than eschewing theory, it adopts multiple theories or stances and considers them non-exclusively.

Different Ways Of Seeing

To clarify the differences among the paradigms, as well as the ways they can co-exist, let us take a simple and hopefully well-known interface example. In the 1960's, the United States Air Force developed automated cockpit warning systems to alert pilots to hazardous conditions. The systems used recorded voices to tell pilots to turn, climb, or dive to avoid head-on collisions, among other things.

The 1st Paradigm.

The situations that drove the initial system design were classic examples of "critical incidents" [10]. The Air Force realized they needed to quickly gain the pilots' attention. At the time, all pilots and fight controllers were male, so someone had the bright idea of using a woman's voice so that it would be immediately identified as the "emergency voice". This was clever and worked well.

The 2nd Paradigm.

Of course, thinking about it terms of information theory, this not only reduced errors (a fundamental value of the 1st paradigm), it transmitted information more efficiently. It is easy to see that there could be a taxonomy of voice types created based on cognitive load and response times.

[2] The name of the paradigm seems to distress many reviewers; the authors are quite open to alternative names for the paradigm. In fact, we see the indeterminacy of the name to reflect the emergent nature of paradigm.

	Paradigm 1	Paradigm 2	Paradigm 3
Metaphor of interaction	Interaction as man-machine coupling	Interaction as information communication	Interaction as phenomenologically situated
Central goal for interaction	Optimizing fit between man and machine	Optimizing accuracy and efficiency of information transfer	Support for situated action in the world
Typical questions of interest	How can we fix specific problems that arise in interaction?	▪ What mismatches come up in communication between computers and people? ▪ How can we accurately model what people do? ▪ How can we improve the efficiency of computer use?	▪ What existing situated activities in the world should we support? ▪ How do users appropriate technologies, and how can we support those appropriations? ▪ How can we support interaction without constraining it too strongly by what a computer can do or understand? ▪ What are the politics and values at the site of interaction, and how can we support those in design?

Table 1: Paradigms compared

The 3rd Paradigm.

From the outset, there were design issues based on the meaning of this approach. The particular female voice was reputed to have been selected for its sultry and seductive tone[3]. This quality reinforced the idea of the space of the cockpit being "male," echoed in movies like *Top Gun*. Of course, as women became flight controllers and pilots, this 1st and 2nd paradigm strategy ceased to be effective. It also caused interface designers to explore new meanings of the gender of the voice.

While different paradigms focus on different problems, we can see that all three of these perspectives run in parallel – that whatever the solution, pilots should be warned of peril in a timely fashion, that measurable improvement in this context is better, and that the larger issues of the construction of problematic meaning also matter. As we will describe next, the situation becomes more challenging when the paradigms come in competition.

[3] One interesting side effect was to gender popular media representations of flight control automata as female. Particularly notable is the original StarTrek computer.

Challenges of A "New" Paradigm

The description of the 3rd paradigm should not sound new – many researchers in HCI are already working out of this framework, although it has not been systematically recognized as such. One goal of this paper is simply to bring what already appears to be happening in CHI to the surface for conscious consideration. Indeed, a survey of the 151 long and short papers at CHI 2006 shows that 30 could be thought of as developed from the phenomenological matrix (3rd paradigm). But deeper issues and concerns are involved, as well.

The fact of multiple simultaneous paradigms is not in itself a problem – a new paradigm does not disprove an old one, instead providing an alternative perspective that highlights and addresses alternative phenomena. The primary challenge, however for the 3rd paradigm to fully bloom is to break out of the standards which have been set up by incompatible paradigms. Doing so is not easy; the result is a series of misappropriations, misunderstandings, and rejections of work resulting from the 3rd paradigm because it poorly fits ideas of method and validity arising from previous paradigms.

Dourish, for example, argues that 20 years after the introduction of ethnography into the HCI canon it is still systematically misunderstood as a method for extracting user requirements rather than a discipline that analyzes the entire site of human-computer interaction [7]. Thus, an ethnography, by itself, does not constitute a legitimate CHI publication without an additional instrumental component such as user requirements or an evaluation of the interface using information-processing criteria. More recently, we see that Carroll's *Models, Theories and Frameworks of Human-Computer Interaction* [6] presents for students extended discussions of fourteen models, theories or frameworks of HCI, about half of which cannot by themselves lead to CHI publications.

That is, we find many techniques used in requirements development, but not in the conceptualization or evaluation of the resulting system – at least as represented in CHI papers. It is as if physicists said "Now that we have shown that we can create linear accelerators, the findings from these are irrelevant to research." And because techniques arising from the 3rd paradigm are not seen as inherently valid, methods and insights from alternative perspectives are often simply amalgamated to informational or engineering perspectives, without recognizing or dealing with the very real incompatibilities between these perspectives. The notion of communities in the CHI conference may be seen as a reflection of the notion that some new perspectives ought to be acknowledged.

There are three recurrent, pragmatic difficulties in getting a paper through the CHI review process: (1) the legitimacy of only certain kinds of measures of success, (2) limited understanding of validity of methods outside a limited canon, and (3) insensitivity to important innovation. They are symptomatic of the tensions between the 1st and 2nd paradigm methods and values, and the actual approaches that pervade HCI today.

Measures of Success

In the 2nd paradigm, acceptable measures of success focus on measuring the comparative effectiveness and efficiency of information transfer. User self-reported satisfaction might suffice, but is seen as a poor cousin to efficiency. Measures of success from the 3rd paradigm fare a variety of fates when reviewed from this

perspective. Some criteria, such as delight, are not seen as legitimate criteria at all. Other criteria, such as provoking ideas or causing the reader to consider new possibilities, are not considered sufficient criteria of success. Furthermore, balancing the concerns of different stakeholders in a clever way, or enabling activity that would otherwise simply not be possible are not by-and-large sufficient measures of success.

To compensate for this, as Grudin [17] has documented, we see the rise of specialty research communities such as ICLS bearing no relationship to the official communities in the CHI conference with their own conferences and publications. They do not, as they might, form new sub-disciplines with a more particular set of methods, values and aesthetics that derive from the CHI paradigm, but rather must adopt independent standards.

Methods

Many in HCI bemoan the fact that CHI is poorer for not understanding the values or implications of alternative perspectives, but place the onus on the HCI researchers in a potential sub-discipline to analyze the results in 2nd paradigm terms. As represented in accepted papers, CHI holds controlled experimentation with a few kinds of quantifiable outcomes in extraordinarily high esteem[4]. The canon of acceptable methods is even more confined than that in psychology since many of the most famous psychological studies involve quasi-experimental or demonstration designs [14].

[4] By rough count, at least 90 of the long and short papers in CHI 2006 reported quantified results. We cannot, of course, know how well the accepted papers represent the rejection criteria.

Furthermore, even experiment-based theories that grapple with highly contextual content are seen as insufficient, because they are difficult to apply without training and thought. Monk, for example, concludes his discussion of Clark's theory of language as follows: "In an ideal world, a theory should be encapsulated as a set of guidelines or rules that could be used by a designer with very little background in human factors of human communication. Falling this, the theory should be formalized as principles…. the theory is only really usable by researchers…." [23, p. 288]. Insofar as HCI claims to be a scientific discipline, this is a surprising declaration. Insofar as it is an engineering discipline, we note that civil engineers are required to have a considerable understanding of basic physics, followed by considerable instruction in how that physics relates to real materials and conditions before they are certified to build bridges. It is not the theory's job to be simpler than the phenomena it describes. In any case, such limited guidelines or rules run counter to understandings of the complexity of interaction that arise from the 3rd paradigm.

Recognizing Innovation, NOT

If we wish the field to be consequential, we must explain important questions. However, many questions cannot be addressed within the 2nd paradigm framework. For example, in the 2nd paradigm, there is no explanation for why people play games or why there are more Windows machines than Macintosh's. A nice looking interface cannot be evaluated in its own terms, but rather in functional terms. Don Norman has to cite studies showing that good-looking interfaces produce more efficient outcomes to give legitimacy to the notion of emotional design [24]. Furthermore, there are legitimate questions about equivalency of designs rather

than differences between them that cannot be well explored using statistical methods.

For the most part, CHI missed the rise of the Internet; this is old news, often attributed solely to CHI's focus on the very detailed aspects of interfaces and browsers' ability to present information in different formats. From the stand-point of a strict cognitive approach, there is limited language that would describe the general phenomena of a unified information browsing-, socializing-, retail-, play-, educational-, and work-environment. From a 3rd paradigm point of view, we would not demand a single unified language but take each of these and their confluence as significant.

Different Ways of Knowing

The three issues described previously – limited and inappropriate measures of success, acceptable methods, and recognition of innovation – can be traced to a lack of awareness of the epistemological distinctions between the paradigms, as a consequence of which 2nd paradigm measures, methods, and phenomena are often taken as applicable to all forms of CHI work. But the difference between paradigms is not only one of different core phenomena, but also different conceptions of what it means to know something is true. Our goal in this section is to outline the ways in which the 3rd paradigm's epistemological commitments contrast with those of the 1st and 2nd paradigms; these differences are summarized in Table 2.

Objective vs. Subjective Knowledge

The 1st and 2nd paradigms emphasize the importance of objective knowledge. The 3rd paradigm, in contrast, sees knowledge as arising from situated viewpoints in the world and often sees the dominant focus on objective knowledge as suspect in riding roughshod over the complexities of multiple perspectives at the scene of action. As Bannon expresses it in the case of CSCW: "Our goal was to develop a case against an objective reality that can be usefully captured in a model and subsequently used as a sufficient basis on which to develop a computerized system" [3]. A number of HCI researchers have taken it a step further, recognizing the subjectivity of the researcher and the relationship between the researcher and the researched; where issues of intersubjectivity are common in anthropology, they are remote and difficult to address in the 2nd paradigm.

	Paradigm 1	Paradigm 2	Paradigm 3
Appropriate disciplines for interaction	Engineering, programming, ergonomics	Laboratory and theoretical behavioral science	Ethnography, action research, practice-based research, interaction analysis
Kind of methods strived for	Cool hacks	Verified design and evaluation methods that can be applied regardless of context	A palette of situated design and evaluation strategies
Legitimate kinds of knowledge	Pragmatic, objective details	Objective statements with general applicability	Thick description, stakeholder "care-abouts"
How you know something is true	You tried it out and it worked.	You refute the idea that the difference between experimental conditions is due to chance	You argue about the relationship between your data(s) and what you seek to understand.
Values	▪ reduce errors ▪ ad hoc is OK ▪ cool hacks desired	▪ optimization ▪ generalizability wherever possible ▪ principled evaluation is *a priori* better than ad hoc, since design can be structured to reflect paradigm ▪ structured design better than unstructured ▪ reduction of ambiguity ▪ top-down view of knowledge	▪ Construction of meaning is intrinsic to interaction activity ▪ what goes on around systems is more interesting than what's happening at the interface ▪ "zensign" – what you don't build is as important as what you do build ▪ goal is to grapple with the full complexity around the system

Table 2: Epistemological distinctions between the paradigms

Generalized vs. Situated Knowledge

The 2nd paradigm values generalized models such as GOMS. But because the 3rd paradigm sees knowledge as arising and becoming meaningful in specific situations, it has a greater appreciation for detailed, rich descriptions of specific situations. In part, this refers back to the arguments around situated action, which argued that while abstract knowledge and formalisms

are certainly useful, they do not directly drive or explain our activity in the world. In order to better understand what people are doing, we need to track the situated contingencies and strategies people use to apply this abstract knowledge in real situations. Where the 2nd paradigm down-played whether an office had books in it or that a computer sitting under a desk produced lots of heat when analyzing mouse performance, we all now recognize that "externalities" are often central figures in the understanding of interaction.

Information vs. Interpretation

The 2nd paradigm arises out of a combination of computer science and laboratory behavioral sciences that emphasize analytic means such as statistical analysis, classification and corroboration in making sense of what is going on at the site of interaction, often under controlled conditions. As Sengers & Gaver argue, however, new approaches to CHI see interaction as stimulating multiple interpretations in concrete, real-world situations, and the job of the evaluator to identify and track those interpretations, often in collaboration with their 'subjects' [26]. The epistemological stance brought to this site is generally hermeneutic, not analytic, and focuses on developing wholistic, reflective understanding while staying open to the possibility of simultaneous, conflicting interpretation. As Bannon writes, "Our critique relied on the centrality of interpretation in the conduct of work, and also on the fact that the development of computer-based applications requires the collaboration or involvement of a variety of distinct communities.... [characterized by an] essential incommensurability of their world views and languages". [3]

"Clean" vs. "Messy" Formalisms

The 2nd paradigm, reacting to the a-theoretical orientation of the 1st paradigm, values clean, principled, well-defined forms of knowledge. The 3rd paradigm, in contrast, sees the practical trade-offs in design as more often "messy" rather than principled. Paradigmatic for the 2nd paradigm, for example, are design spaces, which are, as Tatar argues [27], clean, mathematical representations of what is at stake in design and suggest that design decisions can be made independently of each other and with little regard for context. Tatar contrasts design spaces with 'design tensions', a series of (non-orthogonal) axes laying out conflicting design opportunities that come out in practice, the contextual issues that they impinge upon, and the ways in which they may be practically negotiated. The difference between these ways of thinking is rooted in whether researchers place the cleanliness and certitude of formal models at the center of their thinking or whether they instead place an appreciation for the complexity of real-world, messy behavior and activity at the center.

Where's The Science?

From a 2nd paradigm point of view, the contribution of HCI may be thought to rest on empirical, generalizable, scientific results. The 3rd paradigm does not promise to address these. Yet a careful look at the state of the 2nd paradigm identifies several kinds of needs for 3rd paradigm thinking.

First, many fields that feature empirical investigation such as that advocated by the 2nd paradigm also build on a substantial tradition of systematic observation of phenomena similar to that advocated by the 3rd paradigm. For example, the Linnean classification of or-

ganisms was a major empirical contribution to biology though not, in origin, experimental.

Second, the empirical status of 2nd paradigm thinking is itself subject to question. Critics raise the question of whether true scientific theory is possible in the social sciences on which much 2nd paradigm epistemology is based. Flybjerg, for example, argues that "the problem for social studies is that the background conditions change without the researcher being able to state in advance which aspects one should hold constant in order for predictions to continue to operate" [11, p. 45].

Third, unlike scientists, even under the 2nd paradigm, we in HCI are not pursuing abstract truth in general, but rather in more particular, technologically defined ways. We are interested in generalizability, but generalizability of meaningful design decisions. For example, we no longer do research on emacs keystrokes because the emacs text-editor is no longer widely used. Our principles are almost always local and provisional.

Thus, in some sense, the science in the 3rd paradigm bears a similar uneasy relationship to science in the 2nd paradigm. Both are ways of coming to know about the world, and both require continual reflection about goals, purposes, assumptions and legitimacy.

Conclusion

In the opening chapter to *HCI: Models, Theories and Frameworks*, Jack Carroll describes HCI as a multi-disciplinary science [6]. By ordering the disciplines into three paradigms, it is our desire to bring some clarity to the field, and begin mapping the relations between them. We may have used some radical language to clarify the breaks we see between the 1st, 2nd and 3rd paradigms, but we also trust that the reader recognizes the elements of their own work that are in each.

We are not arguing that the 3rd paradigm is right, while the 1st and 2nd paradigms are wrong. Rather, we argue that paradigms highlight different kinds of questions that are interesting and methods for answering them. Paradigms frequently co-exist and researchers may work within multiple paradigms. Even so, we believe it would be wise to recognize the differences and incompatibilities between paradigms that make them amenable to different sorts of problems; so that, for example, it would probably be unwise to attempt to uncover the rich appropriations of a situated technology with an objective laboratory test.

We also believe it is important for CHI to understand that, sometimes, paradigms do clash; those clashes may appear in the form of a debates in the field about proper methodology, validity of results, etc. Work in one paradigm can easily look invalid to someone working in another paradigm, because it is based on quite different notions of what knowledge is and how it is to be generated. Or it may seem valid but beside the point, since the driving questions are different.

And when paradigms clash, the overlap of ways of seeing taken with conflicting epistemologies results in a miasma of legitimacies. HCI has always been a hybrid discipline and therefore has used either the intersection or union of legitimate practices from its constituents. Thus the 2nd paradigm defines legitimacy as measurable utility, and it is this standard to which 3rd paradigm work tends to be held. But that is not *a priori* the definition of legitimacy; to allow the 3rd paradigm to bear full fruit, we need to recognize and accommodate its

notions of validity. And a cost of work in the 3rd paradigm is the need to explicate what is legitimate in the 3rd paradigm enterprise. We would expect that any submission in the 3rd paradigm would explain its phenomenological matrix and explain (rather than argue for) its measures of success.

We trust that if these arguments resonate with the reader, they will take the time to consider alternative names for or constructions of the 3rd paradigm.

We would expect that calling out the underlying paradigm will become a standard part of every publication in our field. Thus, we will not be forced into the sort of pro forma corners that Paul Dourish warned us about at CHI 2006. [7] Further, it is also reasonable to expect that evaluation of research and new interface ideas will become more nuanced and situated, and that richer descriptions (no matter what the paradigm) will become the standard. In this way, we hope that the 3rd paradigm, just as the 1st and 2nd, can be allowed to make a permanent contribution to the field.

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