Subjective Objectivity: Negotiating Emotional Meaning

Lucian Leahu
Computer Science Department
Cornell University
Ithaca, NY USA
lleahu@cs.cornell.edu

Steve Schwenk
Department of Architecture
Cornell University
Ithaca, NY USA
sps33@cornell.edu

Phoebe Sengers
Information Science
Cornell University
Ithaca, NY USA
sengers@cs.cornell.edu

ABSTRACT
Affective computing systems face challenges in relating objective measures with subjective human experiences. Many systems have either focused on objective measures as a substitute for subjective experience (e.g. skin conductance as a direct representation of arousal) or have abandoned objective measures to focus purely on subjective experience. In this paper, we explore how to negotiate the relationship between objective signals and subjective experiences by highlighting the role of human interpretation. Our approach is informed by a reflective analysis drawing on the arts and the humanities and by a participatory study examining the emergence of emotional meaning. We demonstrate the potential of our approach for interactive affective systems through a series of conceptual designs that embody these understandings.

Categories and Subject Descriptors
H.5.m. Information Interfaces and Presentation (e.g., HCI): Miscellaneous. K.4.2. Computers and Society: Miscellaneous.

General Terms
Design, Human Factors.

Keywords
Speculative design, reflective analysis, subjective experience, interpretation, art, architecture.

1. INTRODUCTION
A central issue faced by affective computing systems is how to balance the personal, subjective nature of experienced human emotions with the external, objective representations of emotions which computers require to function. Typically, affective computing researchers handle this issue by developing algorithms that map internally experienced emotional states to objective, observable signals, such as heart rate, skin conductivity, pupil dilation, and video and audio input. As a consequence, internal, subjective emotional states can be inferred from objectively tracked signals. Examples of systems embodying this approach include tele-home health care applications [13], instant messaging systems [6] and game playing [19]. Systems based on such mappings may adapt to user emotion to reduce the chance of accidents [22] and even improve team performance in a joint human-robot task [26].

In mapping emotion to a set of objectively measurable signals, affect is treated in these systems as another kind of information [2]. In this model, which we will refer to as the *information transmission model*, emotion is thought of as recordable via readily available signals, transmissable over possibly noisy channels, and uniquely recoverable from the received signal (whether by a computer or by a human). The underlying one to one mapping from emotion to signals makes possible the unambiguous identification of the original emotion. In this model, the subjective nature of emotions is replaced by objective, quantifiable measures such as physiological signals, face images, and so on.

These mappings are simplifications of human affect which for some purposes, under certain conditions, in certain situations certainly prove useful. But as with any computational model, the mappings highlight certain features that appear to be general, and discard less frequent and more difficult to formalize features. While such mappings make it possible for researchers to model and manipulate emotional representations as a form of computational code, they raise problems if our interest lies in the subjectivity, complexity and idiosyncrasies of experienced human emotions. One solution to this problem would be to enrich these representations; but it is equally possible that the underlying issue is not simply a need for specific richer encodings of affect, but more fundamentally, an inappropriate conception of what can be captured in any formal model of affect [2].

Warnings regarding the limitations of such models have been raised since the early days of affective computing in HCI. Indeed, Picard notes that the problem of identifying emotion from observable signals is one of the most difficult inverse-problems out there (p. 39), as emotion is experienced through subjective feelings which she views as an "enigma" beyond the reach of science (p. 224) [24]. Furthermore, Cohn argues that "[e]fforts at emotion recognition… are inherently flawed unless one recognizes that emotion – intentions, action tendencies, appraisals and other cognitions, physiological and neuromuscular changes, and feelings – is not an observable. Emotion can only be inferred from context, self-report, physiological indicators, and expressive behavior" (p. 233) [3].

In reaction to the limitations of substituting objective measures for subjective experiences of emotions, some researchers have responded by eliminating direct representation of emotions

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altogether. Systems like eMoto [31], Affector [29], and MoodJam [21] explicitly avoid modeling emotions, communicating emotion instead through ambiguous and evocative aesthetics derived from captured images of users and/or from user-selected parameters, rather than from computationally derived models of emotion. While these systems present an intriguing option, we believe there is another possibility in handling the disjunction between subjective emotional states and accompanying objective signals in the design of interactive systems: i.e. to take the mapping between objective signals and subjective states not as transparent and automatically calculated but as itself a complex form of human interpretation. Perhaps closest to our approach is work by Lindström et al. on the Affective Diary, a project that presents the users with an ambiguous representation of their own movement and arousal data. Seven characters with different body postures are used to express different levels of movement and arousal, while the character's color is chosen together with the body posture to reflect the level of arousal. The shapes together with photos and text uploaded by the user are intended to "invite reflection and to allow the user to piece together their own story" (p. 1037) [15].

In this paper, we present a design study which explores the rich relationship between objective signals and subjective experiences and suggests how to incorporate this understanding into new affective computing applications. Our research aims to better understand the process of emotional meaning making and to inform and explore the design space of affective computing beyond affect mapping. We provide insights into the possibilities for affective technology by understanding how humans negotiate meaning given their own objective physiological signals and their subjective emotions. We show that even when relying on the same input channels as in the information transmission model of affect, it is not these objective signals that narrow down the space of interpretation and determine a singular meaning, but rather the place where emotion is "recovered", whether in the person's mind or in a machine. To this end, we rely exclusively on objective, measurable data (i.e., location and physiological signals), which through the lens of the information transmission model of affective computing would result in only one unambiguous reading of affect, to explore a broad space of emotional interpretation. Moreover, we demonstrate a new approach that capitalizes on the potential of objective signals to uncover interesting emotional events, while at the same time preserving the richness and complexity of emotion.

In the research presented here, we explore new interaction possibilities for affective systems by way of research through design. We begin by drawing on work in the arts and the humanities to better understand the nature of the limitations of emotion mapping and to identify alternatives that would benefit from the subjective nature of emotions and would facilitate a more natural approach to the interpretation of affective signals. We continue with a participatory study, in which we produce emotional artifacts that embody our approach, in order to probe the potential of these alternative strategies and to closely examine the emergence of emotional meaning from these artifacts. Finally, we explore the design space afforded by this new approach and the insights derived from our study using speculative design.

2. MAPPING SUBJECTIVE EXPERIENCE

Affective computing research in HCI typically draws on sciences of affect, such as cognitive psychology, which focus on objectively measurable attributes of emotion. In looking for ways to think about how objective measures may relate to the subjective dimensions of emotion, we began by looking to the arts and humanities, which have a greater focus on the subjective nature of experience. Indeed, recent years have seen an extraordinary explosion of interest in affect in the arts and humanities (e.g. [14][16][17][20][30]). We therefore began with a humanistic, reflective analysis of an artwork drawing on affective computing, using it to explore the conundrums around the relationship between objective and subjective data and suggesting opportunities for new approaches.

Our project took the Bio Mapping project of the artist/activist Christian Nold as a starting point [23]. Nold gathers information from residents in the form of physiological readings. Residents are instructed to wander through the city, while their physiological data is recorded through the use of galvanic skin response (GSR) readers coupled with GPS locating equipment. Nold then uploads the results to Google Earth, where the route taken by the participants appears mapped onto an aerial view of the location. To visualize the layer of physiological data, peaks and valleys of physiological arousal are mapped at each point along the route. The volunteer can tag her route with annotations, share it with others, and archive it for later reflection.

In a side project called "emotion mapping", Nold has begun publishing collective emotion maps of these cities (e.g. London, San Francisco), showing a gradient of physiological arousal that corresponds to particular locations. Through the aggregation of personal, subjective, responses to places, trends and patterns among collectives begin to emerge. To this end, he states that these maps, "are packed full of personal observations which show the areas that people feel strongly about and truly visualize the social space of a community" [17].

From the point of view of affective systems, based on Nold's work we see two directions for critical design speculation. One is focused on the individual, where the mapped information is used as a mnemonic trigger for more subjective, individual events. The other is concerned with more generalized, collective readings of mapped spaces, registering consistency of more or less arousal within these spaces, and therefore informing the viewer of issues like security, serenity, potential interest, or excitement. Each of these approaches must take a stance on the relationship between objective and subjective representations.

Drawing from documented research in affective computing, Nold's work generally assumes a clear, one-to-one relationship between GSR readings and psychological arousal. At the same time, in the case of the maps, the personal meaning of that arousal is left open to the interpretation of the volunteer, who can add his or her own thoughts and reflections to the map. This openness alters in the emotion mapping project, in which personal, subjective interpretations of the meaning of place are combined into communally-shared, collective interpretations. As executed in this project, GSR readings are no longer subject to individual interpretation but are aggregated as direct, true, and unmediated representations of emotional experience.

The fact that the communal maps appear to fall into the same mode of transparent representation as one-to-one mapping work in affective computing is no coincidence. In creating communal maps, as in creating affective mappings, we are seeking ways to generalize subjective, personal, and idiosyncratic experiences into representations that can hold for many people. Here, then, we analyze the interrelationship of objectivity and subjectivity in the Bio Mapping project through the lens of related work on the problem of mapping the meaning of spaces in art and architecture. We use this analysis to suggest opportunities for handling objective and subjective representations in affective computing, which we will then explore in design in the remainder of the paper.

2.1 Employing the Subjective: Psychogeographies

The problem of designing a system of mapping that considers the subjective meaning of place as interpreted by an individual was first addressed in the 1950's, when the Situationist International (SI) coined the term "psychogeography" ("the study of the precise laws and specific effects of the geographical environment, consciously organized or not, on the emotions and behavior of individuals" [4]) to describe SI's ongoing critique of a single, definitive and institutionalized method of mapping the city. The Situationists deployed a strategy of mapping that relied upon the *dérive*: entirely unorganized and spontaneous wanderings through the city, propelled by subjective perception instead of institutionalized, normalized modes of behavior and navigation. This artistic, heavily politicized work of the Situationists was soon followed by academic, research-based work by urban planner Kevin Lynch that attempted to transparently aggregate these personal psychogeographic interpretations of meaning to discover more collective, universal interpretations. His work was driven by an underlying assumption that a true, universally-held interpretation of a place existed, and the uncovering of this interpretation could serve as a definitive guide for future design work. Through a process of rigorous interviewing and classification of physical spaces, Lynch explored the possibilities of unpacking resident's mental maps, or "images" of the city, in order to inform the design of future urban spaces that already communicated predetermined meaning. His participant pool, however, was restricted to specific class, education, and area of residence thus excluding minority interpretations and compromising the validity of the collective meanings extracted. Although very different in their approaches, the Situationist dérive, and the investigation of "imageability" have become canonical historical examples of two approaches to psychogeographic mapping.

In attempting to map multiple psychogeographies, the Bio Mapping project seeks to enable both the personal interpretation of the meaning of place sought after by the Situationists, and aggregated, more objective interpretation of meaning sought after in Lynch's work. This problem is similar to the one faced by affective computing technologies: given the very personal, idiosyncratic ways of experiencing emotion, how do we chose which aspects of these, sometimes very different, experiences represent a certain emotional state? Inspired by the psychogeographic approach to exploring the city and allowing for individual meaning making, our project situates the user in a similar position. This is achieved by explicitly giving the participant in our study access to the recordings of her objective signals, thus allowing her to take control of the emotional interpretation (similar to the 'dynamic feedback' approach in [2], where any information collected about user and system performance is provided for the users' reflection, analysis and use). This approach is central both to our participatory study and the speculative designs to be presented in the remainder of the paper.

2.2 Challenging a Fixed Meaning

From our point of view, the Bio Mapping project, while inspirational, has several limitations. On one hand, the maps' static nature renders them almost instantly meaningless as a long-term representation of a space. They are archived information of the arousal patterns of a specific group of individuals at a specific point in time. They therefore sideline the fact that the interpretation of these places is constantly updating and changing as different individuals move through them, and as the physical fabric itself evolves. The idea of the city as having a dynamic biological lifecycle was popularized in architectural theory by Lars Lerup [12]. Lerup describes all places as "stimdross", simultaneously holding the potential for stimulation or high-arousal activation, and for dross, or low-arousal deactivation: "Like the surface of a lake during a rainstorm pocked by thousands of concentric ripples, the Metropolis is bombarded by a million Stims that flicker on and off during the city's rhythmic cycles" [12]. Over time, any given place peaks in event activity, temporarily becoming stim, and subsequently returning to dross at the end of its event lifecycle. Lerup's theory exposes the maps as merely static snapshots of a constantly updating stimdross lifecycle, and therefore only a temporary glimpse at the evolving interpretation of meaning of a place.

Another limitation of the maps is found in the conceptualization of the maps as enabling the visualization of the "social space of a community": the community is understood as a single collective, much in the same conceptual framework that Lynch used to develop his urban designs that attempted to communicate universal meaning [18]. A community is taken as a given, and as the guarantor of a single meaning. Instead, one can provide space for multiple, often conflicting interpretations of meaning of place among multiple communities. Here, recognition of individual or personal patterns of arousal can become a gateway to a community that shares the same patterns of arousal, and interprets the meaning of these patterns in similar ways. A conceptual framework that addresses this issue can be found in the work of feminist theorist Donna Haraway. In the 1980's, a similar concern to address the institutionalized marginalization of minority interests within the science profession led Haraway to propose a definition of objectivity based upon the statement that "only partial perspectives promise objective vision" [11]. Haraway describes the construction of objectivity as a temporary, networked negotiation among multiple, situated subjectivities. As such, a single, or "correct" interpretation of the meaning of a place is contested by conflicting meanings held by multiple collectives that are situated in the same place.

In sum, aggregating different, often conflicting views into one fixed meaning is problematic both due to temporal variance and the difficulty of choosing one, 'correct' meaning without seriously misrepresenting the reality. In our speculative designs we rely on

unconstrued (i.e. semantically ambiguous) visualizations of the aggregate data, in order to invite the viewers to interpret the data themselves, thus allowing the emergence of multiple meanings, and at the same time to allow the viewers to question the authority of the maps.

3. PARTICIPATORY STUDY

To further inform more specific designs that address the limitations of current approaches explored in the previous section, at both the individual and the collective scales, we conducted field research inspired by Nold's maps. We used maps similar to Nold's maps as emotional artifacts to examine how meaning arises and to probe the potential of technologies that could benefit from objective signals and human interpretation. Our participatory design study consisted of the construction of a physiological maps, measurement of arousal patterns of a small group of participants, and an interview process to better understand how these maps are interpreted and what potential themes could guide more detailed design work.

Similar to Nold's approach, we decided to focus on arousal by way of skin conductivity. This decision was driven by the broad usage of GSR in the affective computing literature as a linear measure of arousal [19]. Although this likely does not correspond in a direct and transparent way to subjective user experience, it could suggest to users events that might be emotionally salient. Because the correlation is linear, the represented signal might be relatively easy for participants to interpret. Most studies involving GSR have been conducted in a lab setting, so the extent to which physical activity interferes with arousal is not known. Arousal can have positive or negative valence (i.e. pleasant or unpleasant), however valence is not detectable from physiological sensors alone, so we did not incorporate this dimension in our maps. As our work is not concerned with mapping physiological signal to emotional states, we were not discouraged by these limitations. To the contrary, we saw them as opportunities to better engage our participants in the design process and to empower them to take control in the meaning making process. To this end, the participants were able to interpret the data as arousal or just physical activity, and also to comment on the valence of the mapped data, rather than being informed by the system of their experienced emotional state.

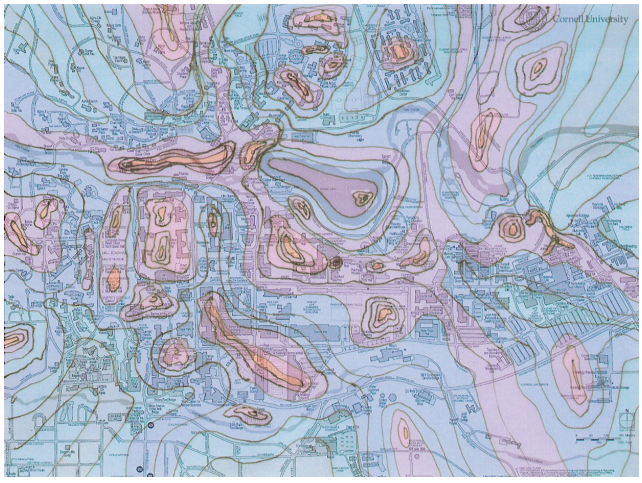

Figure 1. Aggregate mock arousal map given to participants.

The participants, equipped with GSR sensors (Procomp Infinity unit from Thought Technology Ltd.) and a handheld commercial off-the-shelf GPS device recording their location, were given a mock collective arousal map of their city (Figure 1) and were asked to go on a 30 minute walk. There were no constraints as to where to go, however we suggested that they could explore the map, or perhaps visit places that are meaningful to them. After their return, the data was downloaded from the sensors and an arousal map was produced (Figure 2). Similar to Nold's maps, the data from the GSR sensors was represented in the arousal maps as a wall. The elevation of the wall at each point represents the sensor readings (in the range 0-30μS) at that particular location multiplied by a constant factor in order to facilitate the visualization.

The study continued with a semi structured, individual discussion with the participants that lasted approximately 45 minutes. The questions ranged from describing where they went and what they did, to interpreting the maps and discussing how they would use such information in their daily lives, as well as imagining how other people might use them. Inspired by the work of Dunne and Raby [10], some of the questions were deliberately open-ended as they invited the participants to tell stories that would provide a more detailed picture of the way our approach of interpreting physiological signals could be used and of the kind of personal values and social motivations that make it appealing.

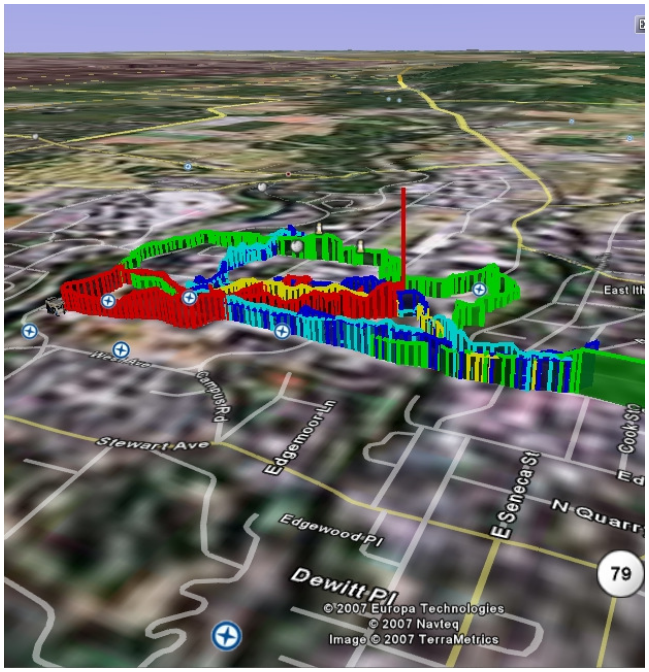

Figure 2. Arousal map – each colored wall represents one participant's path.

3.1 Method

Our goal in this study was to explore affective experiences, relying exclusively on objective representations, maps, navigation technology and physiological readings, to address personal, subjective, intimate experiences. At the forefront of our approach was a concern with balancing objective and subjective

approaches. We found that this concern reflected into the construction of our study itself. Traditional usability-based approaches that place the researcher as an objective observer of participants' activity and aim for objective, generalized knowledge contradicted our interest in exploring the interplay of the subjective and objective.

We therefore structured our exploratory study as an open-ended, participatory event and included ourselves as full participants. Our decision to reflect on our own experiences as well as that of our participants drew inspiration from the notion of autobiographical design, or "[t]he design of technology with respect to details of its designers personal experiences, as a promising approach for bringing richer aspects of experience into design" [27]. As opposed to approaches traditionally taken in HCI which aim for objective knowledge of personal experience, autobiographical design deliberately brings out and focuses on the subjective experience of the designer and the possibility to draw on it when designing for a more meaningful user experience. This particular approach is quite relevant to our work because it gave us another avenue to understand what it means to move between subjective experiences and objective data

A second implication of our interest in exploring subjective experience was in the choice of participants: we recruited the other participants in our study from our own social circle. The recruitment of participants who share social links has been recently demonstrated in several studies involving affect (e.g. [31], [10]) as providing a natural context for the elicitation and expression of personal emotions. The participants in our study were two of the authors and three of their friends (two male and three female, with ages in the 21-36 range). Recruiting volunteers for the participatory study from our social circle provided a familiar setting for our discussions, a setting that facilitated an uninhibited dialog around the feelings, emotions and intimate events that were associated with the maps by our volunteers. Furthermore, the existing social context made it easier for us to gauge the complexity and intensity of the experiences that emerged, while at the same time informing and pointing the conversation in a way that would not have been possible if the relationship between researchers and participants had been decontextualized.

The goal of the participatory study was to refine our understanding of the way emotional meaning emerges from the maps. In addition, the discussions with our participants brought valuable insights on the values and social motivations that make the maps engaging. Of course, our use of ourselves and our friends as participants as well as the small number of participants means that the results of our explorations cannot be taken as objective, generalized facts in the manner of a laboratory study. They are, much more, the result of joint reflections among an intimate group of co-equal participants sharing a common experience. The understandings we developed from our experiences, detailed below, provided a useful lens for furthering our design thinking about how to approach affect. Designs which developed out of this thinking will be detailed in the next section.

3.2 Themes

Since we were interested in studying the way meaning emerges in this specific setting and to explore the potential of systems that rely on user interpretation of objective, measurable signals, we decided to use the maps built for our volunteers and ourselves as a way to provoke discussions concerning the design space afforded by the our approach. The questions and the discussions with the participants were directly informed by our (i.e. the designers') experiences with our own maps. Consequently, we begin by presenting a summary of these experiences.

3.2.1 Autobiographical

While wearing the GSR sensors and the GSP technology, we explored mostly very familiar areas: some were places we pass by daily, while others were special places (emotionally charged places), for example "the house my partner lived for four years". The data for one of the autobiographical maps was collected during the night, while the streets were empty, in order to afford a peaceful, serene experience and to have the opportunity to contemplate why these places are meaningful. Another map was generated with data recorded during the day: *"Most of my thoughts centered around trying to identify certain feelings or mood swings as I walked, and trying to remember specifically where I was when these feelings occurred so that I could check them against the arousal map when I returned."*

Many of our expectations concerning our own experience with the maps revolved around personal discovery: *"it was thundering outside, looking like it was going to rain at any second. I began the trip initially with the thought that I would walk a loop through campus, but as the weather began to worsen, I found myself looking for buildings with awnings, and other open roofs. I remember wondering if my signals would gradually heighten as I stayed outside longer, walking faster all the while. I also remember being very self-conscious of how I looked with the monitoring equipment underneath my coat, and visibly extending down my hands. Every time I passed large groups of people, I was very aware of their reactions to my appearance, and wondered if this response would trigger a visible change in my arousal signals."*

We thought of our maps as being very personal and intimate and therefore we were interested in sharing them with our loved ones; representing some sort of proof of being in a certain place and feeling certain ways; acting as a mnemonic trigger and generating interesting conversations about the reason behind variations in the signal. One of us compared the maps with a "*therapeutic instrument: it could provoke ritual self-reflection of the moments in one's day that seemed to be especially emotionally stimulating, [raising] questions about why certain places seemed to provoke strong arousal patterns: occupants? aesthetics? past experiences or memories? This seems to be a power vehicle for discussion and debate."*

3.2.2 General

The discussions with the other participants highlighted several themes around the potential use of our approach. Some coincided with the ones identified by us, while others extended the discussions to exciting new areas. These themes are not necessarily mutually exclusive: as the separation is artificial, some of the participants' quotes support several themes.

As expected, one of the recurrent themes revolved around the "meaning" of the maps. When explicitly asked to describe the

maps, all participants described them using neutral, very literal, machine-like, non-emotionally charged descriptions (e.g. "just a plot", "some body signals"). As soon as they started referring to the data that was mapped, the participants struggled to take a firm position as to whether the mapped data meant anything to them or not. However, when asked to talk about what had happened on their walk or to explain some high or low arousal points, our subjects used the maps as mnemonic aids to recall or to explain what might have happened or to reflect as to why that particular point might be justified by several factors. The following remarks best express this transition from meaningless in themselves to meaningful when considered in a specific context:

"It maps the physical state, not emotion… if it was emotion it would probably be flat. The map has no significance to me. […] I don't think it really tells anything about me, I mean, it does in a way, but not really. […] Like the peak when crossing the bridge made me think whether it is because I'm afraid of heights, or maybe just because I think it's pretty or I actually thought "I wonder if someone sees me here and think that I'm a suicide bomber and I want to jump off the bridge" and actually I chuckled a little bit."

Another important aspect around the meaning of the maps is their open-endedness. As it will become obvious from the different interpretations that resulted from one map, or even one point on the map, and from the different usage scenarios our participants envisioned, the fact that these maps were not interpreted for them was generally seen as an advantage, as explicitly articulated by one of the volunteers:

"The way we interact with the environment right now is really mediated through language and images and stuff and so maybe we should provide other ways of visualizing [the environment]; like the news are supposed to link you to the world, but "hello! they're not!", because they're already interpreted for you, so I think people would be interested in [the maps] just because they are sick of being told what to think."

Privacy was another issue that repeatedly came up in our discussions. The broad range of reactions was rather unexpected, especially in light of the almost general opinion that the maps were conveying little information in themselves. Some of the participants were reluctant to share the map except with close friends and relatives, since they thought of it as very personal, others would agree to share the data if it was anonymous, while yet others would not mind having their data publicly available.

The maps were also used to reflect on everyday activities (and the way these activities change in time) and discover things that otherwise would be overlooked. One participant wished that there would be a way to build such everyday maps over a longer period of time:

"I think it's more interesting to do it when you're doing more normal stuff, because then you might get to see some things that you might not realize you react to. […]I wish we could have done a map of me over the years that I spent here. And it would be cool if it could fade in time. […] But I don't think this would interest me for other people, because I think this is so personal."

Another participant chose to run errands during the experiment, and so she went back and forth to her office four times, while her position and physiological signals were being recorded. The map consistently shows extremely low arousal around the building where her office is located. She notes:

"Well, that's unexpected! (laughs) This is pretty funny … Can you blame me?!? (examining the map) Damn that's pretty low… I probably looked inside and I was like "Oh dear!" […] [the arousal level] drops to the ground – I was probably thinking "Urgh … papers … boring … (laughs) (looking at the map) And then as soon as I get away from the building, it's back up!!!"

When asked who would they share their maps with, the most common answer was boyfriend/girlfriend/partner/spouse and close relatives, as the maps were seen as a way of enhancing intimacy by sharing something very personal, almost an imprint of emotion or proof of feeling a certain way in a certain place (e.g. "the restaurant where we went on the first date", "his home for four years", "the place we first met") and by acting as an interface with the loved one, or as an opportunity to express and project feelings:

"I would have [my boyfriend] try it out! I would just be curious to see if we would react in a similar fashion to places, although it's so abstract, but still it's really cool. I would like him to take a walk with it and then give it to me! I think it would be great for him, it would be such a great tool. This would be a great tool for people that have a hard time verbalizing their feelings, not that I'm saying my boyfriend has a hard time doing that (laughs) […] but yeah, it would be great as a reflection tool for people. I would be interested in seeing my mom's. She is not a very emotional person, but you know, she does have emotions, she just doesn't talk about them and it would be cool to see her, you know, dealing with life… you know, maybe it would give me more insight into her states."

The 'interface' metaphor of the individual maps also characterizes the collective, or aggregate maps. When asked which city she would like to have mapped, one participant unhesitantly answered: *"[my hometown]. Man, I am so homesick, I could use anything that would connect me to that place. […] The map would help me come up with stories, even though they weren't true!"*. The speculative collective arousal maps triggered a wide array of responses from our participants, from alleviating home-sickness, to exploring and navigating a new city, to opening up new interpretative spaces at the community level. These interpretative spaces often dealt with very complex settings that are hard to describe due to the high number of variables that characterizes them or because the communities they refer to often face sensitive issues (e.g. racial segregation, homophobia, high crime areas, etc.). The collective arousal maps were seen by our participants as a way of visualizing 'the ineffable', and as an opportunity to raise awareness, to start a dialogue and to think of what it would take to address those issues (e.g. one participant suggested using maps that apparently reinforce stereotypes: "*study if some groups are overly emotional, for example if the Hispanic neighborhoods are more emotional than the Asian neighborhoods*").

Figure 3. Public arousal communicators.

Finally, the maps inspired both us and our volunteers to go beyond `conventional' uses of the displayed information, and to explore more unusual, playful, bizarre and even noir potential uses of the maps. Some of these ideas deal with mapping physiological signals for animals, to see how they interface with the city, which parts of the city or events they would find exciting; the use of the maps as law enforcement mechanisms, for example by examining real-time maps of child molesters around playgrounds or schools; exhibitionists manifesting their exhibitionism in a non-exhibitionist kind of way; mapping different churches to advertise them as a fun, happening places (e.g. gospel), or as a serene, meditative space (e.g. Buddhist).

Aesthetics seemed to play an important role, whether describing the individual or the aggregate maps, our participants identified them as visually appealing and especially in the case of the real time collective maps continuously inviting for interpretation, reflection and exploration.

Figure 4. Rituals of reflection: the affective display (in the center of the table) provokes discussions and interpretations.

Throughout the discussions it became obvious that the maps nicely enhance current practices, by supporting reasoning, reflection and decision making on an idiosyncratic level. Our participants' recollection of the way they conduct regular activities showed that they resort to such information as a way of (often unconsciously) discriminating between several alternatives that had been identified using goal-oriented, utilitarian decision making.

4. THE DESIGN SKETCHES

Based on our humanistic analysis, we became interested in enabling individual, idiosyncratic interpretation of objective signals, and in exploring the possibility of creating communities around shared meanings. The following additional themes emerged from the participatory study: gradations of privacy in the sharing of physiological signals, the central role of personal reflection in interpreting the meaning of these patterns, and the potential of aggregated patterns to map and enable interpretation of previously ineffable characteristics of a place and its meaning to various groups of individuals. The final stage of our study was to think through how these themes could inform the design of affective computing systems. We did so through the development of a series of speculative designs.

Speculative design is a method for research through design, and has notably been used in HCI by Bill Gaver and Heather Martin [8] and in RCA's work on the Presence Project [7]. Rather than creating concrete, marketable products, speculative design maps an area of the design space by advancing placeholders "occupying points in the design space" ([8], p. 216). These placeholders are not necessarily practical products but instead embody new possibilities and "a way of thinking through the issues and possibilities" of the proposed technologies, while being "understood to be provisional" ([7], p. 604). In this section, we demonstrate through a series of speculative designs how the themes and issues arising from previous stages in our study could be embodied in the design of affective computing systems.

4.1 From Reflection to Provoking Dialogue

In the following we describe a series of protocols that could be designed into an affective system, that relies on individual or collective maps depicting arousal patterns to provoke users to speculate and reflect on their signals. As the arousal patterns of the user are collected and mapped over time, the system begins to identify exceptional moments of high or low arousal. It provokes the user to acknowledge and explain possible interpretations of meaning of these moments. Wearable arousal communicators can indicate patterns of high and low arousal to the user alone, and/or to the larger public (see Figure 3). These items are examples of personal clothing and accessories that can be worn by users to openly and publicly communicate their patterns of physiological arousal in real time. The items range from more private, concealed jewelry and clothing, to more public displays of arousal activity. The earrings, for example, would enable arousal signals to be read by others, without the user's ability to monitor or screen the signals first. The notion of affective jewelry is not new (see e.g. [24],[25]); here, we highlight not the ability of jewelry to enable transparent emotional communication but the use of jewelry to provoke its wearers into active interpretation of its apparently objective displays of emotion.

Figure 5. Arousal memento: sharing individual arousal signals.

Another set of opportunities arise from supporting the user in opportunities to reflect upon moments of high and low arousal either of their own accord, or due to the advice of the system. This can take place as part of a time-based ritual of reflection and annotation, either alone or in a group. Technologies networked to the system can prompt this reflection by highlighting moments of exceptional arousal (see Figure 4). The intention is that these recording technologies would be used as part of a ritual where users would meet at a given time to reflect on their recent arousal signals. These annotation sessions could range from completely private, individual annotation rituals (e.g., every night as the person prepares for bed) to more public, group annotations where arousal signals are reflected upon in the presence of others (family dinners or larger group gatherings).

Figure 7. Annotation Recording Technology: Public Infrastructure Prototypes.

Once these arousal signals are interpreted and annotated, they can be shared with other members of the social network. At the most private and personal level, the user can share these arousal maps with close friends or relatives (see Figure 5). These maps can become mementos or gifts to be publicly displayed. In this way, the arousal signals are interpreted as proof of certain emotional responses. At a more public level, the user can share their arousal patterns anonymously with the entire networked public, where their identity is only described by abstract demographic information like age, ethnicity, etc. This information can be manipulated to reinforce or break stereotypes that relate the identity of a place to certain arousal characteristics (Figure 6). Engaging with the networked public even further, the user can share their annotated arousal patterns virtually from any networked location. Redesign infrastructural elements, like sidewalks and streetlights, locate areas of virtual dialogue in the physical public realm (Figure 7), by allowing the annotations recorded in regard to these locations to be physically represented. The physical representation of this dialogue serves as signage for public debate, potentially provoking passerby to investigate and perhaps enter the dialogue. Similarly, physiological maps that are placed in high-traffic public areas can provoke conversation between strangers sharing public transportation, or tourists deciding how to navigate a new area (Figure 6 and Figure 8).

Figure 6. Public advertisement.

As multiple users annotate the same place and realize they share similar interpretations of meaning, they have the opportunity to create new socially networked groups. These groups might desire to identify areas of arousal where the meaning is interpreted in a certain way, like adrenaline junkies identifying sites for extreme sports, or mothers identifying safe routes for their children to walk home from school. Alternatively, the groups might desire that their interpretation of the arousal patterns of a specific place are communicated to a broader audience, like preservationists who desire to communicate a historically important meaning of a place, or activists who desire to communicate a political message or propaganda related to a place. As places are annotated by these groups, and their interpretations of the meaning of the place is made public, we hope that situated dialogue related to conflicting interpretations of emotional meaning in a particular place might emerge. For example, concerned mothers may engage in conversation with drug dealers outside of the school, adrenaline junkies may engage in conversation with local law enforcement officials at a popular streetcar racing site, or historical preservationists may engage in dialogue with real-estate developers.

As initial arousal signals and patterns are interpreted by users, their public annotations could enable the building of constituencies who share similar interpretations of the meaning of a place. The success of this social networking system depends on

Figure 8: Public maps

the virtual and physical transparency of the dialogue maintained by these constituencies. This ensures multiple, conflicting user groups are situated in the same physical and virtual space, provoking the emergence of civic debate and negotiation, and the eruption of multiple situated, civic voices.

5. DISCUSSION

One goal of this research was to better understand how affective meaning emerges in a setting characterized by exclusively objective input signals, and how the design of affective computing systems could support an engagement between subjective experiences and objective signals. In our participatory study, the participants found the data depicted in the maps to be emotionally meaningless in itself, yet the maps were still seen as ambiguously and provocatively conveying some emotional information. Furthermore, they triggered rich, emotional narratives, which convey affect to significant others and close family as `affective body memorabilia' [15], and to construct emotional readings of partners and close family. The maps and the reaction to the maps support the design of systems that view emotion as situated, socially and culturally constructed and point towards using technology to facilitate affective meaning making [2]. In this section, we describe the lessons learned from this design study for affective computing more generally.

5.1 Situated Emotional Artifacts

Contrary to everyday maps, which are generally viewed as abstract, universal representations that have an established way of being read and hardly call for the viewer's imagination, the maps were perceived as personal objects, capturing the interest and imagination of the viewer while at the same time acting as a gateway into one's emotional states. By incorporating one's physiological signals, the map becomes personal, and concretely tied to a certain space and a certain time. It defamiliarizes [1] the standard experience of using a map, and therefore invites the viewer to take charge of the meaning making process. As such, the possibility of generating an emotional artifact, personalized to the user and affording the user space for interpretation, is central to our approach. The maps represent a proof of the potential benefits embodied by such artifacts in the design of interactive affective systems.

5.2 Using Proxies

When designing interactive systems in which the responsibility of interpretation moves from the system to the user and physiological measures are not readily available, our work suggests the usefulness of proxies for these signals. Indeed, the interviews and the design sketches highlight this possibility: as the data itself was only seen to marginally represent affect, alternative (easier to access and manipulate, less invasive) cues that correlate with arousal could be used, rather than wiring directly to users' bodies. From this point of view, the use of proxies is similar to the use of 'shy sensing' in the Home Health Horoscope [9], a system which uses changing patterns of usage of objects to identify emotional issues that may be pertinent for reflection in the home. The system is designed so that exact correlation between sensors and well being in the home is secondary, since the people that inhabit the house make sense of the provided horoscopes with respect to their much richer background knowledge and therefore can make up for lapses in system understanding. However, careful experimentation is needed, as the signals used should correlate at least partially with emotional activity in order to keep users interested and thus to facilitate interpretation, If little or no correlation exists, the person interacting with the system is likely to lose interest and to disengage from the meaning-making process. Similarly, disengagement can occur if the representation chosen to depict emotion does not sit comfortably with the users or is not flexible enough to allow the user to customize it, as reported in the Affective Diary [15].

5.3 Representing 'True' Emotion

In our design sketches, the system does not know the exact emotional state of the user; however, it can direct the user's attention towards unusual patters of the signals, thus allowing for personal discovery and reflection. It does not rely for its success on the assumption that what it has found is in fact a true emotion, as this aspect is for the user to decide. As such, our approach allows us to refocus our efforts away from deciphering emotion and towards the interaction between the user and the emotional artifact, as this interaction will lead to affective meaning. We consider the lack of a predetermined meaning of these artifacts to be an opportunity for the designed system to embody a different kind of interaction, one that positions the user as an expert who makes sense of his or her emotional states with the help of the system, in contrast to a more rigid interaction between a passive user and an expert system that transparently identifies the user's emotion.

6. CONCLUSION

Our approach does not abandon the use of objective, measurable signals when dealing with affect, nor does it exclude user interpretation from the process of meaning making. Instead, it addresses the problem that measurable signals are often not, by themselves, directly informative of affective states, and that automatic, transparent interpretation often cannot capture the subjective, situated nature of human emotions. Our solution to these problems rely on balancing the potential of objective signals to draw attention to events that could be emotionally significant with the human ability to make sense of this information and interpret it without losing track of the multitude of dimensions that characterizes its context (cultural, social, physiological, etc.).

Our approach is not feasible, nor desirable in every type of affective system as, for example, there may be cognitive constraints on the user while her signals are being recorded (e.g. while driving [22]). However, in scenarios in which the subjective aspects of emotion are central to the success of the system, our approach is most suitable, as, at least for now, there is no computational model that can compete with a human in understanding and recognizing emotion.

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