Affect: From Information to Interaction

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ABSTRACT

While affective computing explicitly challenges the primacy of rationality in cognitivist accounts of human activity, at a deeper level it relies on and reproduces the same information-processing model of cognition. In affective computing, affect is often seen as another kind of information - discrete units or states internal to an individual that can be transmitted in a loss-free manner from people to computational systems and back. Drawing on cultural, social, and interactional critiques of cognition which have arisen in HCI, we introduce and explore an alternative model of emotion as interaction: dynamic, culturally mediated, and socially constructed and experienced. This model leads to new goals for the design and evaluation of affective systems - instead of sensing and transmitting emotion, systems should support human users in understanding, interpreting, and experiencing emotion in its full complexity and ambiguity.

Keywords

affective computing, situated action

INTRODUCTION

A social, interactional approach to understanding cognition in human-computer interaction has emerged in the last twenty years in contrast to the dominant information-processing approach to capturing, modeling, augmenting and supporting human activity. The recent emphasis on the importance of emotion for cognition further advances these arguments to look "beyond the cognitive" and to understand new aspects of human experience. Nevertheless, there is a critical difference between the turn to emotions and the turn to the social in HCI. While the social and cultural approaches attempt to deconstruct conventional approaches to cognition (and in particular the underlying cognitivist computational claim on mind), the recent exploration of the role of emotions leaves traditional cognitivism intact, and in fact depends on it as the base for adding "emotional" understandings.

Emotion, in the informational model, is a dual of cognition, but it is nonetheless the same sort of phenomenon – an internal, individual, and delineable phenomenon, which operates in concert with and in the context of traditional cognitive behavior. That is, while emotion is proposed as a supplement to traditional cognitive accounts, it is nonetheless located within the same information-processing frame. For this reason, emerging understandings of emotion are subject to the same critiques that have been leveled at purely cognitive approaches in the past – that is, their failure to account for and adequately incorporate an understanding of everyday action as situated in social and cultural contexts that give them meaning.

In contrast to the informational model, we offer and critically explore an interactional account of emotion and the role that it plays in action and practice. As argued by Boellstorff and Lindquist [5], citing Rosaldo [31], "feelings are not substances to be discovered in our blood but social practices organized by stories that we both enact and tell." The production and interpretation of emotion – of national pride, justifiable anger, or shame – is social and cultural in origin. We take emotion as a social and cultural product experienced through our interactions.

This interactional approach to emotions extends current HCI agendas, and in particular current affective computing research, in three ways. First, this approach sees emotions as culturally grounded, dynamically experienced, and to some degree constructed in action and interaction. This expands the ontological view of emotions as informational units that are internally constructed and subsequently delivered. Second, as an interface paradigm, an interactional approach moves the focus from helping computers to better understand human emotion to helping people to understand and experience their own emotions – the raw elements and perceptions of emotions, the constructed conceptions of these emotions, and the resulting effects such as behavioral or cognitive changes. Finally, the interactional approach leads to new design and evaluation strategies for devices. Systems inspired by the interactional approach to emotion emphasize the expression of emotion in a co-constructed, co-interpreted fashion. Measures of success for such systems are therefore not whether the systems themselves deduce the 'right' emotion but whether the systems encourage awareness of and

reflection on emotions in users individually and collectively.

In this paper, we consider the turn in HCI to affective computing and, in particular, the different expectations, commitments, and entailments of the informational and interactional models. Our argument is anchored by two experiences developing technologies in the affective tradition. Our initial experiences highlight the limitations of the informational approach that we had adopted; after exploring the interactional approach, we use a second case study to show how these ideas can be embodied in design.

EMOTIONS, AFFECTIVE COMPUTING, AND HCI

Our starting point for this discussion is the emergence of interest in affective computing within HCI as one of a set of challenges to the prior cognitivist focus of HCI. We then examine the ways in which affective computing repeats some of the central tropes of the cognitivist model which have been questioned by other challengers. Finally, we discuss the difficulties we ran into in practice with a system that was based on a model of affect as information.

Expanding the Cognitive Model of HCI

HCI's historical and intellectual roots lie in cognitive science and the central underlying philosophical claim of cognitivism, that the mind can be understood and modeled in computational terms. This philosophical approach has served the dominant agenda of computer applications during the rise of HCI: the automation and formalization of standard work practices. Extracting the standard practices of work activity and modeling corresponding abstract thought processes proposes (theoretically) to optimize the interaction and interface between humans and computers. In shorthand, this match-up reads something like: procedural/abstract work involves procedural/abstract thought requiring procedural/abstract systems.

This perspective has underwritten an extensive empirical and theoretical program exploring the operation of the human cognitive system from a representational and information-processing perspective, couched in terms of symbol manipulation, storage and processing. This model is so deeply engrained in the practice of HCI that even when deliberately trying to escape it, we can detect the model's influence, as we will describe in our own case study later in this paper.

More recently, a number of researchers, drawing on varying traditions and with different evidence to offer, have begun to articulate alternatives to the traditional approaches of cognitive interpretations of human behavior and the designed systems that result from them. Some of these researchers, such as Lucy Suchman, have focused on re-conceptualizing the idea of what constitutes procedural work, arguing that what looks to be easily standardized and therefore open to computation is actually much more situationally-informed [e.g. 37]. Other researchers have pushed on the historical approaches to cognivism in HCI by looking beyond task oriented applications and the

environment of work to everyday experiences of technology. They look at technology uses for ludic [17,19], fun [3], or felt [24] experiences outside, as well as within, the work environment. In these examples, the focus of HCI is pushed beyond limited domains of application and typical notions of 'work'.

Likewise, HCI has undergone transformation in the cognitive models informing design. Researchers have drawn on sociology and anthropology to enhance the notion of cognition as more than rational thought and as more than an individual responding to an outside world. Cognition has been proposed instead as something social and cultural [33] embedded in our everyday practices of making sense of and interpreting the events we encounter.

In line with these other advancements, the term 'affective computing' has emerged in the HCI community. Affective computing researchers argue that cognition is not solely rational, but emotional as well, and that systems built on models of cognition must also address affect. Affect has long been ignored by computing design, partly because cognition portrayed as abstract, logical, sequential processes had no room for phenomena thought to be messy and subjective. By bringing affect on a level par with logic and rationalism, HCI researchers seem to take a further leap away from the historically limited model of cognitivism.

However, as we shall demonstrate, the very models of cognition as discrete, abstract, and formalizable that are being disbanded for rational thought are at the heart of how affect is being modeled for computing design. In other words, rather than affect further dismantling a dated view of cognition, affective computing is often following the same trajectory only decades later.

Affective Computing and Rational Cognition

Affective computing was popularized as a formal agenda for HCI by Rosalind Picard and fellow researchers at MIT, although inspiration for affective computing draws from several fields including artificial intelligence (AI), neurology, and cultural studies. AI researchers have a long history of studying 'emotion' as an aspect of 'intelligence' [e.g. 34,13,1,27,7]. Likewise, neurologists, most notably Antonio Damasio [10], have convincingly demonstrated the interdependence between emotions and activities previously considered to require rational thought, such as problem-solving and decision-making. Finally, cultural critiques [e.g. 22] have questioned rhetorical distinctions of emotion and reason that relegate emotion to a second-class status. Hierarchical oppositions that cognition is controlled, precise and objective, while emotion is wild, vague, and subjective are entrenched in everyday life and discourse. Indeed these distinctions and the common conception of computers as aligning with the attributes of cognition are one reason the affective computing agenda has only recently been gaining formal momentum.
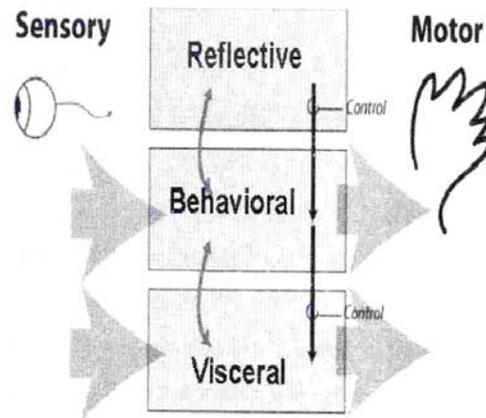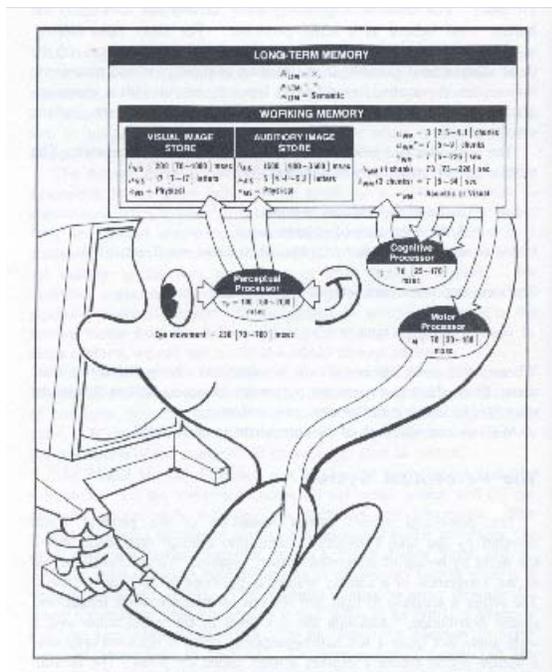
Figure 1: (a) the model human processor [9] (b) Norman's three-level model of emotion [25]

In contrast to this cultural opposition of emotion and cognition, Picard [28] argues that emotion is a crucial element in our experience of and interaction with the world, and has gone on to demonstrate the role that it can play in interaction with information systems. Her model of affective computing is broad, encompassing not only computational responses to, but also computational influences upon the emotions of a system's users. An emotional competence on the part of computer systems, she argues, makes interaction more efficient and effective, mimicking aspects of how humans interact in the everyday world. Emotion, here, becomes a step along the way to creating "intelligent" systems which can effectively simulate human behavior [36].

Similarly, Don Norman [25] has become a prominent and influential advocate of emotions as a key component of people's experience with each other, with the world, and hence with the physical objects around us. Norman, whose studies of design have been hugely influential, has extended his approach to incorporate emotion as a central component, noting that the experience of "everyday things" is conditioned not simply by practical or "logical" concerns but also by aesthetic and emotional ones.

Despite this shift away from a purely "logical" and to some extent "rational" aspect of HCI, Norman still addresses emotion as an additional internal component of the traditional information-processing model of cognition. It is instructive, for example, to compare how cognition and emotion are diagrammed. Figure 1a is taken from Card et al.'s [9] classic HCI text, *The Psychology of Human-Computer Interaction*; it shows a schematic overview of their "Model Human Processor," a quintessential

expression of the computational basis of cognition. Figure 1b is taken from Norman's [25] *Emotion and Design* and shows an overview of Norman's three-level model of emotion. What is interesting to note about these two images is where cognition and emotion are located. In both cases, they are contained within the boundaries of the body – caught between eye and hand. Like cognition, emotion is an internal, thoroughly individual phenomenon.

Both cognition and emotion are construed here as inherently private and information-based. Although emotion is thought of as being "beyond" cognition, or encouraging us to think more broadly about the relevant aspects of interaction, both emotion and cognition are conceived of as essentially biopsychological events that occur entirely within the body, which are communicable intact from one person to another or to a machine. The idea of emotion is thus subject to the same constraints as traditionally ideas of cognition – it is internally processed and fully "transmitted" through some sort of information channel or conduit.

Reddy [29] argues that this "conduit metaphor," in various guises, underlies information-processing accounts of language, interaction, and collaboration. Indeed, the idea that everyday interaction can be modeled in terms of flows of information – from world to person, from person to world, from person to person through world, and so on – is central to the development of information science and the rise of computation as a broad master narrative for cognition, interaction, social action, and more [11]. Where the word "information" was once used largely to describe a process of informing, it is increasingly being used as a mass noun, to denote some substance that can survive both

in the world and in our heads. With the continual encroachment of digital processing on elements of everyday life, the information-processing metaphor becomes a dominant way of thinking about the world; witness, for example, the transition between early descriptions of computers as "giant electronic brains" to more recent depictions of brains as computational entities.

In particular, the conduit metaphor has become a central part of how we in HCI think of emotional experience and affective computing. Affect comes to be seen as consisting of discrete units which are internally experienced and can be transferred intact between people and machines. This informational notion of affect influences the way we design and evaluate systems. As an example, we present the first of two case studies drawn from work in Cornell's Culturally Embedded Computing Group.

Case 1: Miro, Affect as Information
This first case, Miro, highlights problems in designing for affect as information to motivate designing for affect as interpretation. Miro [4] was a system installed by Boehner, Chen, and Liu in an office building to provide building occupants with a sense of the overall emotional climate in the office. The designers surveyed the office for a week prior to installation to get a sense of the overall emotional rhythms during the day. They installed emotion entry stations in several locations that allowed users to input their emotions. The emotional data collected through these two techniques was aggregated and displayed through the movements and colors of objects in the display. The goal was for users in the office space to be able to develop a sense of the lab's emotional climate by interpreting the display, learning the language of the display over time.
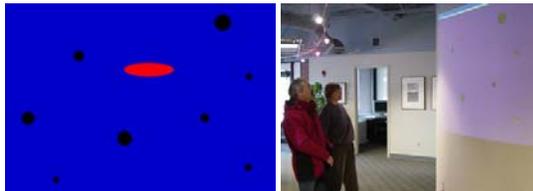
Figure 2: Miro (left) and puzzled users (right)

The designers chose to communicate affect by animating an abstract painting ("Blue" by Joan Miro) specifically because they wanted to counter the idea that emotion could be represented in a codified manner, by for instance displaying 'happiness level = 5'. Instead, the designers wanted a degree of interpretability and fuzziness in the presentation of the collective emotional climate. However, they later realized that they had simply created an ambiguous information visualization. Happiness was not presented as a number or a chart, but was indicated in a one-to-one manner by attributes of the display: sociability mapped to the clustering of the black dots; energy levels were depicted by the speed of the animated red swath, and so on. The system design corresponded to a discrete input-output model, only the output was presented in such a way

that the one-to-one map between input, internal model, and output was more difficult to decipher.

Nevertheless, the ambiguity in Miro's output turned out to be key to Miro's unexpected success. In practice, users did develop a sense of the lab's emotional climate by interpreting the display. This interpretation, however, did not consist of developing an understanding of the internal map that the display was intended to communicate. As one of its users said, "Uh, I have no idea what it means." Still, users would stand in front of the display and interpret its meaning for each other: "it's clearly displaying the stress levels related to that NSF deadline next week" – even when the display, according to the internal map, was 'actually' displaying happiness.

As an object to be decoded, Miro was a clear failure. Nevertheless, users *did* develop a sense of the office's emotional climate from the discussions that Miro incited. Users created interpretations of the system that were often more correct than the system itself, based on background knowledge of what was happening in the office. Miro acted as a trigger for interpretation but did not directly transmit information. Oddly, Miro fulfilled its designers' intentions of encouraging reflection on emotional climate, but not in the way the designers intended.

EXPANDING COGNITIVE MODELS OF AFFECT
Miro succeeded in unexpected ways because of its uptake as a stimulus for talking about affect. Whereas it failed to represent an existing affective state, it encouraged active construction of what might be happening in the office. This shift in purpose, from modeling affective information to supporting affective interpretation, underscores the need to look beyond information-processing models of affect where emotion is addressed as an input-output mapping problem. In this section, we draw on previous challenges to information-processing models of human behavior to examine the new directions they suggest for understanding affect.

Social and Cultural Affect
Cognitive models of interaction have increasingly been supplemented by social, cultural and historical accounts that draw attention to how interactional patterns take on meaning and significance in collective contexts. Similarly, in this section we move beyond an informational, individual understanding of affect by exploring affect as an element of social and cultural practice.

Traditional readings of cognition and rationality have been subject to a continued critique that cognition is relevant and meaningful as a category only in how it is demonstrated and used in the course of everyday social interaction. Scholars such as Schutz [33] and Garfinkel [16] draw on a range of empirical material to show that rationality is a witnessable feature of social settings rather than a pure, logical form; the mutual recognition and demonstration of rational behavior is a property of social interaction.

In order to understand rationality, then, we must look at the way in which it emerges and is put to work in everyday settings. This is, essentially, an argument about the conceptual categories of cognition and rationality: that they are linguistic terms whose meaning emerges from socially shared practice [39], so that when we describe the properties of the brain in terms of rationality and cognition, we are in fact re-inscribing features of our social life into our model of mental operation, rather than uncovering features that exist within the phenomena themselves. The idea of rationality – and our interpretation of everyday events as being rational – has a social origin.

Similarly, Catherine Lutz's [23] study of emotion as an aspect of everyday life on the south Pacific atoll Ifaluk – and in particular the comparison between emotion on Ifaluk and emotion in Western culture – demonstrates the strong cultural component in the construction of emotion and emotionality. Lutz differentiates here between biological and physiological aspects of feeling, and emotion, which is the culturally grounded set of meanings that both inspires those feelings and provides a basis for their interpretation. Emotion, she argues, is part of cultural and social life. It has social value and social meaning. To experience a feeling as, say, anger, love, happiness, lust, or frustration, one must be grounded in a cultural context that makes anger, love, happiness, lust, or frustration meaningful (and in turn determines a response to that emotion – whether it is something to be proud of, ashamed of, etc.)

One example is the Ifalukian concept of *song,* as detailed by Lutz in her ethnographic investigations. *Song* is, loosely, anger. In a Western context, anger is a negative emotion, one that is largely antisocial. *Song*, though, is used rather differently. Lutz translates *song* as "justifiable anger," and notes that its use is, in fact, pro-social; rather than tearing at the social fabric, the cultural use of *song* is cohesive.

The justifiable anger of *song* is provoked by a failure to uphold social norms and responsibilities. Taking more than one's fair share at a communal meal, shirking responsibilities in group work, failing to pay appropriate respects to elders or others with whom one stands in a subordinate social relationship, acting inappropriately in social settings, breaking the dignified silence of daily life: these are all actions that might provoke *song*, justifiable anger, in others. Given the strong social shaping to the conditions under which *song* might be provoked, there is similarly a strong social pressure not to provoke *song* in others. Children are frequently warned against or chided for inappropriate behavior (e.g. boisterous play) by being told that it might make others *song*; similarly, the reluctance to provoke *song* in others is often cited as a justification for particular acts. *Song* is something to be guarded against, and the way in which it is guarded against is by acting in accordance with appropriate cultural conventions.

Song, then, is culturally grounded in two ways. Firstly, the experience of *song* stems from a cultural embedding; it is a response to culturally meaningful events, a personal experience of the violation of norms and expectations which can be understood only with respect to the patterns of cultural interpretation that give social actions meaning. To experience *song*, then, is to be grounded in the cultural patterns that make *song* an appropriate response to have. Secondly, it plays a role in supporting and reinforcing those cultural experiences; the concept of *song* is used to mark behaviors as appropriate or not, as acceptable or not, and so to impose some normative structure on everyday life. Most interestingly, then, *song* has a quite different connotation than anger does in our own culture, due to its pro-social nature; *song* is used to reinforce social structures, patterns, and expectations.

It is critical to note that Western conceptions of anger, while clearly not pro-social, are still equally culturally situated; they also require an appeal to cultural understandings of the settings within which anger is a culturally appropriate response. That is, the identification of a particular setting (or its associated endocrine reactions) as related to anger (rather than frustration or angst or hatred or disappointment) is every bit as culturally determined as *song*. Neither *song* nor anger is primary, natural, or inherent; they are both cultural products.

It is also important to recognize that this is not simply a problem of translation. A simple reading of this example might suggest that "anger" is simply a poor translation of *song* – that the boundaries between one emotion and another on Ifaluk are different between the boundaries that we are familiar with, and so we might need a more nuanced vocabulary in order to translate or express them. This is certainly true, but it misses the point of Lutz's analysis. What Lutz shows is not simply that emotions on Ifaluk are different than in Illinois, but that emotion and emotions are culturally constructed categories. What constitutes an emotion at all – why something is experienced and classified as an emotion rather than as a stomach-ache, for example – is a cultural question. It is cultural contexts that do or do not allow for such distinctions.

What is more, emotional life then becomes a site for cultural production, a stage upon which cultural dramas are played. Geertz's studies of Javanese life and, for examples, emotional displays at funerals, suggest ways in which not just the management and display but the experience of emotions is a means by which cultural narratives are enacted [20]. Similarly, emotions such as ethnic or national pride can scarcely be separated from cultural traditions of identity. Or again, writing of the Ilongot (a tribal people of the Northern Philippines), Rosaldo [30] discusses the feeling of shame not as a curb on potentially antisocial behavior, but rather as an aspect of the ways in which individual autonomy is defined and negotiated. For the Ingolot whom she studied, part of the process of being an

individual is refusing to allow others to shame you, which in turn means that it is a way in which issues of equality, kinship relations, and social responsibility are manifest. Similar issues are at work in Western traditions and the embedding of emotion within a series of rhetorical oppositions (emotion as hot/cognition as cold, emotions as body/cognition as head, etc), perhaps most significantly the gender association of dispassionate rationality as male and irrational and uncontrollable emotion as female.

Broadly, then, what we take from these investigations is the fundamental principle that an emotion cannot be seen purely as an internal, individual, and private phenomenon; not only is the experience of emotion mediated by cultural and social situations, but it is also used to enact and sustain those settings. As summarized by Schieffelin [32, p. 181], "the experience, justification, and meaning of affect are not separable from either the role affect plays in the expressive order of interaction, or from the implications of the cultural scenarios in which it participates."

Interactional and Interpretive Affect

When we talk of social and cultural aspects of emotions, it is important to avoid two potential misreadings. By emotion as a social fact, we do not mean to point merely to the social value or social role played by emotion, but rather to talk of the ways in which our notions of what things might constitute emotions or might be thought of as emotional behaviors is a social notion. Similarly, by emotion as a cultural fact, we do not mean to examine culture as a taxonomic phenomenon (say, distinguishing between ethnically defined cultural regions, as in a comparison between emotion in British culture, emotion in Latin culture, and emotion in Asian culture), but instead want to think of culture as a productive phenomenon, one that shapes individual and collective experience and gives it meaning. We are concerned with the ways in which our very definitions, categorizations, and experiences of "emotion" is socially and culturally bound.

The binding of the social and the cultural, however, does not negate the agency and subjective feelings of the individual. As productive phenomena, culture and social contexts are also realized, reconstituted, experienced, and over time re-imagined, through the interaction of individuals. With an interactional approach to culture, and subsequently to the experience of emotions, we can reframe the dichotomy of the individual and the social/cultural into a mutually constitutive relationship. In this relationship, emotions are constructed and experienced as individuals act in and through their culture and social interactions.

Imagine, for example, that Lucy is in conversation with her friend Kristina and announces: "I'm going to Paris this weekend with my friend Simon." Kristina smiles and says, "That sounds like fun! But, whatever happened to our trip to Paris?" Lucy says, "I know. I know. We've been talking about that forever but it just never seems to materialize. I'm

sorry. Are you upset?" Kristina pauses for a moment before responding, "No. I'm not upset. You're right, I've been terribly busy the past couple of months and too stressed about work. I'm not upset. I'm disappointed I can't go but we'll do it another time."

If we were to apply the informational model of emotion to this example, we would look to uncover Kristina's 'true' emotion. Is she actually upset and hiding her true feelings? Or did she first respond with the emotion of being 'upset' and then downgrade this to 'disappointment' because of Lucy's sympathetic response? That is, perhaps multiple discrete emotions are felt and communicated in sequence, punctuated by some stimulating event such as Lucy's response. The "information transmission" model of emotion suggests that Kristina had or possessed an emotion and communicated it, consciously or unconsciously, to Lucy.

In contrast, the interactional model of emotion suggests that Kristina's emotions are shaped not only through their expression but also through their reception. In other words, what she's 'actually' feeling is worked out through her conversation with Lucy with reference to their shared cultural understandings of what it is one feels. The interaction model would also argue that Kristina may be feeling multiple emotions at once: she may be happy for her friend but disappointed at missing out on the fun. She may simultaneously be present and attending to the conversation but at the same time feeling stressed about the work she is neglecting in order to do so. Whereas the transmission model seeks to bind truth into discrete and often sequential units, the interaction model allows for meaning to be enacted and negotiated within the situation.

From the interactional perspective, affect is not a representational state to be transferred from one place to another, but rather is an aspect of collectively enacted social settings. Emotion is a witnessable property of social action, a way in which actions are rendered interpretable and meaningful. The question of the dynamic, situated interpretation (and attribution) of emotional behavior is critical here. Negotiation, interpretation and inference are inextricably intertwined. Picard [28] notes that we can never know exactly how someone is feeling, but must always draw inferences about emotional states. Drawing on phenomenological sociology and on McCarthy & Wright's theories of emotion as part of socially grounded sense-making [24], we would take this one stage further and suggest that emotion is an intersubjective phenomenon, arising in encounters between individuals or between people and society, an aspect of the socially-organized lifeworld we both inhabit and reproduce. Just as verbal interaction is more than the transmission of information through a conduit, but is rather a form of social action [8], so too is affect a form of social action, both in the ways in which it achieves social ends collectively, and in the ways in which collective meaning shapes individual experience.

DESIGNING FOR AFFECT AS INTERACTION

The notion of affect as social action substantially changes the centrality and complexity of affective communication. In the informational model, an individual has an emotion internally, whether this emotion is influenced by social and cultural norms or is a biologically induced state. When an individual then expresses this internally intact emotion to another or even to oneself, this is done through a process of encoding, transmission and decoding. When the encoded emotional message and the decoded emotional message equate, the noise of the transmission was effectively navigated and the expression of emotion successful.

Communication of affect in an interactional model, however, is more than transmission - it consists of an active process of co-constructing one's affective state, which requires, not decoding, but active interpretation. While affect as information is considered to be discrete, well-defined, and transferable, affect as interaction supports a different quality of affective communication: complex, ambiguous, malleable, and non-formalizable. This requires a shift from designing systems to model and transmit emotion to designing systems that support humans in producing, experiencing and interpreting emotions, an idea we will now explore through our second design study.

Case 2: Affector, Affect as Interaction

Evaluating Miro made it clear to us that because of the complex and ambiguous nature of affect, users do not interpret a system's affective output the same way it is represented in the system's relatively simplistic internal emotional model. Instead, people's contextual knowledge of one another's emotional states and situations is brought into the process of interpreting system behavior to develop a more subtle, rich, and situated understanding of emotion than the system alone can have. We wondered whether internal emotional models distracted us as designers; was it possible or perhaps even better to build systems to express emotions without directly and perhaps misleadingly representing them? Could one develop a computational system that users can usefully interpret emotionally without building emotional models in? And, in doing so, could we deal with emotion in a more ambiguous, rich, and situated way than is possible when it must be reduced to discrete categories to make it understandable to computers?

The result of these musings is an Affector, an ongoing experiment in the co-interpretation of affect. A video window between the offices of two friends communicates their moods by systematically distorting the video feed according to sensor readings using rules defined by the friends. Emotion is not directly represented in the system but is instead interpreted by its human users as they tune the mapping from sensor readings to distortions to match their intuitions of their moods.

The central goal of Affector is to support friends in shared office spaces in maintaining an ambient sense of each other's moods. The system requires little active intervention – it communicates a background sense of mood autonomously, rather than being told by the office residents what it should communicate. The system does not directly model user emotions, understood as discrete and well-defined units, but rather gives a continuous, rich, and potentially ambiguous background sense of emotion. Disambiguating system output is done by the systems' users, drawing on the friends' existing rich understanding of one another based on their day-to-day interaction.

Figure 3: Example distortions produced by Affector.

Affector's implementation is inspired by Rodney Brooks's argument that systems can appear intelligent and exhibit complex behavior without complex representation and manipulation of abstract information [6]. Instead, Brooks defines effective connections between sensors and effectors so that, when the system is placed in a complex environment, it triggers a complex sequence of actions that can be narrated as intelligent behavior. Similarly, Affector's behavior may be read as emotionally expressive without it representing emotions internally.

A video screen is mounted on each side of the shared office wall to act as a virtual window. A video camera mounted under each screen captures images of the respective office occupant at work and transmits them to the neighboring office. Based on sensor readings in each office, the images are distorted, in ways that may be read as representing emotion, using visual algorithms developed by Eunyoung "Elie" Shin and Rev Guron such as pixelization and color inversion and reduction. Mapping between sensors (e.g. movement in the office) to effectors (specific distortions) is accomplished through a set of rules defined by the office occupants themselves. These rules select and combine visual distortions based on ambient information (currently visual attributes, in the future to be extended to include audio and potentially other sense modalities). Users of the system select and refine the rules until they seem, for them, to be accurately readable as expressing their friend's mood.

Design Principles for Affect as Interaction

In switching from the affect-as-information model implicit in Miro to the interactional model underlying Affector, the following principles emerge:

The interactional approach recognizes affect as a social and cultural product. In Miro, 'emotion' was a set of a priori categories that were independent of the concrete context of the system - although it was interpreted very differently, in discussions and based on local culture. In Affector, users undergo a period where they co-construct the affective implications of the system grounded in their existing relationship. Affector only works in the context of an ongoing relationship outside of the system that provides the grounds for meaning-making with the system.

The interactional approach relies on and supports interpretive flexibility. In Miro, the 'meaning' of the system is intended to be the one supplied by the designer, although in reality the situated understanding of users turned out to be more effective. By leaving the definition of emotion and its interpretation to the users, Affector instead allows emotional meanings to emerge in a situated way over the course of interaction.

The interactional approach avoids trying to formalize the unformalizable. In informational approaches, emotions are characterized as discrete units within the system (or e.g. as points in a multi-dimensional space). Even when they are based on psychological models of emotion, it is not clear that emotions as experienced by users in complex social and cultural ways map neatly onto these underlying emotional structures Sometimes emotions cannot be articulated by users in straightforward ways, yet informational approaches can unintentionally attempt to force users into a straightjacket of formalized expression. The interactional approach does not require emotion to be formalized by the system; instead, all the emotional meaning in the system can be supplied by the users.

The interactional approach supports an expanded range of communication acts. Informational approaches focus on communicating affect through a well-defined set of signs with clear meanings assigned by the designer of the system - "red" should be decoded as angry, "green" should be happy, or in the case of Miro, "fast-moving dot" should mean "high energy office" whereas "slow-moving dot" should mean "lethargic office." In Affector, meaning is communicated through a combination of video feed and a distortion language that can be overlaid on that feed. Rather than designer-defined signs, Affector supports user-defined signs as well as indexes and icons, which can give a more open-ended sense of the complexity of emotion.

In systems like Affector, emotion can be communicated in a richer way than clearly-defined signs allow. E.g., instead of users thinking, 'I feel sad. Sadness in this system is represented by the color chartreuse. Therefore, I feel chartreuse,' an alternative is to allow users to express themselves directly using the expressive capabilities of the system: 'I feel chartreuse today. Chartreuse demonstrates how I'm feeling' - with the exact interpretation of what 'chartreuse' means open to the people involved and depending on the detailed situation of their discussion.

This approach is similar to the principle at play in the design of eMoto, a system designed for expression of affect in mobile phone text messages [38]. eMoto allows users to alter the background color and pattern of their message through affective gestures with the stylus. Rather than requiring a verbal articulation and translation of how someone is feeling, the system allows users to shake it out, to demonstrate with varying pressure, movement patterns, and pace something that reflects how they feel.

The interactional approach focuses on people using systems to experience and understand emotions. We tried, but failed, to have Miro understand emotion. Given the complex, ambiguous, and situated nature of emotions, it seems unlikely that emotions will ever be fully understood by computer systems. The interpretational approach side-steps this problem, since the focus is instead on using systems to stimulate reflection on and awareness of affect. For example, in Höök et al.'s articulation of the affective loop [e.g. 14], affective input to systems is managed, not by extracting emotional information from users, but by having users directly express emotions to systems. While users may express emotions they do not feel, in an affective loop the expressive gestures and the system's reactions are set up to reinforce whatever emotion the user expresses. That is to say, a user may express an emotion they do not feel, but they will likely come to feel the emotion they are expressing through the course of the interaction. Such a system does not primarily transmit emotion as information but instead supports its experience. The important thing from the interactional perspective is not making systems more aware of emotions but making people more aware of emotions through system use and design.

Design Challenges for Affect as Interaction

An approach to affect as information has challenges in seeking to take a complex, rich, amorphous experience and turn it into something logical and demarcated into units of signals and meanings. In approaching affect as interaction, we do not try to simplify complexity but instead to augment it and perhaps in some ways to evolve with changing experiences of affect. This approach generates new challenges. In this section, we will briefly touch on three challenges to the affect as interaction model, which we have uncovered in our case studies so far.

The first challenge is that affect as interaction is not yet as well-understood as affect as information. In choosing to augment complexity rather than simplify it, we may find the design challenges become too great. Indeed, in a previous study, the Influencing Machine, we found the ambiguities in complex communication of affect as implemented often frustrating for users, although this frustration does not necessarily undermine the success of the system [35,21]. To support affect as interaction, we need new design strategies supporting interpretive flexibility [e.g. 18].

The second challenge for affect as interaction is that the systems work only by bootstrapping interpretation based on existing, rich contexts. In Affector, for example, initial meanings to be applied to the system must come from users' existing relationships and interactions; e.g. noticing the system output tends to be in color negative when one's friend is particularly cheerful. It may be hard to make such connections for people who have no other communication or interaction except through these systems.

The third challenge for affect as interaction is the necessity to develop substantially new evaluation strategies, since existing evaluation strategies are based on an informational model. In systems designed for the informatics of affect, the goal of evaluation is to see if information about the 'right' affect is recognized, communicated, and/or responded to successfully. These evaluation strategies are inadequate for understanding how affect is re-interpreted and co-constructed in rich contexts of use.

For example, Batliner et al. [2] discusses the limitations of a study on automatic dialogue systems' ability to accurately recognize frustration or breakdown. The goal of the system was to determine if frustration in a caller's voice could be accurately measured, signaling the need to transfer the caller to a human operator. To test the system, a laboratory experiment was designed with actors expressing frustration, most likely in an exaggerated fashion marked by the stereotypical indices of frustration used to program the system itself. In this setting, the call center system performed quite well. Yet, in an actual environment, results and reliability degraded sharply.

We would argue that the experiment itself reinscribed what it was looking for, namely discrete emotions. In other words, the measures of success for the system are built into the system itself. If we believe that emotions are discrete, contained and transferable, then we measure for the successful transmission of bits. But if we eschew the notion of affect as information bits, then we shift our focus from measuring the accuracy of transmission to measuring things such as awareness, expression, and engagement - aspects for which HCI as yet has developed few strategies.

CONCLUSION
Emotions occur dynamically at the interface of experience in the world. As Dewey remarked,

> Joy, sorrow, hope, fear, anger, curiosity, are treated as if each in itself were a sort of entity that enters full-made upon the scene, an entity that may last a long time or a short time, but whose duration, whose growth and career, is irrelevant to its nature. In fact emotions are qualities, when they are significant of a complex experience that moves and changes…All emotions are qualifications of a drama and they change as the drama develops. [12 as cited in 24, p. 83]

This perspective of emotion as moving and changing, entering the scene incomplete, directly counters the approach to emotion as one of transmission of information. We have been concerned here with an alternative reading of affect, in line with Dewey's concerns about reading emotion as natural facts and as discrete events. We have examined an alternative account of emotions as interactional products rather than informational objects, and demonstrated how this approach supports an alternative form of affective computing design. This reading draws from and further develops other alternative approaches to affective computing [e.g. 15, 19, 24, 38].

More broadly, this is part of a larger research program into the relationship between technology and practice, and in particular a move from technologies of representation to technologies of participation. Participation emphasizes the ways in which information systems act as platforms upon which social structure is enacted, rather than as entities employing representations of the world and therefore always at one step removed from it.

Emotion is a particularly interesting topic from this perspective, precisely because it is deeply enmeshed in a broad range of cultural meanings and oppositions – mind/body, cold/hot, male/female, serious/frivolous, etc. The complexity and dynamism of emotion that Dewey observes are precisely the properties that make emotion suitable for this treatment. The richness of emotion in interaction mitigates against reductive representation.

More broadly, as information technologies increasingly inhabit the everyday world, we need to understand them on multiple levels simultaneously – as technological artifacts, social facts, and cultural narratives. As we have demonstrated here using emotion as a lens, this view is not a technologically limiting one, but rather opens up new avenues for design and development.

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