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Experiencing the Affective Diary

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Abstract: A diary is generally considered to be a book in which one keeps a regular record of events and experiences that have some personal significance. As such, it provides a useful means to privately express inner thoughts or to reflect on daily experiences, helping in either case to put them in perspective. Taking conventional diary keeping as our starting point, we have designed and built a digital diary, named Affective Diary, with which users can scribble their notes, but that also allows for *bodily memorabilia* to be recorded from body sensors and *mobile media* to be collected from users' mobile phones. A premise that underlies the presented work is one that views our bodily experiences as integral to how we come to interpret and thus make sense of the world. We present our investigations into this design space in three related lines of inquiry: (i) a theoretical grounding for affect and bodily experiences; (ii) a user-centred design process, arriving at the Affective Diary system; and (iii) an exploratory end-user study of the Affective Diary with 4 users during several weeks of use. Through these three inquiries, our overall aim has been to explore the potential of a system that interleaves the physical and cultural features of our embodied experiences and to further examine what media-specific qualities such a design might incorporate. Concerning the media-specific qualities, the key appears to be to find a suitable balance where a system does not dictate what should be interpreted and, at the same time, lends itself to enabling the user to participate in the interpretive act. In the exploratory end-user study users, for the most part, were able to identify with the body memorabilia and together with the mobile data, it enabled them to remember and reflect on their past. Two of our subjects went even further and found patterns in their own bodily reactions that caused them to learn something about themselves and even attempt to alter their own behaviours.

Keywords: *Affective Interaction, Emotional Computing, Social Factors, Interaction Design, Contextual Information*

1. Introduction

A diary is generally considered to be a book in which one keeps a regular record of events and experiences that have some personal significance. As such, it provides a useful means to privately express inner thoughts or to reflect on daily experiences, helping in either case to put them in perspective. Through our diaries, we are thus able to brood over intimate thoughts and feelings, shedding some and re-experiencing and “saving” others. To quote Csikszentmihalyi (1990):

...to remember the past is not only meaningful in order to create and maintain your personal identity, but it can also in itself be a very pleasurable activity. [S] To keep the past registered can contribute to quality of life. It frees us from being enslaved by the present and makes it possible for our minds to visit the past. It makes it possible to choose and in our memory keep events that have been particularly pleasant and meaningful and thereby ‘create’ a past that helps us to deal with the future.

In diaries, we sometimes achieve this form of personal expression and the re-living of memories through the assemblage of words and occasionally pictures. Crucially, it is how we actively include personal jottings, song lyrics, photos, drawings, etc. and how we choose to combine and juxtapose them that shape both our ways of expression and how we relive the past. In short, the creation of the past in diary keeping, that Csikszentmihalyi writes of, hinges on our ongoing interactions with media and the distinctly personal approaches we take to arrange and interpret them.

The increasing production and use of various new, electronic media introduce a range of possibilities for this creative process. With the widespread use of camera-phones, for instance, many of us have access to media such as text messages, audio recordings, photos, etc. that we might come to associate with events or people. For the most part, however, it is still difficult to find ways of saving these mobile memorabilia, so to speak, and create narrative structures around them, as we do with our diaries.

In this paper, we present research undertaken as part of an ongoing project targeted at exploring this potential design space. As well as addressing the types of new media produced and shared via mobile phones, this work has given specific focus to the possibilities introduced by sensor-based technologies such as bio-sensors (pulse, skin conductivity) and other sensors that can record physical, bodily experiences (accelerometers, pressure sensors and those registering body movement and posture)—each offering a means of recording what we have come to refer to as *affective body memorabilia*. As we will go on to describe, our reasons for this focus relate to a view of emotions that emphasises their active production in the world (Boehner, *et al.*, 2005) and, importantly, the significant role the physical body has in this production (Damasio, 1994, Davidson, *et al.*, 2003). For diary keeping, this view has encouraged us to examine how we might support the recollection and perhaps re-living of past bodily experiences, and what this might offer in terms of personal reflection.

Broadly, then, we present three related lines of inquiry pursued so far in our research. First, we draw on the relevant theoretical underpinnings of affect and bodily experience to outline the position that has motivated much of the presented work. Second, we present our efforts to incorporate our thoughts on emotion and personal reflection into a working system, the *Affective Diary*. We report, in particular, on our efforts to incorporate a user-centred approach in the design of the Affective Diary. Third, we describe an exploratory study of the Diary system with

four participants and discuss the impact the findings have had on our continuing research.

2. Embodiment and an interactional view of emotion

As we have suggested, a premise that underlies the presented work is one that views our bodily experiences as integral to how we come to interpret and thus make sense of the world. This premise draws heavily on the notion of embodiment. Playing a central role in phenomenology, embodiment offers a way of explaining how we create meaning from our interactions with the everyday world we inhabit (Dourish, 2001). Our experience of the world depends on our human bodies, not only in a strict physical, biological way, through our *experiential body*, but also through our cultural bodies (Fallman, 2003). Fallman provides an example of a basic human activity, such as sitting on a chair. Since our physical bodies are erect, have two arms and legs, get tired, can bend forward at the hip and so on, chairs lend themselves to being sat on. However, it is only when we have acquired the skill of sitting we are able to do so. We need to live and act in a culture where sitting on a chair makes sense.

This concept of embodiment can be similarly applied to emotion. From such a perspective, it becomes apparent that the experience of emotion depends both on our experiential (physical) and cultural bodies. Thus, emotions are partly experienced through the constitution of our experiential body. Emotions, such as fear or anger, make our autonomic nervous system react, change the hormonal levels in our body, change our facial expressions and focus our senses and cognition, preparing us for flight or fight behaviour (Davidsson, *et al.*, 2003). Other emotional processes, such as shame or pride, which are crucial to our ability to maintain social relationships, also have associated corporeal processes affecting our body, facial expressions, body posture, and cognition (*ibid.*). But we do not make sense of our emotional reactions as biological processes nor are we predetermined to react in only one way to a particular circumstance. Emotion is a social and dynamic communication mechanism (e.g. Parkinson *et al.*, 2005). We learn how and when certain emotions are appropriate, and we learn the appropriate expressions of emotions for different cultures, contexts and situations (e.g. Katz, 1999). The way we make sense of emotions is a combination of the experiential processes in our bodies and how emotions arise and are expressed in specific situations in the world, in interaction with others, coloured by cultural practices that we have learnt.

In considering the design of affective computing applications, Boehner and her colleagues (2005), have drawn on what might be called this socially situated perspective of emotion. They suggest that affective computing systems have typically tried to identify users' emotions as discrete information units. In an effort to counter this trend, they provide a set of requirements for systems that engage users in embodied emotional processes with an emphasis on the cultural body. They name their design requirements *the interactional approach*. Their ontological view on emotion is that it is "culturally grounded, dynamically experienced, and to some degree constructed in action and interaction". Emotions are created in a co-constructed, co-interpreted fashion between people in social situations. Hence, in designing for emotional experiences Boehner *et al.* contend, the focus should be moved "from helping computers to better understand human emotion to helping people to understand and experience their own emotions" (Boehner, *et al.*, 2005).

In our own related research, we have attempted to expand on this interactional design approach by directly addressing everyday, physical, bodily experiences—capturing aspects of the experiential as well as cultural bodily influences on emotion (e.g. Sundström *et al.*, 2007). Our efforts have in essence been to build systems that re-unite the physical and cultural features of our embodied experiences. We see that it is not only problematic to reduce emotions to their physical, corporeal processes. It is similarly problematic to separate emotion from physical experience. Our design research, as we will go onto present, has therefore aimed to mirror some of the aspects of physical everyday bodily experiences while, at the same time, leaving room for users to actively interpret them. Our position has been that data recorded from the body should be represented in ways that feel familiar to end-users, but still be open-ended and ambiguous in such a way that they can recognise them, make sense of them and appropriate them for their own purposes (Höök, 2006).

3. Designing the Affective Diary

The work surrounding the Affective Diary system reflects our efforts to explore some of the ideas above. Taking conventional diary keeping as our starting point, we have attempted through the system to explore various strategies for combining data from body sensors with other types of electronic media. As we shall elaborate on, the Affective Diary has enabled us to investigate a particular approach to representing bodily experiences and how people might incorporate these representations into their personal, creative and reflective practices.

In this section, then, we detail the processes we followed in developing the design of the Affective Diary and how we came to settle on a particular representational style to display the sensor-based data and personal media. The functional details of the system are first described followed by a description of the process we followed to design the interactions with the Diary.

Functionality of the Affective Diary – in short

The Affective Diary consists of a mobile phone (with camera), body sensors, and a Tablet PC (see Figure 1). As a person starts her day she puts on the body sensor armband on her upper arm and activates the Affective Diary logging system on her phone. During the day, the sensor armband collects sensor data indicating *movement* and *arousal* levels (technical solution detailed below). The mobile phone logging system logs activities on the mobile phone such as SMSs sent and received, photographs taken and Bluetooth presence of other mobile phones in the vicinity¹.

Once the person is back at home she can transfer the logged data from the armband and the mobile phone into her Affective Diary application on the TabletPC. The armband has a wire that can be used to connect it to the PC and the mobile phone transfers the logged data automatically when docked to the PC.

The collected sensor data is presented as somewhat ambiguously shaped and coloured figures mapped out along a timeline. Above the figures, the materials from the mobile phone are placed according to when in time they arrived (see

¹ Bluetooth works at a range of ~10 meters. A fair amount of users do have their Bluetooth on their phone enabled and some rename their device to, for example, their own name or something interesting (Rudström, *et al.*, 2005). This means that logging Bluetooth presence will tell the user who has been around during the day at different times.

Figure 1. Final Affective Diary system design.

Figure 1). About one hour at a time is shown in the window. The representation of the data can be played as a movie, animating the body over time. The background changes from light blue in the morning, via yellow midday, reddish in the afternoon, all the way to dark brown in the evening to help users locate where in time certain events have happened.

To help users to reflect on their day, the representations invite interpretation and can be altered: changing the posture or colour of the figures, or scribbling diary-notes on top of the materials.

Design Process

The same theoretical underpinnings that shaped our view on emotional processes also influenced the design methods used to arrive at the Affective Diary design. The design process was user-centred, involving users throughout the design process, allowing for a reflective design process (Schön, 1983). Below we briefly describe some of the steps in this design process.

Cultural Probes

To gain an insight into people's everyday bodily experiences we used cultural probes (Gaver, *et al.*, 1999). We invited three categories of probe-participants (12 participants in total): teenagers (4), dance students (3) and senior citizens (5). Teenagers and senior citizens were chosen because we assumed that they would be occupied with their own emotional reactions and also have time engage in a dialogue with us. The dance students were invited because we assumed that they would have a more reflective perspective on bodily experiences.

The probe material we handed out was designed to tap into the participants' bodily experiences. For example, we designed some of the postcards based on yoga-material making participants move into certain positions and report on their experiences; we encouraged the participants to write about and sculpture (in clay) their bodily experiences of emotions; and we asked participants to choose colours to describe their days (see Figure 2). These materials contributed to the sketching of different graphical representations.

As noted by others (Gaver, *et al.*, 1999), people are surprisingly willing to share quite intimate, personal aspects of their lives when confronted with a (sometimes provocative) probe. With the probes, we attempted to abide by Gaver and colleagues original intentions (Gaver, *et al.*, 2004), looking upon the collected probes as inspirational materials—keeping the “magic aura” that surrounded them—not as materials to be used for a more analytical analysis. Thus, some ma-

materials were more important than others in our design process. For example, the probe materials showed that emotions circle around life as it occurs not only today, but also tomorrow and yesterday. One of the probe postcards had participants add to the statement “My strongest emotional experience today was when...” and an older man answered “I became a father for the first time Nov 20, 1956”. It appears that some days the awareness of the past or thinking about the future might be very much in focus, whereas on other days it just lingers in the back of our minds. A woman also touched on this when asked on a postcard “What happened to you today? Which feelings come to mind first?” Her reply was “I went to the cemetery with flowers for my husband, who died fourteen years ago.” Another woman, in her seventies, talks about how she feels bullied by her friends and how she worries about how it might feel when they next meet.

In general, we learnt how important it is to allow for expressions of not only positive, but also negative emotions. There appeared to be a wish amongst our participants to ‘take the lid off’ and be more expressive of their inner thoughts and emotions. On the positive side, many revisited their positive moments looking to re-live them.

Figure 2. Example of probe return (left) and early design sketching (right).

As an aside, it was obvious from the probe exercise that the participants were very aware of the fact that their materials were being viewed by others and in particular by researchers, contrasting with the personal qualities of a diary. The materials we obtained should therefore only be seen in this light. However, since the idea of our probes was to serve as an inspiration and to see how people express themselves using other modalities, such as colour, shapes, clay, or photographs, we remain convinced of the value of the materials.

From Sketching to Staged Lived Experiences

Several graphical representations were sketched, discussed and tested with users. In parallel, a group of users, including some of the authors, tested different sensors (e.g. GSR, pulse, pedometer²) to identify what kind of bodily experiences they could represent and what it would feel like to interact with a representation based on that data.

In the first stage, three different concepts were sketched, each created to be as different as possible in order to encourage discussion. Out of these, a human-like figure was chosen based on user feedback (see Figure 3). The sensor data was used to influence the shape and colour of the somewhat abstract body (see Figure

² Two sets of commercially available sensor solutions were tested: Polar’s Pulsewatch™ and the SenseWear® armband from BodyMedia.

4, upper picture showing seven figures). As discussed above, we wanted users to recognise themselves and their previous experiences through the representations. We wanted the representations to feel familiar to the users so that they resonated with their real-world practices and understandings, thereby encouraging, as it were, the affective loop. This is why we chose an anthropomorphic figure design as it offers a way to illustrate bodily processes, allowing for example, body-posture, movement and physiological measures to be represented and the figures could be animated to show changes over time. We were mindful, though, in our designs that such representations have to be used with care; users can easily over-interpret their meaning and attribute more intentionality and meaning to them (Reeves and Nass, 1996).

The body posture of this anthropomorphic figure was used to convey how much the user had been moving around. The colour inside the body was used to convey users' arousal as measured by GSR (Galvanic Skin Response), that is, how much electric conductivity the skin allows for (see discussion below).

The power of colour as a means to convey emotion has been known for centuries (Goethe, 1976). Typically, in the western culture, red is often seen as containing the most energy while at the other end of the scale, with the least amount of energy, we find blue colours (Ryberg, 1991, Sivik 1997). The analysis and choice of colours was based on our previous work in colour and its relationship to emotional expression (Ståhl, 2006, Sundström, *et al.*, 2007). Colours are interesting as they do not have a definite meaning, they are inherently ambiguous, and still we attribute meaning to them. Colour blindness is, of course, a problem, but (as we shall see from the study below) the ambiguity of the mapping from sensors to colours means that the system might work equally well even if you can only discern and distinguish some of the colours.

Figure 3. The concept chosen to go forward with

Figure 4. The original figures (top) and final figures (below) used in Affective Diary to display arousal and movement.

Mobile Phone Materials

A representation of people's everyday experiences also has to capture elements of the social context to help in remembering events and allow meaning to be inferred from interactions in the world. In our system, this is achieved by detecting activities on the mobile phone. The SMSs are shown as increasing or decreasing sets of circles inside circles, visualising received or sent SMSs. The content of an SMS can be viewed by clicking on the circle. Bluetooth presence is represented by lit up icons in a pattern, where clicking will show the name of the Bluetooth device encountered. Photos pop up as a semi-transparent background and when clicked move to the foreground of the display.

Staging Sensor Use

In order to arrive at the mapping between what could be obtained from the sensors we could reasonably expect users to wear, and a representation in the diary that would indeed remind them of their bodily and emotional everyday experiences, we did a range of experiments. We decided to work with a very simple two-dimensional model that we created from the sensor input so that the relationship between users' daily experiences and the representation would be clear to the end-users. This was also based on our previous design work (Sundström *et al.*, 2007) where we had seen that dimensional models, such as Russell's circumplex model of affect (1980), seem to be easily mapped to subjective, physical experiences of emotions. The two dimensions we finally picked were *arousal* and *movement*.

Similar to how we worked with the design of the diary representation described above, we have worked from a user-experience driven perspective on the sensor interpretation. Some of the authors as well as some other participants from outside the project wore a range of sensors for 24 hours and kept a diary of their activities. At this stage in the project, we could not dynamically translate the sensor data into the different possible representations, so instead we had to map data out by hand, sometimes changing the figure design in the process. While this meant that the use situation was partly 'faked', it still allowed for some insight into what it would feel like to wear sensors and how their output could be reflected in different representations. We look upon this way of studying sensor use as a *staged lived experience* in the terminology by Iaccuci and colleagues (2002). That is, while the use is partly simulated (or staged), the experience is still a real, *lived* one.

Participants' sensor data were also used to examine when and where they got feedback on something that they did recognize from their day as an important event; when the sensors provided feedback that was surprising or intriguing; or when the data simply failed to catch some important experience. Our own experience of using the sensors showed that there was a risk that the representation encouraged an interpretation that felt removed from the subjective experiences. The standard output from the software for the sensors is in graph form (see Figure 5). When studying those graphs, it felt as if the body had lived a life of its own—it was no longer our own bodies but some strange organism that had its own ups and downs. Our conclusion was that events during the day (as picked up by the sensors) needed to be represented in such a manner that it resembled and reminded us of our own bodies. We found moving away from graph-like representations to the body postures and colours discussed above encouraged a more holistic, bodily grounded, experience.

Mapping Sensor Data

To see if the seven figures we first came up with could fulfil the role of reminding us of bodily experiences, we mapped out which figures should represent a certain combination of sensor data. As it turned out, these original seven figures expressed too much emotional valence—negative or positive. For example the figure sitting down looked as though it was eagerly listening to someone. This did not map very well to, for example, the experience of sitting in a very boring meeting, not listening at all (as pointed out by one of our test users). Also some of the figures looked female and some male, preventing identification. Finally, there were too few variations in the representation. These issues lead to a redesign of the figures to make them valence neutral, less humanlike, and two more figures were added to enable a richer set of interpretations (Figure 4).

The mapping from sensor to figures became based on a dimensional model with movement and arousal as the two dimensions (*cf.* Russell's circumplex model of affect with arousal and valence, 1980). Overall the dimensional models of affect are interesting, since they capture aspects of the experience of emotions. Unfortunately, the valence of the arousal level, that is whether it is negative or positive, cannot be known from bio-sensors alone. Sensor mappings were very simple: movement was mapped to the pedometer sensor (measures the number and frequency of steps a person takes) and arousal was mapped to the GSR sensor. GSR measures the skin's ability to lead electricity, thus the more the user sweats, the higher sensor value. In certain places on the body such as forehead, palms of your hands and soles of feet, a strong relation can be found to your emotional reactions (*cf.* e.g. Mandryk, *et al.*, 2007). But we also sweat for other reasons, like when we are engaged in physical activities or when the outdoor temperature is high. Most studies of GSR have been done in controlled lab environments rather than used in people's everyday life. In a controlled lab situation, physical activity and outdoor temperature can of course be controlled and consistent correlations between GSR and fun (Mandryk and Atkins, 2007) and GSR and annoyance (Scheirer, *et al.*, 2002) have been found. There are also large individual differences which makes it important to calibrate the readings for each person.

Figure 5. Sensor data a graphs

For the system we envisioned here, a complicating factor was of course that we expected the sensors to be used in everyday life where someone might put on a jacket enclosing the sensors and thereby sweat more (which happened in our early trials during the wintertime), or someone might go to the gym and sweat. The commercial sensor solution we used is placed on users' upper arm, rather than close to the hands, feet or forehead where GSR-measurements are more clearly related to emotion. On the other hand, our aim was not to inform users about their emotional states, but to allow them to interpret the bio-data based on their own experiences. Users probably know if they have been to the gym and can therefore sort out these differences themselves. The commercial sensors were also adequate for the kinds of early experimentation we wanted to do here.

The highs and lows were calculated relative to each 24 hour period and mapped out to a maximum of five figures within each hour (the five most significant states within an hour) using nine different movement states (represented by nine different shapes of the figures) and nine arousal states (mapped to nine different colours filling the figures). While this is certainly an approximation and more experimentation is needed to make a better mapping from sensors to representation, it was capturing enough to allow us to experiment with our overall design idea.

Verification of the Design

When all the changes were implemented we did a verification of the design and tested it on three users for a period of one to three days. What became evident in this first exploration of using Affective Diary, was that it should be used for a longer time period to make the (very positive) novelty effects wear off and to allow users to start observing patterns in their own reactions. This first study lead to some adjustments of the design and substantial bug fixing.

4. Study setup

In order to see whether Affective Diary could provide materials that would encourage reflection and enable users to create their own stories, we let four participants test Affective Diary for 2—4 weeks each.

Study Set-up

We wanted the use of Affective Diary to be a natural part of the participants' daily lives. We therefore decided to lend the system to our participants for about three weeks (roughly between 2-4 weeks per participant depending on what other activities they had planned). First participants were instructed on how to use the Affective Diary and were told (in detail) how sensor data was mapped to the col-

colours and shapes of the figures. They then got to try the system for a couple of days, to familiarise themselves with the concept and functions. After this initial trial, they used the system in two phases. After each phase we conducted an interview, where the participants showed us their diary and discussed their interpretation of it and showed us their scribbles. Using a semi-structured interview schedule we also asked participants how well they could identify with the figures, and whether their usage had made them remember and reflect on particular aspects of their experience. Because Affective Diary is a prototype the participants could not upload the data from the biosensors and the mobile phone themselves, so this was done by us some days prior to the interview, which gave the participants time to work with their diary material.

Data Analysis

The resulting data consisted of videos of the interviews (where the users showed us how they interpreted different parts of their diaries), the actual diaries themselves with photos, SMS and scribbles made by the participants, and finally, transcripts of the interviews.

The analysis of the data started with a brainstorming exercise in which we aimed to identify the most important units of analysis. This was based both on the original cultural probe returns and also on our first impressions of the four users' experiences. Broadly, we found that the participants demonstrated varying degrees of engagement with and commitment towards the system that changed with time and under different conditions. We devised four related stages to characterise this:

1. An attempt to identify one's own experiences with the materials in the Dairy and either succeeding or failing to do so.
2. Engaging in some form of reflection resulting from stage 1.
3. Stages 1 and 2 leading to a learning experience beyond anything already known about one's self.
4. An attempt to change behaviour based on reflections and things learnt through using the Affective Diary.

To find evidence or counterevidence for these Stages and the Affective Diary's role in them, the user data was analysed more thoroughly by one member of our group. Subsequently, a second group member checked this analysis to see that the interpretation of the data was consistent. Special care was taken to separate what our users said in the interviews and what they actually scribbled in their diaries.

The Four Participants

The participants were recruited through a call on a range of mailing lists where we explicitly looked for people outside our own circle of friends and colleagues. The number of people that could participate in the study was limited by the equipment that we lent the participants; we only had two sets of sensors and two Tablet PCs. This meant that we could only run two users in parallel.

Monika is 27 years old, lives alone in apartment in the city of Stockholm, and she has a boyfriend. Monika works with customer support for email software. She plays the violin in a string quartet and likes to practice renaissance dances. Monika normally keeps a paper diary that she feels provides some structure in her life—it helps her sort out thoughts and emotions and to remind her of mainly positive experiences. Periodically she writes in her diary every day.

Ulrica is 52 years old, has two grown-up sons, and lives in the city centre of Stockholm. She works as an artist and has a studio nearby her home. Ulrica does not separate her time into work time and spare time—she lives one life. She goes jogging everyday in a forest outside Stockholm and afterwards she takes a sauna-bath. She has kept a diary for the past 30 years to understand and deal with aspects of her life.

Jeff is 48 years old, lives with his family in a small village 70 km northwest of Stockholm. He works as an advisor, which involves a lot of travel. Jeff is interested in music. He maintains a blog, which he does for two reasons: he wants to give his view on things that interest him and he wants to practice a bit of journalism since he used to be a journalist.

Erica is 42 years old, married, with two teenage sons, and lives in a house in a suburb of Stockholm. She works as a customer- and service analyst. She also runs a personal coaching company, works out, meditates every day, and swims with dolphins. Erica likes to travel and spend time with her family. She keeps a weekly diary, but goes through what has happened each day when she meditates.

5. Experiencing the Affective Diary

Understanding the Representations

As discussed in the introduction, we wanted to know whether the Affective Diary's representations supported and sustained the reflection of embodied experiences. A basic but key element of this was whether our participants understood the representations. Overall, participants demonstrated they were able to do so.

With the mobile phone, for example, our aim was to collect materials that could serve as reminders of events and people in users' lives (in short, providing hints of social context). This proved to be successful. The participants regularly referred to the SMSs and photographs represented in the diary. The ways in which the participants juxtaposed the mobile phone materials with the figures on the time line illustrated this recognition; participants used both text messages and photographs when making sense of and reflecting on their dairy figures—emphasizing how emotional processes can be embedded in our interactions with other people and events in our lives.

Figure 6. Screenshot from Ulrica's diary where the Bluetooth device Dirren has been clicked. Ulrica scribbles "Who is Dirren?"

The Bluetooth presence of others also intrigued our participants and offered clues to understanding the context of past events. One example was Ulrica's discovery of two Bluetooth units, Rossi and Dirren, near to her home (see Figure 6).

Identification and interpretation

Critical, besides mere recognition, was how participants identified with and interpreted their figures in the Affective Diary. This identification and interpretation varied in a number of ways. At times participants immediately related to the figures, seeing the shapes and colours as familiar and representative of their past experiences.

One of the participants, Erica, easily identified with the figures, interpreting them directly:

"You can see it here, that it was very creative for me at that point—at least, that is my interpretation. This yellow here is to me [a sign of a] very creative and engaging [process], the yellow and the orange, so that was interesting to see, to follow the differences colourwise. And this is also such things I like—everything that has to do with creativity."

Another user, Ulrica, deliberately worked on how to identify herself with the figures. She even toyed with re-producing them by taking a photograph of her shadow that she felt was similar in shape (see Figure 7):

"I'm trying... I saw my shadow and I thought: Well I almost look like one of those! I think I will keep on trying, try to make such a photo. If you can capture the whole shadow. That was...it was a trial."

Figure 7. Ulrica's diary in which she scribbles "I'm trying to photograph myself as my AD-representation".

Ulrica's playful additions to her diary hint at what we came to see as a dialogue between participants and their diary materials. Participants massaged their materials, working them up to be meaningful in particular ways. These dialogues were not necessarily straightforward however. There were a number of design elements, for instance, that complicated the mapping between the representations and the participants' personal experiences. There were times, for example, when the Diary's hour-by-hour time line mischaracterized or deemphasized important events and users' subjective experiences of time. The timeline, however, was important in allowing participants to find patterns and reoccurring themes in their days, ones that, as we shall see, they reflected on.

Participants also struggled with the mapping between their bodily experiences and their Diary's figures. Monica, the violinist, presented a position in her interviews that contrasted with her actual use of the system. Although she talked about the figures as 'uninteresting medical data', having nothing to do with her experiences, she was able to incorporate them into her processes of reflection:

"One often wonders, especially during a concert, if one gets nervous and how much so. If it goes well or not. If it goes well it is usually the case the one does not remember playing. You end up in a...not trance...but something similar. And that [state] I think is the same as being red."

Similarly Jeff, at times, assigned emotional responses to recorded moments. Referring to the Diary's timeline during one interview, he recounts being enthusiastic when being served his meal on a flight and suggests, somewhat cautiously, that the changing shapes of the figures capture this: *"Here, the grub arrives. 'Fun!' I take a picture, and then the bloke gets happier I suppose [points to the upright blue figure]"*. (See Figure 8).

Figure 8. Jeff gets his food on the airplane and interprets the upright figure as “happy”

Jeff’s use of “the bloke” and “I suppose” is instructive here. In effect, he disassociates himself from the representation. What this highlights is a tension of sorts between the Diary’s system of representation and the personal, subjective experience. The dialogue we referred to earlier appears to be a mechanism for working out this tension, working up or massaging the materials so that they feel personally meaningful. Because of his sceptical reaction to the Diary, however, Jeff takes this dialogue to an extreme:

“I have actually assembled the xml-files here and put them in an Excel-page to see if I can interpret them... That is a completely different thing. Then you have a technical angle and you can see here is your pulse, here if you are walking or not, here is the body temperature... In [the Affective Diary] everything is put together in some mysterious way that I don’t have a clue how it is judged. It’s a black box and it annoys me.”

We see here that the Affective Diary is unable to fully engage Jeff in the interpretive process. He is insistent on seeing the raw data for each sensor, opening up the “black-box” as he describes it. For both Monica and Jeff, the mobile materials were useful, but the figures did not provide them with the kind of materials they could make sense of and identify with. But their reasons for dismissing them were quite different. In Jeff’s case this was because he could not see any consistent pattern in the way they appeared and he would have preferred a less ambiguous view directly portraying the biodata—preferably as a graph. In Monica’s case, she was reluctant to see sensor data as bearing any relation whatsoever to her subjective experiences. She dismissed them because they were too objective. In both cases, their reactions relate a lot to what they expect from body sensors and their interpretations of what the sensors can provide.

In sum, we found that participants came up with a range of ways to identify with and interpret their diary materials. Where tensions did exist, the Affective Diary, more often than not, provided a flexibility and openness for reinterpretation. Broadly, the efforts to create an ‘open’ system were successful. Arguably though, Jeff’s subversive dismantling of the system revealed a failure in the Affective Diary: its inability to present data at a range of levels of abstraction. It is worth noting that this failure had significant implications for Jeff in the reflective process that we will discuss next. Jeff’s inability to resolve the tensions he discovered appeared to lessen its value as a reflective tool. Reflection, it would appear, hinges on an ability to work out an open dialogue with the Diary and in particular to identify and interpret meaningful representations.

Reflection, learning and change of life

Apart from interpreting and relating to the materials in the diary, re-living experiences, adding scribbles and creating stories of past events, a more reflective process sometimes took place amongst the participants. This process took different forms. Sometimes, the participants distanced themselves from the recorded events, interpreting and making sense of them from a somewhat removed perspective. At other times, intimate associations were made with the representations, with participants directly relating to the figures.

Despite the struggle she had with identifying her subjective daily experiences in her Diary's figures, Monica, for example, appeared to reflect on and learn from her Diary's content. Through the colours of the figures, she observed how her violin playing was subject to a range of factors; at different times she saw herself as more or less engaged with her music playing and with varying intensities.

Something we initially had not anticipated to see so strongly in these reflective processes was the extent to which the Diary influenced learning and changes in behaviour. This occurred especially when our participants had used Affective Diary several times and could look back, consider and compare interpretations of different events. Ulrica, for example, worked through and reflected on her social and close relationships using the Affective Diary over the course of the study. Looking through her diary, she came to associate emotionally upsetting situations with figures that were coloured blue and thus calm. She found, however, that a few hours after an event the figures would change colour. This, she associated with her usual coping mechanism, jogging. On one occasion during the interviews, for example, Ulrica reasoned about her calmness as her son was telling her that he was moving to France:

"And then I become like this kind of. I am sort of both happy and sad in some way. I like him and therefore it is sad that we see each other so little, I think. Then [at this time] I cannot really show it. Or there is no reason really, since there is nothing wrong about anything, it is just kind of sad."

Reflecting on the Diary's content, Ulrica expresses surprise that she was able to see a pattern emerge:

"But that it shows me how I work. That I... [In fact] I get quite surprised by that. By the fact that I can see this so clearly here [points to the figures on the screen]. Or that is how I interpret it anyway. That I'm not, that I am not so emotionally engaged in, eh... when I interact with people. That I am [emotionally engaged] only when I am alone, kind of."

Nicely captured in this excerpt is Ulrica's struggle with the Dairy materials. She sees the figures revealing the way she 'works'. She recognizes, however, that it is possibly her way of interpreting them that allows her to see such workings. Whatever the case, what is apparent is how Ulrica comes to use the Diary as a resource for her own reflection and learning—the Diary becomes valued in this way. As she describes: *"I have gone back several times to the earlier days, and when I... read the figures I think that it sort of confirms what I have talked about now, what I said about how I function."*

For Ulrica then, her reflections using the diary provided an explanation of why people sometimes misunderstood her and her emotional reactions. Further, it led her to conclude that she should let more of her inner feelings be expressed in the moment. In short, Ulrica used the diary to reflect on her past actions and, as a consequence, to decide to change some of her behaviours; a process of reflection, learning and change appeared to result from using the diary.

Something similar also happened with Erica. Revisiting the materials in her Diary, Erica found a pattern in her reactions when working at work versus working at home. Overall she saw herself as much calmer when at home. This was not a surprise to her, but it became evident in a way that she had not reflected on before:

"[...] here I was home working, so I was very...didn't have much to do, was just sitting there taking it easy, relaxing. To me it looks like when I'm at home there are lots of green, yellow and blue and when I'm at work there is usually more red and lilac. It's sort of interesting to wonder why that is?"

Erica goes onto explain how she came to interpret and learn from these representations:

"You can connect certain states to certain situations which means I can also learn how to change my state in situations where I normally know I would feel bad in. Now I know that it is OK that this is this kind of trigger that will trigger me and then I can think about that before and then I can kind of become more aware of my own states. Even though I am pretty aware already it becomes so obvious when you see it like this, I think."

Examples like Erica's (as well as Ulrica's and Monica's) suggest the Affective Diary's role in a fairly slow cycle of reflection. Perhaps surprisingly, the Diary's sparse detail—displaying time, day, text messages, Bluetooth presence and representations of physiological state—gradually became meaningful, at least at times, for the participants. What appeared to be particularly important in this process of reflection and learning was the ability to see patterns between their figures and the situations they found themselves in. In short, the process built on the long-term use of the Diary and the capacity to visualize patterns and map connections over time.

Re-experiencing the embodied

As we suggested earlier, one motive in designing the Affective Diary was to offer a novel method for revisiting past situations. Specifically, we wanted to investigate how bodily representations could, if at all, become a part of re-experiencing the past and possibly help to introduce new forms of recollection.

From our trials, we found there were mixed reactions to this aspect of the Diary. Two examples, one from Erica and the other from Ulrica, illustrate how bodily reactions provided a definite resource for revisiting past experiences. In the first, Erica describes her meeting with Conchita (see Figure 9):

"...it was a lovely sunny day; I had breakfast on the patio, very nice. After that [points at the last lilac and red figures] I thought of going to town, I was going to meet a couple of coaching friends, so I was really positive and looked forward to meet them. Because I hadn't met one of the girls before, she is from Cuba and works a lot with shamans and healers and has worked in Peru, I was really excited. So a lot of emotions and thoughts, that was fun. [...] Exactly here [points at the standing red and lilac figure] one can see that something happened and it was exactly when Conchita walked in. It was so cool because she came into the café and I had never met here before and it was there we met at Wayne's, and immediately when she walked in the door I thought, that is Conchita so I shouted across the café: Conchita! And that was so amazing because how could she know that it was me! It was exactly around this time [pointing to the diary]. So that was fun. After that we talked and the discussions were very intense, a lot about, which shows here [points at the figures], lilac is spirituality, we talked a lot about clair-

Figure 9. Two subsequent screenshots from Erica's diary from when she met with Conchita. In the second, she scribbles: "lilac=spirituality".

voyance, shamans, healing. Everybody shared their experiences, a very intense meeting."

Using the Diary, Erica walks through the experiences she had around meeting Conchita. Striking is how the Dairy and figure representations become an active part of her working up the details. She points to the different figures, evoking definite and sometimes strong recollections associated with the meeting. Pointing, she remarks: *"one can see that something happened..."* emphasizing an association between the bodily representations and the feelings she had at the time. She even goes as far as drawing an association with the colour lilac and a sense of spirituality. Of course, there is nothing in the sensor-data that supports this interpretation and Erica is likely aware of this. The point is that the Diary's bodily representations provided, at the very least, a means for Erica to recollect and engage with a past experience—to re-experience, in a fashion.

The example from Ulrica reveals how this reliving can be less positive. She recounts how she felt anxious for her son, when he'd received an upsetting text message:

"And then I receive an SMS, the connection on the phone is very bad, but still I receive an SMS. It is like this...[points to the lilac and red figures in her diary]I know for sure that I get it exactly here and I'm very sad and upset because it is from Chris, my youngest son, who receives very bad news. And I become really frustrated because I feel very sad for him, because it is something he has struggled really hard for. So he must keep on struggling and I know he is dejected. So I am very worried and sad for him. And then I can't contact him on the phone. So I think: Help! What is he doing now? Then I feel powerless, because I can't change anything and I'm only the mother, I can't comfort and protect him now. He has to deal with it and... [...] then I get hold of Chris and everything is sorted out because he realizes that he will manage."

Like Erica, Ulrica engages with the Diary's bodily representations in this case to recall the worry she felt at the time. For better or worse, the bodily representations allowed her to follow the chain of events to their eventual resolution.

The capacity for re-experiencing was not always supported by the Affective Dairy however. At times, figures were produced that participants thought to be poor renderings of their bodily reactions. On one occasion, Ulrica, for example, recalled a vivid dream she had, where she awoke with her heart pounding in a cold sweat, but she could not find strong evidence for this in the Affective Diary.

"But the result was not more than this [referring to the representation]. I think it is strange, because it was really dramatic. And I woke up totally exhausted, I had palpitations when I woke up."

To varying degrees then, we found the Affective Diary to enable a reliving or re-experiencing of the past through the visual representations of participants' bodily states. A significant feature of this re-experiencing was how participants' interpretations interleaved with the data-driven representations; in effect, the bodily representations became a part of the active engagement participants had with recollections of past events. Even in Ulrica's disappointment with the Diary not adequately recording the effects of her dream, we see an expectation that the system should render the drama in some visible form; that interpretation of the Diary's figures is unproblematic and even expected. Largely, we were encouraged by this expectation of the Diary and active engagement with it. It suggests the Diary's design lends itself to the experiential and interactional ideas of emotion that we discussed earlier in the paper. Crucially though, the Diary does this by incorporating a bodily component, one that tries to account for our physical presence in the world, as well as social and cultural interrelations.

6. Discussion

We have presented our investigations into three related lines of inquiry: (i) a theoretical grounding for affect and bodily experiences; (ii) a user-centred design process, arriving at the Affective Diary system; and (iii) an exploratory end-user study of the Affective Diary. Through these three inquiries, our overall aim has been to explore the potential of a system that interleaves the physical and cultural features of our embodied experiences and to further examine what media-specific qualities such a design might incorporate.

The Affective Diary system took us some way towards our goal. In our empirical work, we found participants developed particular ways of seeing and handling the Diary's materials. While Jeff and Monica struggled to make sense of the figures, wanting to interpret the bio-sensor data as objective physical measures, Ulrica appeared open to reading her own subjective experiences into them and Erica, at times, went well beyond anything that was available in the representations, believing, for example, they could display her spirituality.

In different ways, our participants' interpretations of the Affective Diary revealed that measurements read from the body are not necessarily linked to subjective experiences in straightforward ways. It appears that users of the Diary 'massaged' their collected materials into accounts that were meaningful for them. Even our most sceptical participant, Jeff, used his readings to recount and interpret past events. In this sense, the Affective Diary's design lends support to Csikszentmihalyi's view on the past as a resource for the present (a point we referred to at the beginning of this paper). The use of the Diary thus demonstrates how the past is actively made sense of in the present; its use reveals how we work with, rationalise and deal with what has happened so as to narrate our pasts in the present (*cf.* Harper, *et al.* 2008).

Despite the generally promising use of the Affective Diary there was one constraint that we felt limited the system's acceptability. Presenting the kinds of bodily data Affective Diary captured back to users had them confronting specific behaviours and patterns they were not able to interpret or, in some cases, prepared or equipped to deal with. In specific instances, the representations felt foreign to the participants and difficult for them to incorporate into their ordinary ways of understanding themselves. This led, on occasion, to our participants dismissing the

the Diary (even though they all wanted to continue using it). This occasional reluctance to use the system and its potential dismal raises a two-fold danger. One, it raises the prospect of the system being rejected in its entirety, something Jeff bordered on. A second and arguably more significant implication to consider is the Diary's role in provoking new ways of thinking about and acting on one's past. Might systems such as the Affective Diary be the cause of angst in such reflection and leaning? It would seem reasonable to assume its promise to support emotional reflection would also pose a potential pitfall: leading a user to learn something they did not want to know.

Both these dangers return us to the issue of the active interpretation of emotion that underlies this paper and our investigations into the Affective Diary. The dangers above appear to hinge on how we design affective systems so that they remain open to a co-production of emotion. The key appears to be to find a suitable balance where a system doesn't dictate what should be interpreted and, at the same time, lends itself to enabling the user to participate in the interpretive act. Somewhere, it would seem, a balance must be struck that promotes a dialogue of sorts between users and the resources for expression they have to hand.

As we have noted, our prolonged design of the Affective Diary has been targeted at examining and reflecting on just this balance, and encouraging such a dialogue. In short, by using sensor and mobile phone data, and considering how they relate to colour, form, and temporal/spatial representations, our efforts have been directed at exploring a space between the ambiguous and familiar. Like Boehner and her colleagues (2005), this work thus draws attention to the interactional qualities of emotion making—how emotion is actively produced through (inter)action—and how working with the tensions between familiar but ambiguous representations can offer resources for recalling and recounting thoughts and feelings.

Building on the work of Boehner *et al* (2005), our efforts give particular emphasis to how the recordings of and from the body and their subsequent representation may play a part in this production of emotion. Specifically, the Affective Diary has gone some way towards illustrating how our bodies and our embodied experiences can shape our recollections and the ways we emotionally reflect on them. The system also demonstrates how the body, combined with technology, might be used in recording experiences and influencing the systems used to represent them.

To develop these ideas, in future work we plan to further consider technologies role in emotion making and the bodily expression of emotion. We aim to explore, for example, how we might introduce less linear representations of time and space into systems like the Affective Diary. The Diary's current design maps the body's relationship to both using fairly conventional representations that leave little option for interpretation. To aid the interpretive act, one might ask how these representations might be made less familiar. Most importantly, our continued investigations into embodied (inter)action and its role in emotion will, we hope, motivate research into what bodily data we are able to capture and the ways in which such data might be represented.

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