Designing Affective Loop Experiences

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Abstract

There is a lack of attention to the emotional and the physical aspects of communication in how we up to now have been approaching communication between people in the field of Human Computer Interaction (HCI). As designers of digital communication tools we need to consider altering the underlying model for communication that has been prevailing in HCI: the information transfer model. Communication is about so much more than transferring information. It is about getting to know yourself, who you are and what part you play in the communication as it unfolds. It is also about the experience of a communication process, what it feels like, how that feeling changes, when it changes, why and perhaps by whom the process is initiated, altered, or disrupted. The idea of Affective Loop experiences in design aims to create new expressive and experiential media for whole users, embodied with the social and physical world they live in, and where communication not only is about getting the message across but also about living the experience of communication—feeling it.

An Affective Loop experience is an emerging, in the moment, emotional experience where the inner emotional experience, the situation at hand and the social and physical context act together, to create for one complete embodied experience. The loop perspective comes from how this experience takes place in communication and how there is a rhythmic pattern in communication where those involved take turns in both expressing themselves and standing back interpreting the moment.

To allow for Affective Loop experiences with or through a computer system, the user needs to be allowed to express herself in rich personal ways involving our many ways of expressing and sensing emotions—muscles tensions, facial expressions and more. For the user to become further engaged in interaction, the computer system needs the capability to return relevant, either diminishing, enforcing or disruptive feedback to those emotions expressed by the user so that the she wants to continue express herself by either strengthening, changing or keeping her expression.

We describe how we used the idea of Affective Loop experiences as a conceptual tool to navigate a design space of gestural input combined with rich instant feedback. In our design journey, we created two systems, eMoto and FriendSense.
List of Publications

Included Publications


Petra Sundström, Anna Ståhl, and Kristina Höök (2005) eMoto - Affectively Involving both Body and Mind, CHI’05 extended abstracts on Human factors in computing systems, April 02-07, 2005, Portland, OR, USA.


Related Publications


1 Fagerberg was my surname before I through marriage changed my surname to Sundström


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Part II - The Papers

Designing gestures for affective input: an analysis of shape, effort and
valence

eMoto - emotionally engaging interaction

eMoto - affectively involving both body and mind

In Situ Informants exploring an emotional mobile messaging system
in their everyday practice

Probing the potential of non-verbal group communication

Hand in Hand with the digital material: designing for suppleness
Part I - The Cover Paper
1 Introduction

During the past few years, I have tried to clarify the design idea of Affective Loop experiences through building systems that embody such experiences. But to begin to explain what we mean by Affective Loop experiences it is best to start by recounting the feeling I get when I go for a night out with my friends. At those times there is usually some wine, good food and intense conversation. The best and most relaxing occasions are those when everybody knows one another, when everyone present has some knowledge of the other’s lives. On those occasions time just flies with conversations touching upon the real, the emotional and the interesting. There can be moments when the shared understanding is so much more than the actual words, moments when we start to fill in each other’s sentences and when the emotional character of the conversation stops us from noticing anything else and we exist just ‘in the moment’. In conversation, our individual personal experiences, emotions, and feelings become blurred with and part of the experiences and emotions we share together as a group of friends. We might be laughing loudly together, hugging and leaning on each other in a moment of pure joy. Or there might be another, more calm, moment where we silently but with our whole essence express our empathy for one another or towards one of us who is relating something of a more serious nature. But there are also moments when we disagree and when it perhaps becomes more obvious that we also are a group of individuals with our own personal ways of being, acting and expressing our unique selves. In those moments there is no longer a harmonious flood of warm and cozy emotions but perhaps more of intense and sometimes even rather negative feelings. These variations in emotions, conversational topics and each and everyone’s personal ways of being and expressing themselves is why those nights and being there together is so great. Why communication and friendship is so immensely interesting.

To my mind, there is a lack of attention to the emotional and the physical aspects of communication in how we up to now have been approaching communication between people in the field of Human Computer Interaction (HCI). As designers of digital communication tools we need to consider altering the underlying model for communication that has been prevailing in HCI: the information transfer model. Communication as described above is about so much more than transferring information. It is about getting to know yourself, who you are and what part you play in the communication as it unfolds. It is also about the experience of a communication process, what
it feels like, how that feeling changes, when it changes, why and perhaps by whom the process is initiated, altered, or disrupted. The idea of Affective Loop experiences in design aims to create new expressive and experiential media for whole users, embodied with the social and physical world they live in, and where communication not only is about getting the message across but also about living the experience of communication - feeling it.

1.1 A Design Journey

In 2003 when the design journey, presented in this thesis began, the field of HCI mainly saw digital communication tools from the perspective of a calm tempered, rational user in front of her stationary computer in her isolated environment writing an email to her work colleague/s. As a user in 2003 she had a clearly defined purpose for why she wanted to use her computer and the specific program, and she was using them as they were intended to be used. Also, as a user in 2003 she was thought of as a user with no more body than her hands and her brain. Since then we, and others (e.g. Norman 2004), have worked on trying to expand the HCI research field to also consider emotions, the complete human body, experiences, and lately also, the digital material.

This thesis is a bundle thesis consisting of a cover paper and six peer-reviewed and published papers that together present our design journey, where we began from HCI as it was in 2003 to today, where we see that we are designing not so much tools for the single user in a narrow/dedicated environment but rather expressive media for the user reminiscent of the social and cultural world context she lives in.

To explain what is meant by a design journey, and my take on what design has come to mean in my research work, I need to start by providing a short background to the idea of a design space. I also need to describe what we mean by experiential qualities and how they arise in and from the interaction with a designed artifact.

1.1.1 Design as a journey in a design space

Our design journey set place and sets place in the design space of gestural input combined with rich instant feedback. A design space is a “multi-dimensional space containing an endless amount of solutions” (Westerlund 2005, p. 1) where it is a concept, an imagined experience or the idea of something rather than a problem that directs the design process. The notion of a problem hints at a way of thinking where there exists one best solution to a given problem, a solution that is measurable. In a design space there is an endless amount of solutions or designs that could allow for the imagined experience. Thinking of design as a space of imagined solutions moves us
closer to a rich landscape of possibilities where there is not one optimal solution, but many possible designs. Gaver and Martin (2000) talk of these specific designs as placeholders “occupying points in the design space without necessarily being the best devices to populate it” (p. 216).

A design space can never be fully described due to its complexity and size. And as indicated above, there will never be one defined way to follow to a successful design, a design that allows for the imagined experience, as there can be many such designs. Westerlund describes how the imagined experience itself can act as a conceptual tool to direct a designer within a design space, to help the designer choose both between what methods to use, but also between various potential designs and design alternatives. And how it in turn are all the different methods and techniques used during the design process that will help another designer when approaching that same design space aiming for that same imagined experience but set up in a different way or in another context.

In turn, Löwgren (2007) describes how “abstractions of core ideas and essential elements from a class of coherent examples, pointing to promising regions in the design space” (p. 165) can be said to be inspirational patterns or i-patterns for a design space. How a more defining design and the design knowledge gained from that specific design can be what directs a designer (other or the same as the one who designed that i-pattern) within a design space. The i-pattern for a design space can of course change the more the designers come to understand of the design space itself and also the imagined experience.

1.1.2 Experiential Qualities

Löwgren (2007) further describes how “interaction design needs its own set of experiential concepts that are strongly oriented towards how the interaction feels” (p. 2). How there needs to be “articulations of key qualities in the use of a certain genre of digital artifacts, indentified for other designers to appropriate in order to develop their own judgment ability, and to elaborate and modify drawing on their own experience” (p. 2), which is what he refers to as experiential qualities (referred to as use qualities in his previous work (Löwgren and Stoltzman 2004)). Experiential qualities are not to be confused with usability qualities or seen as a checklist for design, but as articulated values that can help steer the design process. One example articulation of experiential qualities that we also will come back to further in the thesis is Löwgren’s own articulation of interaction aesthetics using pliability, rhythm, dramaturgical structure and fluency as four concepts that begin to characterize the interactional sensations of aesthetics. Similarly to Löwgren’s work on aesthetics we see the Affective Loop experience as a collection of experiential qualities. In section six of this thesis we will describe a few of the expe-
riential qualities we have found valuable in our work on designing for Affective Loop experiences.

1.1.3 The design journey towards Affective Loop experiences

In this thesis we describe how we have used the Affective Loop experience as our conceptual tool to navigate the design space of gestural input combined with rich instant feedback. We will see how our design efforts within this design space have helped us expand on and further define this idea of Affective Loop experiences in design. How we have been able to articulate experiential qualities for other designers to take inspiration from. In this thesis we will also see how the Affective Loop design idea no longer simply is an abstract idea or a definition of an idea but also encompasses all the experiences and design knowledge we now know/have for how to approach this idea in design.

The procedure for this work can roughly be divided into:

1. A traditional user-centered design process (Norman and Draper 1986) for a system we call eMoto: holding established brainstorming methods, investigation of theoretical influences, an analysis of emotional body language, implementation and, iterative user testing, re-design and final evaluation.

2. A more exploratory but, still, user-centered design process -- of a Technology Probe (Hutchinson et al. 2003) called FriendSense. A probe we used to understand more about our design material: sensor networks, and also non-verbal communication within a group of friends.

1.2 The Genesis

In 2002 my professor, Kristina Höök, started to formulate what she came to call the Affective Loop. Her ideas stemmed from evaluating the Influencing Machine (Höök and Sengers et al. 2003) and SenToy (Andersson et al 2002, Höök and Bullock et al. 2003).

The Influencing Machine is an interactive installation built by Sengers and colleagues to explore issues in the ‘enigmatics of affect’ (Sengers et al. 2002). Users influence the emotions of an artificial agent by choosing from among a set of postcards that are posted into a virtual wooden box. The artificial agent responds to the postcards in the form of unsophisticated doodle-drawings (see figure 1.1) and through an emotionally evocative soundscape. The relationship between input and output are intentionally left “complex, enigmatic and open to interpretation” (Sengers et al. 2002 p. 88) in order to
trigger questions on emotion and computer technology; having or expressing emotion. The postcards are a set of art works chosen beforehand by the designer where the aim for each card is to clearly represent more than one emotion but not too many. The output doodle-drawings are meant to express emotion in terms of color, shape and animation.

Figure 1.1 Influencing Machine (with permission from Phoebe Sengers)

In Höök and colleagues evaluation of the system (Höök and Sengers et al. 2003), they found that users did start to think in terms of the system as being in some kind of emotional process but they also found that the emotional model behind this system was a bit too complex for the users to apprehend. The emotional value of the postcards was not so easy to assess and the meaning or relationship of a postcard with the doodle reply was far too complex for the users to interpret and interact with. Höök and colleagues also found that one of the issues underlying the problem of understanding what the Influencing Machine was experiencing and expressing, came from the timing of the system’s reactions to inserted postcards. Too fast changing of doodle-drawings responses did not allow the users to get the time they needed to recognize and interpret the emotions, but on the other hand too slow changes of doodle-drawings made users quickly lose their interest in the system as it started to seem random. The coupling between their interaction with the system and the emotional process inside the Influencing Machine became obscured. Later, this would become a similar problematic issue for us in our work on eMoto.

SenToy is quite a different system to the Influencing Machine. SenToy is a forty centimeter tall plush toy with sensors inside its body held by the user to interact with FantasyA, a computer game, see figure 1.2. As a player, you assume the character of an apprentice wizard who has to fight battles with various opponents (Paiva and Chaves et al. 2003). Playing FantasyA, players influence their respective avatar’s behavior and emotional processes through acting out various emotional gestures with their SenToy-doll. Depending on the character’s current emotional state, the emotional state of the opponent
and the emotions fed by the user the character will either defend itself or attack the opponent. There are six emotional gestures for the user to choose from. Due to the size of SenToy most of those gestures could strongly utilize the player’s whole body. For example, happiness is expressed by moving SenToy quickly up and down, dancing happily, in your lap. As the player has to perform these gestures with SenToy, the player will also herself have to move her arms in large, wavy gestures up and down in front of her, gestures that might make her more inclined to experience the associated feelings of happiness. Sadness is expressed by bending SenToy into a slumping, sad posture. To make that happen the player will find herself leaning forward into a slumping, sad position where it is rather hard to, e.g., burst out in laughter.

Figure 1.2 SenToy and FantasyA (Paiva and Prada et al. 2003)

The problem with this application is how these gestures affect the game plot. In Höök and colleagues’ studies of FantasyA and SenToy (Andersson et al 2002, Höök and Bullock et al. 2003) users had a hard time understanding how their gestures affected the result of the battles as a jumping movement with the doll did not necessarily lead to jumping movements of the avatar. Instead, the jumping movement would be interpreted as happiness making the avatar happy, which in turn made it more inclined to perform certain actions. The control of the avatar became indirect. It was hard for the users to see what emotions had to do with the events in the game as the avatar turned the emotions expressed into a choice of an activity; e.g. attacking or defending itself against an attacker. But Höök’s interest was caught by how players sometime became very influenced not only by their own movements with SenToy, but also by the gestures their avatar performed on the screen in response (Höök 2008). For example if the avatar portrayed happiness after having won a battle with some opponent it would wave its arms in the air in delight over its victory. This was a gesture that was sometimes imitated by the users, who waved their arm in response – mirroring their avatar’s behavior – almost feeling as one with its body and experience.
From her insights gained from studying the Influencing Machine and SenToy, Höök got the initial idea of the Affective Loop experience in interaction with a computer system. An experience where the user would become more and more emotionally involved via interaction, through the use of gestures and correctly timed and coherent feedback on those gestures from the system. Her idea was to move this interaction from the games domain (where, in a sense, such sensations are probably more easily designed for given the playful and open character of games and of the people that play them due to a suspension of belief) to other settings, such as communication between people, or with oneself mirrored in the computer medium.

On becoming professor at Stockholm University in January 2003, Höök employed myself, an engineer, and Anna Ståhl, an interaction designer, as her first PhD students working in this area. The three of us together set out to explore this idea of Affective Loop experiences in interaction. As we started to work on Höök’s initial, sketchy, ideas for how this could be done, we came to apply them first on communication between two friends and later on communication amongst whole groups of friends. This thesis will tell the story of how those design experiments unfolded and how the idea of Affective Loop experiences evolved through this process.

1.3 The Affective Loop Experience - The Conceptual Tool

Starting our work on designing for Affective Loop experiences we had Höök’s first encounters with the Influencing Machine and SenToy as guiding concepts. Working on eMoto and FriendSense we further refined our understanding of this experience, the Affective Loop experience – our conceptual tool. The shaping process benefitted from successful moments in our design processes as well as the failures, and both from our own usage of the systems as well as other users’ encounters with them.

Initially the idea of Affective Loop experiences in design, as discussed by Höök and colleagues, was a way to help users understand how to use SenToy to express certain emotions:

“users will not behave in the same way when expressing emotions through a doll rather than through their own bodily behaviors ... we needed to put users in a loop where they are given feedback from the system through how the avatar reacts. Users will learn how to create the right behavior through watching the face of the avatar on the screen when they perform actions on the SenToy.” (Andersson et al. 2002, p.351)

Today, our focus is on the experience itself. Our hope is that the idea of Affective Loop experiences in design can help us create new expressive, expe-
ential media that takes people's bodies and emotions into account and where communication will not only be about getting the message across but also about living the experience of communication, feeling it:

An Affective Loop experience is an emerging, in the moment, emotional experience where the inner emotional experience, the situation at hand and the social and physical context act together, to create for one complete embodied experience. The loop perspective comes from how this experience takes place in communication and how there is a rhythmic pattern in communication where those involved express themselves but also ever so often stand back interpreting the moment - feeling it.

To allow for Affective Loop experiences with or through a computer system, the user need to be allowed to express herself in rich personal ways involving our many ways of expressing and sensing emotions – muscles tensions, facial expressions and more. For the user to become further engaged in interaction, the computer system needs the capability to return relevant, either diminishing, enforcing or disruptive feedback to those emotions expressed by the user so that the she wants to continue express herself by either strengthening, changing or keeping her expression.

As indicated the work presented in this thesis follows a ‘research through design approach’ (Zimmerman et al. 2007, 2010) and in this thesis we will describe how the Affective Loop design idea has evolved through our design efforts on eMoto and FriendSense. We will identify the key issues for what happens to the interface when the tool becomes a medium; a major research question the HCI research field faces today. The answer to that question is however outside the scope of this thesis, although, an aim of this thesis is to provide other designers and researchers with an extensive cache of design experience on this matter that we together can continue to build upon.

1.4 Contributions

Let me provide a summary of the contributions of this thesis wherein are also noted those parts that are more explicitly my contributions, thoughts and analyses. Throughout this thesis the more common notion of ‘we’ will be use as much as possible, but for those parts of this thesis that are my own thoughts and learnings a first person notation will be used. To some extent also an autobiographical design approach has been applied where also my own explicit experiences have played a part in the design process.

The contributions can be divided into three categories:

1. applications that embody Affective Loop interactions named eMoto and FriendSense

2. an empirically grounded understanding of what Affective Loop experiences are
3. **practical design knowledge** for how to go about designing and evaluating systems that aim to involve users physically and emotionally in interaction

I have, together with my colleagues, created two fully-fledged, working applications, *eMoto* and *FriendSense*, that embody the idea of Affective Loop experiences in design. We look upon these two applications both as embodiments of Affective Loop experiences, but also as a proof that we can, sometimes, involve users in expressive emotional interactions.

*eMoto* is a mobile system for sending and receiving emotionally enhanced text messages. *eMoto* was truly a joint effort between me and interaction designer/PhD student Anna Ståhl under the direction of professor Kristina Höök. Ståhl did the main part of the graphical design while I was responsible for the implementation and also the evaluation of this system. Martin Nilsson at the Swedish Institute of Computer Science (SICS) constructed the specially designed hardware device used in *eMoto*.

*FriendSense* is a sensor network based system for expressing emotional closeness within a group of users. The *FriendSense* project was conducted in a slightly different way than our design process for *eMoto* as an attempt to in a more explorative fashion study how the socio-digital material evolves in interaction (Taylor et al. 2007). *FriendSense* was a system I worked on together with computer scientist/PhD student Tove Jaensson, master student Alina Pommeranz and master student Annelie Swanecke. Again under the supervision of professor Kristina Höök. I helped with and supervised the implementation of *FriendSense*; and, together with Tove Jaensson, ran the *FriendSense* system as a Technology Probe in a set of workshops and user studies on emotional closeness as expressed in a group of friends.

Second, through the design, implementation and evaluation of these two systems, we have gained an **empirically grounded understanding** of what Affective Loop experiences are and what they are not. In section four the Affective Loop experience is presented as an active, intense and rather short emotionally engaging experience where the longer but perhaps less intense similar experiences from our own lives, such as how we express ourselves to our friends, and over time get feedback on who we are and how we fit in a larger context with all our friends, how these longer experiences build up for the rather short experiences we aim for with the idea of Affective Loop experiences. In our work we have for example found **suppleness, being in play, depth, ambiguity and openness for personality in expressivity and interpretation** as some of the experiential qualities needed to consider to allow for these experiences in design. Discussions on the Affective Loop experience have been an ongoing process throughout this thesis work. Most issues brought up in this thesis have been things we have collectively worked with and discussed throughout the above mentioned projects, while the analysis as it is presented in the cover paper of this thesis is my own.
Third, we have from our work on eMoto and FriendSense gained practical design knowledge for how to go about designing and evaluating systems that aim to involve users emotionally in interaction. One major insight gained from designing and evaluating eMoto was the importance of considering (digital) material properties in the design process. As mentioned above, we built a special-purpose hardware device for the eMoto system. The physical, HW-, SW- and network capability of this interaction determined the experience of this system. Without a perfect match between what the material (more or less) effortlessly affords/permits and the requirements on emotional expressiveness the illusion of being involved in an expressive, interactional loop is easily broken. The slightest wrinkle or crack in this kind of interaction will kill the experience. And here we do not only refer to the physical appearance of the digital material but also how the actual code is written. Building this kind of advanced system, combining special hardware and software solutions, with advanced graphical and gestural design, requires more than one competence. Finding a single person who can master all parts of such a system development becomes very hard, why it is imperative to communicate and share the affordances of the material among all members of a design team. For this the design process for FriendSense kept a more careful focus on the material and explored if and how we could design a system that went hand in hand with a pre-chosen digital technology rather than fighting the material in order to reach a design concept -- brought out without first considering the material properties. This focus on material, spurred from my own experiences working on eMoto, together with Anna Ståhl, was my contribution to the FriendSense project. What we propose was a working style, similar to that of designers who are taught to bring out many design concepts, branching out and communicating possibilities to their customer and to themselves (Buxton 2007). By creating a range of design concepts, they are in a sense mapping out aspects of the design space. This can be contrasted with how people trained in HCI- or engineering are taught to work in a more linear way – moving from problem formulation, to solution specification, to working their way towards an optimal solution. We end up working iteratively refining one idea (rather than exploring many) without ever changing much of its fundamental properties, and so often, find ourselves fighting our material - the digital material – instead of working hand in hand with it, exploiting its affordances.

Also, the design and evaluation methods available in the HCI field were, at the time, not directed at capturing emotional experiences and users own interpretations of their experiences (Wright and McCarthy 2008). Therefore, during the design process, we repeatedly found that we had to explore new grounds where little design knowledge existed that we could be inspired by. We also lacked methods that could guide us through this landscape. The eMoto design we for example based on the theories and notation system of choreographer Laban (Davies 2001, Laban and Lawrence 1974). To evaluate
In this system we used a combination of the Technology Probes (Hutchinson et al. 2003), Cultural Probes (Gaver et al. 1999) and the Experience Clips method (Isomursu et al. 2004).

1.5 Outline

This so-called bundle thesis is composed of six papers and a cover paper. The purpose of the cover paper is to aid the reader to follow and connect the reasoning going on between these six papers. Each of the six papers will be presented in more detail in part two. Part one consists of the cover paper of this thesis that aims at presenting more of the overall design journey that goes on both in and around those papers.

Part I - The Cover Paper

Section 1 – is the introduction that you have just read. It motivates this research by taking us back to HCI as it was in 2003 when the work presented in this thesis started and how we, and others, since then have worked on trying to expand the HCI research field to also consider emotions, the body, experiences, and lately also, the digital material. This section provides the reader with a short presentation of the design space mapped out by this thesis and the experience we are seeking to substantiate and use as a conceptual lens to our design efforts – the Affective Loop experience. This section states how the aim for this thesis has been to explore and further develop this idea of Affective Loop experiences through design.

Section 2 – presents the academic landscape this thesis belongs to. It outlines the theories on emotion that has inspired our design work. This section outlines what we have come to understand as what an emotion process is, and what our theoretical home is.

For the main part, our theoretical home is that of phenomenology. Researchers from other schools, such as ethnomethodology, might find our use of more cognitive or bodily oriented theories of emotion, movement and friendships, difficult to join with a constructivist and culturally situated stance towards emotion processes. For us, there is no contradiction and we have been able to make use of both perspectives. But most of all, we see the theories on emotion as inspirational sources to design – we loosely base our design processes on those theories. Our contributions are to the field of HCI and how to design computer technology that in and through the interaction with the user creates for certain kinds of experiences. We do not aim for a contribution to social or psychological accounts of emotion. We do not adhere to any simplistic notions of ‘natural’ expressions of emotions or bodily gestures, but instead see design as artifacts that will carry novel expressions and even instigated novel experiences.
This section also provides an overview of other Affective Interaction systems and design methods relevant to this thesis.

Section 3 – presents the design process behind the first application we built, eMoto. eMoto is a mobile service for sending and receiving emotionally expressive text messages. The user uses a set of expressive gestures to express the emotions she wants her message to communicate. The emotional characteristics of these gestures are expressed in colors shapes and animations shown to the user while performing her gestures. When the user is satisfied with the expression, she stops doing the gestures, and the current colors, shapes and animations become part of her text message. She can then send the composed message to one of her friends. The design process for eMoto follows a rather traditional user-centered design process (Norman and Draper 1986).

Section 4 – presents three results from our work on eMoto that came to have a significant effect on our continued work. (1) The contradictions that arose between seeing and using eMoto as a tool for a single user to express and experience herself, and eMoto as a medium for the user to communicate with others. (2) How the digital material matter to whether we can achieve an Affective Loop experience or not, and how HCI-practitioners need to be more inspired by how designers work with their materials. (3) Last how we as researchers also cannot just imagine and plan for movement, but instead need to move ourselves in order to find what the experience really can and should be.

Section 5 – presents how our learnings from working on eMoto made us choose a completely different approach for our work on FriendSense. FriendSense is a technology probe we set up in order to in a more explorative fashion find ways for how to design for non-verbal communication within a group of friends, as a way for us to see how the socio-digital material evolves in interaction. FriendSense is not designed to be a perfect application that could be turned into a viable product. Instead it has helped us outline the smaller and to some extent disregarded but so important details in designing a system allowing for Affective Loop experiences. It should be seen as a stepping-stone towards building other, richer, interactive applications.

Section 6 – outlines the experiential qualities that are important when designing for Affective Loop experiences: suppleness in terms of rhythm, timing, harmony and coherency and kineastetics; a sense of being in play; and depth, ambiguity and openness for personality in expressivity and interpretation. This section argues for how we find the idea of Affective Loop experiences to be more than a framework for design. In our view, it conveys an interactional pattern for how to practically bring these experiences into design, this on top of a theoretical framework for design. Last, we provide a designerly critique of the idea of Affective Loop experiences in design.
Section 7 – discusses the work presented in this thesis and points out how the design knowledge we have gained from working on eMoto, FriendSense and the idea of Affective Loop experiences potentially could help us and other designers create new expressive and experiential media for whole users, embodied with the social and physical world they live in, and where communication not only is about getting the message across but also about living the experience of communication.

This section also outlines potential future work on how to develop better methods for interdisciplinary design teams, helping them to come to a shared understanding of the properties of the digital material – beyond designing for Affective Loop experiences.

Part II - The Papers

Paper A – The Affective Gestural Plane Model


This is the first paper we wrote on eMoto and how it embodies Affective Loop interaction. At that time, we were still experimenting with the concept, and the definition given has since been modified repeatedly.

Having said that, this first paper lists embodiment, natural but designed expressions, the Affective Loop experience and ambiguity as our four guiding design concepts. Our aim was to design for users to express themselves in rich personal ways involving more of our many ways of expressing and sensing emotions than before that used in HCI system design. We present an analysis of emotional body language based on work we have done with actor, Erik Mattson. We had asked Mattson to act out a set of nine emotions. Acts that we later analyzed using Laban notation system for shape and effort (Davies 2001, Laban and Lawrence 1974, Zhao 2001). This Laban analysis will also be presented in more detail in section three of this thesis. What we wanted was to design a system with which users can interact in their own personal ways. But what we then needed was to find some underlying dimensions of emotions in terms of movement that we could use to capture users' movements and interpret those in our design. What we found from our analysis of emotional body language that we could use was how one tends to get more tensed when expressing emotions with negative valence, and more loose and open in our movements when expressing emotions with positive valence. We also found that more energetic movements were used for emotions with high levels of arousal, as anger or happiness, while slow movements indicated low arousal emotions, such as sadness or being calm in a positive sense. These two dimensions, tension and energy of the movements came to be the basis for our affective gestural plane model, used as the basis for the eMoto design.
This paper also provides a first sketch of the eMoto system.

Ståhl and I are listed in alphabetical order on this paper since the project this far truly was a joint effort between us two with Höök as our supervisor (and thereby last author). It has to be added though that to this point Höök helped us find and construct most of our theoretical framework.

**Paper B** - eMoto


For this paper we had implemented an almost complete version of our eMoto system. At that time, in 2003 and 2004, the SonyEricsson Symbian phones had just opened up their operational system for developers. Our first version of the eMoto system was developed for the P800 series where one used a stylus to interact with a touch screen. We used this interaction model to develop a system where the user first had to write her message using either free text or the virtual keyboard. Having completed the text of her message the user can apply more (or less) pressure and energetic (or less energetic) movement to a stylus pen that we had extended with sensors. Through this combination of pressure and movement, the user add a colorful, animated background to her message. If the movements are tensed and energetic, users gets a negative animated expressions, while if they perform less tensed and less energetic movements, they get positive expressions with slow animations. Users are not limited to any specific set of gestures but are free to adapt their gesturing style according to their personal preferences. This was made possible through building a special-purpose hardware device replacing the stylus that came with the phone. Our new stylus was equipped with a pressure sensor and an accelerometer to capture movement. The stylus for this paper was wired up with a laptop that in turn communicated with the mobile phone. Later we upgraded the system to run on the P900 series of SonyEricsson Symbian phones and for this later version we also moved to a wireless Bluetooth connection between the stylus and the mobile phone.

This paper also presents the graphical background Ståhl designed for the affective gestural plane model presented in the previous paper.

Similar to that paper Ståhl and I are also here listed in alphabetical order and Höök last, being our supervisor.

**Paper C** – A Two-tiered Evaluation Model

*Published as: Petra Sundström, Anna Ståhl, and Kristina Höök (2005) eMoto - Affectively Involving both Body and Mind, CHI’05 extended abstracts on Human factors in computing systems, April 02-07, 2005, Portland, OR, USA.*
The evaluation process of eMoto followed Höök’s two-tiered evaluation method (Höök 2004), that advocate that each part of an affective interaction system must be evaluated separately before combined into an overall design. Once combined into a whole interaction, it needs to be evaluated again, this time against the overall purpose of the system. It might be that an idea for some affective interaction system is really good but unless the expressions used in each part of that system are understood by the end-user, the overall idea will fail anyway. After each part has been evaluated on its own there should be a final evaluation conducted in a natural setting and on “real” usage. Not much can be said about real usage of for example a mobile system if it is only evaluated in a lab environment. Still, there are things we need to adjust first in the lab in order to become able to get to a fully working mobile system that we can let users have and bring with them into their own lives.

This paper presents results from a lab study we conducted to validate the affective gestural plane model. The graphical background was at that time already validated and redesigned (Ståhl et al. 2005).

The results from the study presented here showed us that it was not enough that we had faster moving animations for emotions with higher arousal but also we had to speed up the time it takes in eMoto to reach these expressions. Emotions such as sadness or being content and relaxed seemed to take more time for users to get into and therefore benefit from a slower moving interaction model.

I am first author of this paper since I was responsible for this user study and Ståhl for the user study evaluating the graphical background circle. The work was still very much a joint effort although Ståhl had started to work more on the graphical shaping of the system and I had started working more focused on how to implement our ideas. I also implemented special set ups of the system for the two user studies validating the separate parts of this system.

**Paper D – In Situ Informants**


This paper presents the final ‘in the wild’ evaluation conducted on the eMoto system. Five female friends in their late twenties from Uppsala in Sweden, were given eMoto devices to use over the course of two weeks. To get at these users’ everyday experiences, we combined a Technology Probe approach (Hutchinson et al. 2003) with the Cultural Probes method (Gaver et al. 1999), and we also made use of the Experience Clips method (Isomursu et al. 2004). The combined method we call In Situ Informants. In short, a close friend or partner acts as the gatherer and to some extent analyst of the
data from the user. S/he provides an informed analysis of his/her partner’s experiences with a mobile system based on their joint everyday lives.

This ‘in the wild’ evaluation of eMoto provided us with results on how users both could and could not ‘do their friendships’ in and through eMoto. To ‘do’ friendships involves a special rhythm in communication where friends talk of their past together, plan for a shared future and repeat special meaningless jokes that has meaning only to them. Friends also need to be responsive to one-another’s needs. For example, we could see that the eMoto-circle was not used in a simplistic one-emotion-one-expression manner mapping emotions directly to what is experienced at the time of sending an emoto. Instead they, for example, used the graphical expressions to convey mixed emotions, a sense of time (such as darkness when it was late at night), their personality (“I like green”) and so forth. What we saw was that we had to focus more of our design efforts on generic expressivity of all sorts of bits and pieces that makes up a dialogue, rather than singling out emotions as a separate part of the communication. As we had designed eMoto to be open to users’ own interpretation, it managed to afford most of what users wanted to express. They easily appropriated the tool. But it was still important for us to see and be reminded that emotions very rarely are expressed and experienced in an isolated channel between a set of two friends sending and receiving emotos. In addition, the two friends never act in total isolation from their other friends and family. Many times, the expressions needed to cater for the whole group of friends. It was exciting to see how the emotional setting emerging in one discussion not only had an effect on the people being directly involved in that discussion but also how those emotions colored the discussions they had on completely different subjects with their other friends, outside our study.

What we also learned from our experiences with eMoto and that became extremely obvious in this real life evaluation was how much the digital material mattered for a fluent and embodied Affective Loop experience.

I am the lead author of this paper since I designed, conducted and analyzed the results of this final evaluation of the eMoto system. Both Ståhl and Höök helped with the analysis and in writing of the paper.

**Paper E - FriendSense**


After eMoto we were curious about and needed to deepen our exploration of two issues; first, how non-verbal emotional expressivity within a group of friends is done and would unfold through technology mainly aimed at physical expressions, and second, how to make better use of the properties of computer technology as a design material in designing for Affective Loop.
experiences. To explore these issues, we decided to take the rather extreme position of letting the material be our starting point, rather than starting from users’ needs. Obviously, we also took other influences used in the early stages of the design process, such as an ethnographic study of friendships (to be published by Jaensson) and theoretical inspiration. Starting from the technology is taking an extreme position in that it, in a way, takes us back to the highly criticized technology driven design processes taking place before we understood the benefits of user-centered design and taking advantage of designer competencies.

In this paper we present how we used a sensor network technology to build FriendSense. The FriendSense system was never a fully-fledged application, but instead a rough, unfinished technology probe, that we exposed to interaction designers and potential users both in our own lab but also with another group of interaction designers at Telia Sonera. The aim was to explore the potential of non-verbal group communication, building our understanding of the socio-digital material as we went along. By socio-digital material, we mean both the social processes that arise around novel technology, but also how the digital material plays a role in shaping that technology, in turn shaping the social processes. The set up is a public screen where each user has her individual graphical expression, which she can change by expressing herself through her own personal sensor node. The sensor node we refer to in our paper had a vibration and a temperature sensor. We later changed to a sensor node equipped with accelerometers. The graphical expressions on the public screen were (for this paper) transparent, but at the same time colorful, moving ‘marbles’. Inside the semi-transparent marble, users could put photographs of themselves or something they thought symbolized them or their state of mind or whatever they wanted.

We used our experiences with this probe to open up for more informed discussions on a topic we ourselves knew little about and also found very few contributions to in the existing research and design literature. In this paper we extract four key challenges; how to design for group membership, how to mediate physical contact, relaxing and enabling physical bonding activities and catering for the individual experience.

It has to be said that this paper to some extent provides a very crude perspective on friendships. A perspective also not as well grounded in social sciences and psychology where these matters of course are more familiar topics. But our aim was not to explore friendships as such. Our intention was to explore friendships in the context of groups and non-verbal expressivity when mediated by computer technology. But since this paper presented our own experiences with the FriendSense system, and thereby exposed our own (workplace-related) friendships, it also came to discuss aspects of friendships that were exposed in the interaction with the FriendSense-probe.
I am the lead author of this paper since I supervised and helped Pommeranz with implementation and also together with Jaensson planned, conducted and analyzed the results of the user study presented here. Höök, as always, was a great help throughout this project.

**Paper F – Material Matters**

*Published as: Petra Sundström and Kristina Höök (2010). Hand in hand with the material: designing for suppleness. Proceedings of the 28th international conference on Human factors in computing systems. Atlanta, Georgia, USA, ACM.*

One can say we had two purposes with our FriendSense project, where one was to explore non-verbal group communication as presented in the previous paper; and, where the other was to put focus on how computer technology as a design material has properties that matter or even determine, designs aimed to create for Affective Loop experiences. This paper focuses on suppleness, which is one of the experiential qualities we find important when designing for Affective Loop experiences, an issue not mentioned in this specific paper though but later in this thesis. We point out three different examples of digital material significance in the FriendSense design; one being, the perhaps most obvious, the actual physical property of the sensor nodes, another was on the algorithmic level of the implementation, and the last one exposed the properties of the wireless signal reach and shape. We show how the last material encounter, with the wireless properties, reshaped one of the design ideas and, instead of fighting the material, had us take a step back and reconsider what it was that we wanted from our design from the potentials of the material.

This conceptual contribution of this paper presents my analysis and reflections arising from both the eMoto and FriendSense projects, which is why I am the first author of this paper. Höök has all along helped me to a formalization of these thoughts, which is why she is a co-author.
2 The Academic Landscape

The aim of this section is to clarify what we mean when we say we are designing for the whole user, bringing in the whole social and cultural world she lives in. We address what we mean by ‘emotion processes’, bringing in some background on the emotion theories we have chosen as the basis for our work. We will also attempt to explain our own position in the ongoing discussions of what emotion processes are and how we can understand them.

Once we have given some (limited) background to the rich, multidisciplinary area of emotion research, we will move on to describing how emotion has been understood and picked up in AI and HCI and briefly describes some of the systems that have inspired our work. We will also mention a few systems that were built in parallel with our work on eMoto and FriendSense, and some systems that took advantage of our experiences of designing for Affective Loop experiences. Finally, we will discuss the problem of evaluating whether a design has succeeded in creating for Affective Loop experiences, as these are hard to define, hard to express, and hard to expose in user studies.

2.1 Theory of Emotion

To simplify, we could say that there are two extreme perspectives on how to view emotion; on the one side there is a ‘pure’ biologist stance where emotion is seen as an inherited trait, biologically determined, possible to characterize and study irrespective of culture or upbringing, and on the other side there is the ‘pure’ constructivist position that sees emotion as a learnt trait, modified by culture, shaped in interaction with others, and even experienced differently depending on the individual’s learning, prior experiences and culture. Our perspective on designing for emotion -- to personify / represent / incarnate the bodily, social, and cultural product -- is positioned somewhere in between those two.

Important to remember here and throughout this thesis is that for our uses we see theories on emotion as inspirational sources to be used as a starting point for design, but not necessarily as proof or disproof of their validity as such. Nor do we implement them in some kind of one-to-one-mapping, directly into our designs. Instead, they are used, reformulated, and massaged through
our design processes, into designs that seem to work in our ‘in the wild’ studies of our artifacts. In that sense, our approach can be seen as a grounded theory approach to design, loosely based on theories of emotion processes. Our results aim to contribute to the field of HCI and how to design new experiential media for the complete user in the social and physical world she lives in. Our intention is not to contribute (in any substantive way) to social or psychological definitions of emotion, but to design theory on how to design for emotional processes and communication.

Before proceeding, we need to clarify a few pieces of terminology. Important to say is that we see emotions as processes that build up and disappear over time and not as clear-cut states, which is why we find the difference between emotion and emotion process important. To differ between the both very commonly used notions of emotion and affect is not as easy; Picard (1997) for one does not make this difference but use them interchangeably. As will we not state a difference between emotion and affect but will for clarity reasons use emotion processes and perhaps at some occasions emotion and affect.

2.1.1 Emotion Processes

There are a number of emotion related states that all tend to be referred to as emotions. Working in the HUMAINE project, a European network of excellence, between the years of 2004 and 2008\(^1\), we were introduced to psychologist Claus Scherer’s work on emotions and emotion theory. Scherer (2005) provides the following differentiating explanations of preferences, attitudes, moods, affect dispositions, aesthetic emotions and utilitarian emotions:

- **Preferences**: “Relatively stable evaluative judgments in the sense of liking or disliking a stimulus, or preferring it or not over other objects or stimuli...” (p. 703)

- **Attitudes**: “Relatively enduring beliefs and predispositions towards specific objects or persons...” (p. 703)

- **Moods**: “Diffuse affect states, characterized by a relative enduring predominance of certain types of subjective feelings that affect the experience and behavior of a person...” (p. 705)

- **Affect dispositions**: Stable personality traits with a “strong affective core (e.g. nervous, anxious, irritable, reckless, morose, hostile, envious, jealous) ... the tendency of a person to experience certain moods more frequently...” (p. 705)

\(^1\) http://emotion-research.net/
Interpersonal stances: “... an affective style that spontaneously develops ... with a person or a group of persons, coloring the interpersonal exchange in that situation (e.g. polite, distant, cold, warm, supportive, contemptuous).” (p. 705)

Aesthetic emotions: “produced by the appreciation of the intrinsic qualities of the beauty of nature, or the qualities of a work of art or an artistic performance. Examples of such aesthetic emotions are being moved or awed, being full of wonder, admiration, bliss, ecstasy, fascination, harmony, rapture, solemnity.” (p. 706)

Utilitarian emotions: emotions that are “utilitarian in the sense of facilitating our adaption to events that have important consequences for our wellbeing.” (p.706) Examples of such emotions are anger, fear, joy, disgust, sadness, shame and guilt. Psychologist Ekman and colleagues refer to these emotions as the basic emotions (1972)

The Affective Loop design perspective is directed at the latter two terms, utilitarian and, to some extent, aesthetic emotions; both short, relatively intense emotional experiences.

Having used Scherer’s terminology to further describe what mean by emotion processes and what kind of emotional experiences we aim to design for we will not use this terminology in the rest of the thesis but stay with emotion processes and at some occasions emotion and affect.

2.1.2 Emotion Models

There are a number of different models of human emotion processes – some explaining the process of initiation of an emotion process, others their evolutionary development, their developmental progression, pathological illnesses affecting our emotion system, etc. Scherer (2002) has summarized the most common emotion models with respect to their focus on the components of and phases in the emotion process (table 2.1).

The classic definition of the components of an emotion is the emotional response triad composed of the following: psychological arousal, motor expression and subjective feeling (Scherer 2002). Psychological arousal manifests itself as changes in body temperature, muscle and heart activity and other physical processes, processes that under ‘normal’ circumstances are hidden from people in our surroundings. Motor expressions are the processes that people share with others, such as changes in facial and vocal expressions, gestures. Subjective feeling concerns how people experience and consciously reflect on their emotions, and how they can verbally express how they feel. Scherer also explains that this classic triad definition has been augmented with two additional components: behavior preparation and cogni-
tive processes. Behavior preparation implies that emotions change ongoing behavior with changes in emotion processes. Cognitive processes explain and show how emotions may have a strong effect on attention and memory. Scherer argues that emotional processes take place with changes in these components over set phases, from low-level phases to communicative phases. He claims that emotions can be evoked both cognitively and physically, and emotion stimuli can be anything from external events to internal psychological changes. The order of the phases depends on the stimuli.

<table>
<thead>
<tr>
<th>Phases</th>
<th>Low-level evaluation</th>
<th>High-level evaluation</th>
<th>Ongoing priority setting</th>
<th>Emotional states</th>
<th>Behavioral preparation</th>
<th>Behavioral expression</th>
<th>Communicative sharing with others</th>
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Table 2.1: Comparison of major emotion models (named and highlighted in color within the chart) with respect to their focus on components and phases in the emotion process (Scherer 2002)

In table 2.1 Scherer lists the major emotion models with respect to their focus on components and phases in the emotion process evoked by external stimuli:

- **Adaptational models** of emotion imply that emotions emanate from what we experience in daily life. Evolution has equipped people with a biological preparedness for stimuli that are potentially harmful, such as snakes and spiders. Emotions that are not innate are experienced and learnt when we are exposed to some particular situation for the first time and are then stored in our emotional library.

- In **Dimensional models** each emotion has its own unique region in a multidimensional space. Examples of such dimensions are arousal and valence used by Russell in his *Circumplex Model of Affect* (1980). Dimensional models focus on the subjective experience, what is often referred to as qualia in philosophy. The subjective nature of experience in these theories are emphasizing that these dimensions might not be experienced in exactly the same way by everyone.

- **Appraisal models** view emotions in terms of the needs and abilities of the individual experiencing them in a particular context. Appraisal models not only describe the experience of an emotional state but also explain how and why an emotion arises in that specific context.
moment. Appraisal models cover the whole area between a stimulus and the response it creates. This group of models is in fact Scherer’s own contribution to the field of physiology and research conducted on emotion and emotion processes (as presented in e.g. Scherer 2001).

- **Motivational models** are similar but oriented more to the output end of the emotional process. They focus on the goals and principles of the individual and not so much on her basic needs and abilities.

- **Circuit & Discrete emotions models** define a limited set of basic emotions that can be mixed or blended into the large variety of emotions that exist. Many of the discrete emotion models are derived from Darwin’s *The Expression of Emotion in Man and the Animals* (1872), where each chapter defines the physiological changes and the expressions for emotions such as hatred and anger, disgust, guilt and pride and so forth. A more recent and well referred to discrete emotion model is Ekman and colleagues’ six basic emotions; anger, disgust, sadness, happiness, fear and surprise (Ekman et al. 1972).

- Finally, **Meaning-oriented models** suggest that there are relations between semantic meaning and emotional value and that there are categories of emotions meaning nearly the same thing, like the anger category including rage, irritation, being cross etc. These theorists also argue that not all categories are used in all cultures.

What are missing from Scherer’s list of emotion models are the models that hold a cultural perspective on emotions. For example Katz (1999) has written about how various emotions emanate from and are shaped by the culture we live in. These emotion models do not simply discuss emotions from a simple stimuli-response order but also consider emotions as part of the social, physical and cultural world we live in.

In our work on the idea of Affective Loop experiences in design it is the subjective experience of emotions that is important and therefore it is emotions from a dimensional perspective rather than emotions as defined isolated states that matter to us. We also do not want to limit users to a specific set of emotions but allow for a range of expressions and emotions.

### 2.1.3 Beyond Dualism

One of the main issues behind the whole range of emotion theories, an ongoing debate since Descartes, is where an emotion starts, how it starts and what parts of the human body it affects. Descartes suggested that the material body works like a machine controlled by the nonmaterial mind (the soul),
but that the body also can influence the otherwise rational mind, such as when people act out of passion (1989). Followers of Descartes have portrayed emotion as a hormonal and physiological matter that interferes with rational thought, and in some respects as being a ‘feminine’ trait, and therefore does not need to be considered in the design of, traditionally, the more business oriented computer systems. In 1994 Damasio in his book Descartes’ Error pointed out how emotions are not ‘in the way’ but how we in fact need emotions to make rational decisions.

A dualistic perspective/attitude has continued to affect the field of Computer Science as well as many other research fields and also society in general. Many are those who critique this dualistic perspective. To take one example, the philosopher Burwood (2009) uses the idea of a brain transplant to consider what it is that defines us as humans in the world. What he wants is to put an end to the idea of ‘the brain-is-self’. He argues:

“our sense of ourselves develops in reply to others and their response to our embodiment. Similarly, our sense of who others are is intimately tied to their bodies as a whole; their appearance, behaviour, demeanour, and so on (the ideocratic tone of voice or accent, the wry smile, the twinkle in the eyes, the infectious laugh, the commanding presence, the healthy complexion, the slightly odd walk, the tall-person’s stoop, etc.) It is impossible to think of someone without thinking of them in terms of such bodily characteristics”

(p. 127)

Burwood explains how someone after a brain transplant would be someone totally different but how that also would be true for a person exchanging everything else but her brain. The conclusion is that we are humans in a social and cultural world and it is impossible to separate activities in the brain from the activities in the rest of the body, nor from the activities that takes place around us in the world. In the perspective of ‘the brain-is-self’ we will later see how Picard and colleagues in their work on Affective Computing in fact have helped the Computer Science research community to see how the body cannot be disregarded in the design of computer systems.

But, as Burwood also points out, dualism is not only about the separation of mind and body but also about the separation of the body from the rest of the world. From a phenomenological starting point, Fällman (2003) provides us with a simple example of how we are situated ‘in the world’ – not separated from it. – How 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. His example is that of 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. Thus we need to live and act in a culture where sitting on a chair makes sense.
In similar ways our emotions cannot be separated from the context and the culture in which they are experienced (Katz 1999). Social and affective communication practice unfolds between people in the world. One, to some extent extreme, example of how emotions only make sense in the culture we live in can be found in anthropologist Lutz’s (1988) studies of the people living on Ifaluk, an island in the North Pacific Ocean. The people on Ifaluk explicitly teach their children the feelings ‘song’ (justified anger) and ‘metagu’ (fear of what that angered person will do). To reinforce feelings of metagu some parents even dress up as ghosts frightening their kids giving them a taste of what might happen if they behave badly and raise song in their parents. Song as felt in the Ifaluk culture is a pro-social feeling in contrast to how anger in the Western world more is a negative, anti-social emotion.

For our work we have chosen to see emotions as processes not states; processes that circulate in and affect our whole body and at the same time, inseparable from the culture and world we live in.

2.1.4 Emotion and Movement

How we move and how we express ourselves in combination with various emotion processes of course varies with our personality, the situation at hand and a range of other contextual factors. But there are similarities. Certain movements and body postures are more likely to coincide with certain emotional experiences (Darwin 1872, Wallbott 1998, Sheets-Johnstone 1999). Ekman and colleagues (1972) have devised a well referred to list of six basic emotions that in all cultures can be traced from people’s face; anger, disgust, sadness, happiness, fear and surprise, see figure 2.1.

![Figure 2.1 Facial expressions for the six basic and cross-cultural emotions of anger, fear, disgust, surprise, happiness, and sadness according to Ekman and colleagues (1972)](image-url)
While some physiologists argue emotional signs only can be found in the facial expression and movement behavior of other body parts only indicate the intensity of emotion, Wallbott for one reports on a post-hoc comparison of 224 video clips of actors expressing a set of given emotions where he has found results on that emotion-specific movements and posture characteristics do exists, see table 2.2.

<table>
<thead>
<tr>
<th>Emotion</th>
<th>Upper body</th>
<th>Shoulders</th>
<th>Head</th>
<th>Arms</th>
<th>Movement activity and quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>E</td>
<td>H</td>
<td>H</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cold anger</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot anger</td>
<td></td>
<td>Up</td>
<td>F</td>
<td></td>
<td>High and expansive</td>
</tr>
<tr>
<td>Elated joy</td>
<td></td>
<td>Up</td>
<td>B</td>
<td>F or U</td>
<td>High and expansive</td>
</tr>
<tr>
<td>Happiness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Disgust</td>
<td></td>
<td>B or F</td>
<td>D</td>
<td>Cr</td>
<td>Inexpansive</td>
</tr>
<tr>
<td>Contempt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>Sadness</td>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Despair</td>
<td></td>
<td>F</td>
<td></td>
<td></td>
<td>Expansive</td>
</tr>
<tr>
<td>Fear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terror</td>
<td></td>
<td>S</td>
<td></td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Shame</td>
<td>C</td>
<td>D</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>F</td>
</tr>
<tr>
<td>Pride</td>
<td></td>
<td>B</td>
<td>Cr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boredom</td>
<td>C</td>
<td>B</td>
<td></td>
<td></td>
<td>Low and inexpansive</td>
</tr>
</tbody>
</table>


To some extent people can choose what they physically communicate, although, some physical reactions, such as blushing cheeks or nervously shivering legs, are hard to hide. Also, a cheerful voice and large wavy gestures are often interpreted as signs of happiness, but it can be hard to know if the person truly is happy or if she uses these signs to cover her ‘real’ feelings. Some claim though that emotional experiences are impossible without the
corresponding physical state in terms of muscle tensions and body postures (Sheets-Johnstone 1999). Sheets-Johnstone points out how “there is a generative as well as expressive relationship between movement and emotion” (p. 262), which means that emotion processes also emanate from how we move and act. How we for example can set ourselves in a happy/happier state by jumping up and down or by starting to laugh.

Most of the above mentioned emotion models are more focused on some very specific stimuli for emotion processes to start, but for our work we have chosen to see emotion processes that in complex ways emanate from anything: a thought, how we move or act, what happens to us in the world, or the social setting of friends and people around us.

2.2 Design Models

For a long time the human body was simply considered from an ergonomic/functional perspective and emotions were as previously stated mostly regarded as in the way of our rational thinking, and in the way of how users in a rational way would use a computer system. Experiences of emotions and of using more of the human body than the brain and the hand were not much considered, if at all. As previously stated, the computer was just a stationary device sitting on some desk in an office, a machine to complete work tasks on. But with ubiquitous computing (Weiser 1991) and later tangible (Ishii and Ullmer 1997) and social computing (e.g. Kiesler, Siegel, and McGuire 1984) the computer was no longer bound to the office but entered the everyday world we live in -- a world full of emotion and emotional reasons for doing things, a world in which emotion cannot be avoided. (Dourish 2001)

Theories of emotions are however not easily applied to computer system design. They should be treated as an inspiration and not as directly implementable models. After all, to quote Davidson and colleagues (2003; p. xvi):

“Much of current research, while sometimes inspired by grand theories, or more often middle-range theories and models, focus on more limited, but more precisely defined, topics within affective science.”

Emotions are, as we have seen, complex matters—arguably, inseparable from our social and bodily selves, and the culture and the world we live in—still, there are a good many researchers in HCI who think that emotions can be modeled, solely, from discrete measurements (facial expressions, posture, biodata). These researchers (e.g. Picard and colleagues [Picard 1997]) in some sense seem to think there is some ground truth in captured biometric data, irrespective of such contingencies as personality, people’s previous experiences, the social context, etc. Such assumptions are troubling because they gloss over the sheer quantity of data that elseways would need to be
captured. In trying to answer the question whether or not emotions can be measured, Scherer writes:

“in an ideal world of science, we would need to measure (1) the continuous changes in appraisal processes at all levels of central nervous system processing (i.e. the results of all of the appraisal checks, including their neural substrata), (2) the response patterns generated in the neuroendocrine, autonomic, and somatic nervous systems, (3) the motivational changes produced by the appraisal results, in particular action tendencies (including the neural signatures in the respective motor command circuits), (4) the patterns of facial and vocal expression as well as body movements, and (5) the nature of the subjectively experienced feeling state that reflects all of these component changes. Needless to say, such comprehensive measurement of emotion has never been performed and is unlikely to become standard procedure in the near future” (Scherer 2005, p. 709)

Scherer though points at how there have been major advances in recent years with respect to measuring individual components such as appraisal, brain mechanisms, physiological response patterns and expressive behavior. This means that if we have a well known, limited and well-specified context, such as the cockpit of a plane, it might be possible to gather enough data to measure whether a pilot is extremely stressed. And it might even be possible to construct a system that can provide a relevant reaction to that stress.

Scherer and many with him seem to think though that emotion is, after all, something that can be reduced to a finite set of measurable phenomena: “if only we had the technology, we could measure emotion”. The mistake these researchers and scientists make is that they seem to think they can determine users’ experiences. It might be that we each show the same amount of stress if measured in terms of some bio data picked up from our bodies but what we experience could be totally different depending on social situation, personality, mood, previous experiences, time of the day and more – aspects that not only are related to what takes place in the individual body, in the present now, but are also related to social processes and the culture we live in (Sanches et al. 2010).

An alternative approach to designing for affect is the interactional approach proposed by the Affective Presence group comprised of Kristina Höök from Stockholm University, Geri Gay and Phoebe Sengers from Cornell University, Bill Gaver from Goldsmiths University of London, Michel Mateas from Georgia Technology Institute, and Ken Anderson from Intel’s People and Practices Group. There the aim is not to reduce affect to something that can be detected, captured and separated from the larger context in which it exists. An interactional view or approach sees emotion as constructed in interaction. In this case, an interactive system would support users in understanding, experiencing and expressing their own emotions to others. In other words, an interactional perspective on design does not aim to detect a singu-
lar account of a ‘right’ or ‘true’ emotion. Rather, it attempts to make emotional experiences available for reflection. It thus creates a representation that incorporates people’s everyday experiences that they can later reflect on. A user’s own, richer interpretation guarantees that it will be a more ‘true’ account of what they are experiencing. This side of the spectrum on emotion theory and design asserts then that no measurement of emotion can be taken and be ‘validly’ applied. Instead all that can be done is to feedback data to users so that they can produce their own meanings and attendant practices.

Our stance is, as implied, more towards the interactional approach, as we are convinced that aspects of facial expressions, biosensors signals, body posture, etc. can be used to provoke users’ interpretation – but does not determine their experience. We are also interested in designing for more of the experiences of communication and in how we can use an interactional approach to communicate and also in a way induce emotion processes in users.

To summarize, the characteristics of emotion we aim to represent with our idea of Affective Loop experiences are:

- Emotions as short, relatively intense experiences
- Emotions as subjective experiences
- Emotions as processes not states; processes that circulate in and affect our whole body and at the same time, inseparable from the culture and world we live in
- Emotions that in complex ways emanate from what both happens within ourselves and from what happens around us in the world
- Emotions as constructed in interaction
- Emotions where a basic more general pattern in terms of facial expressions, bio sensor signals, body posture, etc. do exist
- And last, emotions not as information packages, but emotions as interesting, fascinating, somewhat ambiguous experiences

2.3 Designs

Let us now turn to some of the designs that have served as inspirational sources to our work, and those that have, in turn, been inspired by our work.

We will start with the LEGA system that builds on the eMoto and FriendSense systems. After that we turn to a brief outline of a range of systems that have either been part of our inspiration for eMoto and FriendSense or systems that are based on the same design ideas as in our work.
Obviously, this will be a selection of systems, not all systems that have been produced. The aim is to present the reader with a general picture of what Affective Interaction systems there are but with a focus on the ones that have been most influential for our own work. The classification used is a simple presentational framework starting from our own work and then followed by the most influential research groups working on the topic of Affective Interaction and communication from an experience perspective. There are no commercial systems mentioned as there is very little written about such systems and it is in fact not the systems themselves but the experiences from working with these systems that will be important for the rest of the thesis. But there is no lack of commercial systems that involve users emotionally through physical interaction, more or less explicitly designed for that purpose, such as Dance Dance Revolution\(^2\), Guitar Hero\(^3\) and Nintendo Wii games\(^4\).

Instructions to the reader: this section will provide straightforward system descriptions without any deeper analysis of their role in the affective interactional field. Instead we will come back to such an analysis in later sections. If the reader feels she knows these systems she can continue to the next section.

### 2.3.1 Additional work on the Affective Loop

The eMoto and FriendSense systems have both been built within the INVOLVE research group, first situated at Stockholm University and later moved to Mobile Life and SICS. Apart from these two systems there have been a bunch of systems built on similar ideas to the idea of Affective Loop experiences in design. The LEGA system is the system that most straightforwardly builds on our experiences of the eMoto and FriendSense systems. Other systems that were built by our group during the same time period were the Affective Diary and Affective Health systems. They are mainly Ståhl and colleagues’ continued work after working with me on the eMoto system. I only took part in the very initial faces of the design process leading up to the Affective Diary system. But as these two systems have some interesting qualities that are relevant to this thesis, I will provide just a short introduction to them.

While eMoto, FriendSense and the LEGA system are communication systems, Affective Diary and Affective Health are personal systems, allowing users to explore their inner emotional and bodily experiences.

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\(^2\) [http://www.ddrgame.com/](http://www.ddrgame.com/)

\(^3\) [http://www.guitarhero.com/](http://www.guitarhero.com/)

\(^4\) [http://www.nintendo.com/wii](http://www.nintendo.com/wii)
*Affective Diary* is a digital diary, see figure 2.2a, that allows its users to scribble on top of and interact with a set of collected memorabilia from their everyday life. The memorabilia consists of both bodily memorabilia collected from biosensors and mobile media memorabilia collected from the user’s mobile phone, such as Bluetooth encounters and photos taken. Throughout the day the user will wear body sensors and use her mobile phone. Later, when she comes back home she can download this data to her digital diary and will see her body data as colorful, blobby, characters. These characters are placed along a timeline, to her mobile phone memorabilia. The mapping between biosensor data and the characters is based on Russell’s Circumplex Model of Affect, where arousal (as picked up by a GSR-sensor) is mapped to color and movement (as picked up by accelerometers) to the shape of the characters. Together the materials displayed is meant to spur users’ own interpretation and meaning making processes reflecting on their feelings and activities during the day. A month long study showed that users were indeed able to make sense of the data, and even, in some cases, started to reflect on and change behavior patterns in their life that they felt were detrimental to their way of living their life. (Ståhl et al. 2009)

![Figure 2.2 (a) Affective Diary (VINNOVANYTT 4-2006), (b) Affective Health (Photo: Elsa Vaara)](image)

The *Affective Health* system, see figure 2.2b, is similar to Affective Diary, but also provides real-time feedback on users mobile phones. It aims to provide users with a real time mirror of their bodily reactions to everyday short-term stress reactions. Their bodily reactions are picked up from sensors, measuring pulse (ECG), sweat (GSR) and movement (accelerometers). The aim is to enable users to make their own connections between their short-term stress reactions and their own subjective experiences of the activities in their daily lives – on the fly, in the moment. The system allows the user to see a combination of arousal, heart rate and movement in the moment but also allows users to scroll through their history and discover trends. (Ferreira et al. 2008, Sanches et al. 2010)
The LEGA system, see figure 2.3, is a system built for the Liljevalchs’ art exhibition in Stockholm, Sweden. It is a system for a group of friends that might not go through the art exhibition at all times together but every now and then leave each other and perhaps then find something they would like to show to or talk about with one of their friends. Instead of having to look for each other they can use their LEGAs to leave affective traces for each other to find. The traces are created by holding, pressing on and stroking the pressure-sensitive surface of the LEGA and then pressing a built-in button to leave the trace. The LEGAs are intended to be used by a whole group together (max 5), and only traces left within the group will be found by the members. The users know who within the group that left a specific trace (as these are coloured using LED-lights on top of the LEGAs). This way, users can interpret the traces they encounter at specific places by their knowledge of their friends. A trace is first felt as a vibration in the hand before being played out as it was recorded in terms of strokes, patting or touch patterns. (To be published by Laaksolathi and colleagues)

2.3.2 Affective Presence

Sengers, who is perhaps the most influential member of the Affective Presence group, leads a research group at Cornell University mainly focusing on presence and awareness of another user or group of users through digital media. The aim is to present data of some form pretty much as it is for users to make their own meaning and interpretations from. Sengers and colleagues aim to model data as little as possible.
A very early system from this group that later came to inspire our work on FriendSense, was the Miro system (Boehner et al. 2003, Boehner 2006). Miro was a public display installed in an office building aimed at providing the office workers with a sense of the emotional climate in the office, see figure 2.4a. Each worker could enter her emotions by the use of a set of emotion entry system distributed in the office. The collective emotional state in the office were then displayed on the public display by the use of movements and colored objects inspired by the abstract painting ‘Blue’ by painter Joan Miro. Boehner and colleagues, aimed at an ambiguous representation of the emotional state in the office rather than a representation where the emotions would be listed in a more codified manner, such as happy, sad and so forth. However, what happened was that Boehner and colleagues later found that users could not interpret their representation. But in spite of this, the office workers, very interestingly, spent a great deal of time in front of this display discussing what it meant, making their own wild interpretations of the office mood. Boehner and colleagues sometimes refer to this system as a failure, and in some sense it is, as the users never really understood the designers’ intentions with this system even though they found it fascinating in other ways.

Figure 2.4 (a) Miro (Boehner et al. 2005), (b) Affect or – a typical distortion (Boehner 2006)

Another, very early system in this direction is the Virtual Intimate Object (VIO), a small circle shaped object designed to appear in the Windows toolbar or in the Macintosh dock. It is a system for couples being in long distance relationships. Kaye, one of Sengers’ previous PhD students, who designed and implemented this system, intended the system to be a way of communicating intimacy. When clicking on this circle shaped object the user affects her partner’s VIO to turn bright red. This color then fades over time until it again reaches its initial blue state. (Kaye 2006, Kaye 2009)

A later system from this group is the Affect or system. This is a system designed for two users sitting in offices next to one-another, with only a wall between them. The system consists of two screens placed on each user’s side of the wall. There is a video camera attached to the screen in each room but the video is distorted by a rule set constantly changed by both users. The distortions are meant to give very little detail of facial expression or behav-

35
ior, but enough to see that someone is there, see figure 2.4b for a typical distortion. (Boehner 2006, Sengers, Boehner and Waren et al. 2005, Sengers et al. 2008)

The Affector system is designed for Sengers herself and her office neighbor Simeon Warner, who at the same time are the two designers of this system. This unusual set-up where the researcher is both designer and evaluator is Sengers’ attempt to work from an autobiographical approach to design (Sengers 2006). "Rather than designing for average or typical users, autobiographical design addresses one individual’s experience in the hopes that this may offer something of interest to other users." (p. 1). The autobiographical approach is controversial in HCI, given the tradition of objectively designing a system for someone else than yourself. Sengers however points out how the approach is one way to design for the personal and experiential qualities that are hard to reach using more conventional methods. She points out how the approach will not be applicable in all design contexts: “In designing a ubiquitous system to support bicycle messengers” (p. 2). Instead she provides the following list for when the approach is applicable (p. 3):

- There is a specific aspect of his or her own personal experience which the designer would like to offer to his or her target audience;
- there are reasons why the target audience may be interested in that piece of experience;
- and the designer has thought through carefully how his or her own experiences may be useful for or taken up by the target audience in ways that may be different than he or she would.

We will later in this thesis come to see how we have taken inspiration from this approach and also some of our argumentation for why we find subjective experiences of certain issues valuable in our own design explorations.

2.3.3 Ludic Engagement

Gaver and colleagues, who also belong to the Affective Presence group, have rather than focusing explicitly on emotion or affective interaction, focused on Ludic engagement and Ludic design (Gaver et al. 2004). Ludic design is presented as the combination of entertainment, art, communication, toys, information and tools, where ‘ludic’ refers to “playful, self-motivated exploration based on curiosity and whim” (Gaver 2009a, p. 3603). The concept spurs from the idea of Homo Ludens – humans defined as playful creatures: ‘the playing man’. Ludic design is an antidote to designs that makes “assumptions that technology should provide clear, efficient solutions to practical problems” (Gaver 2009b, p. 165).
The *drift table* is one of Gaver and colleagues’ examples of a ludic design (Gaver et al. 2004). It is an electronic coffee table that displays aerial photography, see figure 2.5a. By placing weight in the form of objects such as cups and books on the table the user will start to move in the landscape shown in this photography.

![Drift Table](image)

**Figure 2.5 (a) The drift table (Gaver et al. 2004), (b) The Home Health Horoscope (Gaver et al. 2007)**

The *Home Health Horoscope*, see figure 2.5b, is another of Gaver and colleagues’ designs, this time together with Sengers’ group (Gaver et al. 2007, Gaver et al. 2009a). The Home Health Horoscope is a set of distributed sensors in someone’s home, placed to detect ‘wellbeing’. ‘Wellbeing’ is loosely defined and refers to things such as ‘sociability’, ‘busyness’ or ‘disruption’ and is set individually to the specific household, where it could be things such as a specific door being closed when the grown-ups in that household want to be left alone. Every morning the household receives the system’s interpretation of the ‘wellbeing’ in the home in the form of a horoscope. Gaver and colleagues refer to this system being a failure in that it failed to engage its’ users, that the users did not reference it to other similar systems they knew of, that they did not accommodate it to their existing routines and patterns in the their household, and that the system did not continue to surprise them over time (Gaver et al. 2009a). Gaver and colleagues installed the system in two households, and to my mind it might be that they did not manage to find the right intriguing ‘sweet-spot’ for any of these two households. I think it is a very interesting system and would be interested in seeing Gaver and colleagues continue working on it.

### 2.3.4 Art and Dance

Both Sengers’ and Gaver’s research groups are working on very similar themes to ours’ and they also approach design in very similar ways. But when it comes to seeing emotions as subjective experiences and as constructed in interaction, there are other fields that have a longer tradition of work. Obviously, this has been one of the methods in art. While we will not
make any serious attempt to take on the whole art field, we want to mention two research groups within HCI that combine art, emotion and body movements in ways that we find inspirational to our work. These two research groups have used LMA (Laban Moement Analysis) in ways similar to us. These two research groups are Shiphorst’s research group at Simon Fraser University in Surrey, UK, and Camurri’s group at DIST University of Genova, Italy.

soft(n) is an interactive art installation that according to its creator, Shiphorst, explores the somaesthetics of tactile interaction, see figure 2.5. It is a set of eight to twelve soft networked objects built in conductive multi-touch fabrics that captures differences in touch. Similarly to us, Shiphorst uses a Laban notation scheme to couple the effort of touch to the vibration, the lighting and the sound of these objects. She says they express experiences of forgiveness, stubbornness, resistance and glee. A use example Shiphorst provides is the example of a couple of users throwing one of the objects up in the air, which triggers the accelerometers so that the object transmits the sounds of ‘weeeeee!’ (Shiphorst 2009)

The Bow is bent and drawn is an interactive dance and music performance set up by Camurri’s research group (Camurri et al. 2008). The system creates for a group experience for dancers using emotional motion cues to navigate, in real-time, a polyphonic music piece. The scene is divided into several areas where each area is associated with one voice in this polyphonic music piece. A single dancer can only dance in one of these areas at a time and can therefore only generate one voice at a time. Only together as a group can the dancers generate the full experience of this music piece. The expressive tone of each voice is given by the emotional expressivity of the movements of the dancer generating that voice. To generate a coherent and harmonious polyphonic music piece the dancers have to move with similar expressive intentions and in a collaborative way.
Camurri and colleagues have spent years on their gesture recognition platform, *EyesWeb* (2003), and later their *Mappe per Affetti Erranti system* (2008), translated as Maps for Wandering Affects. The Mappe per Affetti Erranti system is the system behind the bow is bent and drawn performance. Dancers’ movements are captured using video and in real time translated into emotion using LMA. The chosen emotion process is in turn setting the emotional tone of the corresponding voice for that dancer.

<table>
<thead>
<tr>
<th>Motion descriptor</th>
<th>Happy</th>
<th>Solemn</th>
<th>Intimate</th>
<th>Angry</th>
</tr>
</thead>
<tbody>
<tr>
<td>QoM</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>TQoM</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>IM</td>
<td>Medium</td>
<td>Low</td>
<td>Very low</td>
<td>Very high</td>
</tr>
<tr>
<td>VV</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>HV</td>
<td>High</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>BS</td>
<td>Not relevant</td>
<td>Not relevant</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>dCI</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td>Very high</td>
</tr>
<tr>
<td>SOA</td>
<td>Not relevant</td>
<td>Not relevant</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>DI</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>SA</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>PM</td>
<td>High</td>
<td>Very high</td>
<td>Low</td>
<td>Very low</td>
</tr>
<tr>
<td>SI</td>
<td>Medium</td>
<td>Medium</td>
<td>Not relevant</td>
<td>Low</td>
</tr>
</tbody>
</table>

Table 2.3 Expected levels of each motion descriptor for the four expressive intentions according to Camurri et al. 2008 (QoM = quantity of motion, TQoM = quantity of motion computed on translational movements only, IM = Impulsiveness, VV = vertical velocity, HV = horizontal velocity, BS = speed of barycenter, dCI = contraction index, SOA = space occupation area, DI = directness index, SA = space allure, PM = periodic movement, SI = symmetry index)

While we have used LMA beforehand to analyze the *shape* and *effort* of emotional body movements to find dimensions of movement that we can use in design to let users express themselves in their own ways, Camurri and colleagues have instead used LMA as part of their system design and made use of Laban’s definition of the *kinesphere* and the *general space*. The kinesphere is the ‘space bubble’ that we carry around ourselves and the general space is the space we move in (Davies 2001). Laban and colleagues refer to how some people use a lot of variations to the size of their kinesphere space, from a large space they almost cannot reach to a small space where they almost do not fit, while others use a more constantly sized kinesphere space. Laban and colleagues also state how it is this space that for example some
tall people that are embarrassed of their height should work on increasing and straighten up and instead be proud of their height. This while some small people should work on limiting in order to make better use of their body and to control their bodies better. In Camurri and colleagues work on EyesWeb (2003), and later their Mappe per Affetti Erranti system (2008), they use the amount of movement measured in the kinesphere space in relation to the amount of movement measured in the general space to calculate Quantity of Motion (QoM), movement in general, and Quantity of Motion computed on Translational movements only (TQoM), an estimation of how much the user is moving. In their system they then match these measurements to a specific set of emotions that they beforehand have specified characteristics for, see table 2.3. The EyesWeb and Mappe per Affetti Erranti systems are this way background systems used to translate movement into emotion and then used in systems such as Mappe per Affetti Erranti and the Ghost in the Cave system as described in the next subsection.

2.3.5 Games

An interactional approach on affect in design of computer systems is often used in game designs. Also there are today even more and more commercial games using full body movements in interaction (e.g. Nintendo Wii sports, Guitar Hero and DDR).

A few examples of games produced in academia of relevance here are BodyBug, Ghost in the Cave, Wriggle and EmRoll.

*BodyBug* is the result of Moen’s work on modern dance, kinaesthetics and design at the Royal Institute of Technology (KTH) in Stockholm, Sweden. Her work was a great inspiration source for our work on eMoto and she also gave a dance class in 2004 that helped us formulate a lot of our design thinking on movements in relation to users’ personality and individual usage of gestures and movements in communication. BodyBug is a small ‘robot’ moving on a wire that users strap on to their body (Moen 2007). BodyBug moves in response to users’ movements. It holds an accelerometer and uses accelerometer data to judge its wearer’s movement and then move up and down on the wire according to the time, space and force of the user’s movement. It can be seen as a game, a dance partner, or jewelry depending on how users appropriate it. (see figure 2.7a)

The *Ghost in the Cave* system is a system resulting from a collaboration between Camurri’s research group and Speech, Music and Hearing at KTH. This game was created at the same time as we were working on eMoto and came to be a great inspiration source for our FriendSense system. Ghost in the Cave is designed as a group experience using emotional body movements in interaction. Camurri and colleagues’ first movement and emotion platform, EyesWeb, is the system behind the Ghost in the Cave system.
In Ghost in the Cave, two teams compete against each other in having their avatar fish swim and navigate a sea world. At various places in this sea world there are caves where the avatar fish has to change mood to fit with the ghost that lives in that cave. To make this happen all team members together have to act out emotional acoustical and motion cues that fit with the emotion given by the ghost, see figure 2.7b. Acoustical and motion cues captured by a video camera and translated to an emotion using LMA and the EyesWeb system changes the mood of the avatar.

Figure 2.7 (a) BodyBug (Photo: Movinto Fun AB), (b) Ghost in the Cave (Rinman et al. 2003)

_Wriggle_ is a movement-based game designed by Isbister and colleagues at New York University’s Polytechnic Institute in Brooklyn, US. It is a game designed in parallel with our work on FriendSense and it is one of a set of games Isbister and colleagues have designed working on the notion of suppleness, an experiential quality that will be discussed more in section six. Wriggle is a game where the game controllers (Nintendo Wii controllers) are placed in knitted hats the players have to wear on their heads, see figure 2.8a. This opens up for full-body movement and also stops players from ‘cheating’ the game and perform small movements to set the accelerometers off when it really was large full body movements that was intended, a small but great design feature that really serves its purpose. In Wriggle the movements players have to do are designed to allow for a certain set of emotions although the game itself never explicitly talk of emotions. One example is how the user has to act out jittery, shaking movements to attract critters moving in similar ways, or slow moving critters by the use of slow, nodding movements. (Isbister et al. 2008, 2009)

_EmRoll_, see figure 2.8b, is a master thesis project supervised by Höök and is a game explicitly set up from our results on the Affective Loop. In EmRoll two players with their bodies together control the steering of their shared avatar in the game, one player being one leg and one arm of this avatar while the other player is the other arm and leg. In order to solve a set of riddles the
players also have to breath together and affect their GSR. There are three riddles in the game, one where the players have to make their avatar called Gamboo happy by acting out happy movements together, a second riddle where the players have to scare away spiders by being afraid as noted by their GSR or making their GSR rise by working up a sweat, and finally a third riddle where the players have to breath together to calm down and make their avatar who has fallen into water float up to the surface. (Zangouei et al. 2010)

![Image](image)

**Figure 2.8 (a) Wriggle (Photo: Jarmo Laaksolahti), (b) EmRoll (Zangouei et al. 2010)**

2.4 Evaluation Methods

When it comes to evaluation of emotionally engaging experiences, traditional HCI methods for evaluation are not aimed at capturing the richness of these experiences.

“In developing from emotion as objective, externally measurable unit to emotion as experience, evaluation, too, alters focus from externally tracking the circulation of emotional information to co-interpreting emotions as they are made in interaction.” (Boehner and DePaula et al. 2007, p. 275)

Boehner and colleagues (Boehner 2006, Boehner and DePaula et al. 2007) argue that in our efforts to analyze, understand and construct these experiences we are in fact making them less interesting. As Laaksolahti (2008) expresses it “we are demystifying what should not be demystified but should remain a piece of wonder and magic in people’s lives” (p. 89). But similar to Laaksolahti we argue it is possible to find a middle ground where we can and also to some extent should talk of aspects of these experiences without loosing focus on the unity and wholeness of the overall experience:

“Like a rope is spliced together from numerous smaller strands which we can discern and talk about without detracting from the ‘ropeness’ of the whole, an experience is built up from smaller strands that we can talk about without detracting from the whole—from the unity of experience. This does
For our work we also like to stress how these strands together can form something different and even something more but how we still find it necessary and giving to look at them separately before combining them and evaluating them from the perspective of the overall experience in the wild. We will later in this thesis see how we for eMoto used a two-tiered evaluation method (Höök 2004), where each part of an affective interaction system must be evaluated on its own before combined into an overall design and evaluated against its overall purpose and possible user experience. It might be that an idea of an affective interaction system is really good but unless the expressions used in each part of that system are understood by the end-user, the overall idea will fail anyway. After each part has been evaluated on its own there should be a final evaluation conducted in a natural setting and on ‘real’ usage – in the wild. Not much can be said about real usage of for example a mobile system if it is only evaluated in a lab environment.

But every user encounter during the design process does not need to or even should occur in ‘the wild’. The design and implementation of a system and its expressions are issues that have to be given time to develop and are still things we need to sit down and reflect on and work on in the lab. Computer systems are not built in a day and they are not smooth, complete, supple experiences from start. At the early stages in the design process we should perhaps also not have one set system but should still be elaborating with a range of possible solutions and set ups. This is an issue we did not work with as much in the design process leading up to eMoto but an issue that later became an important part of how the implementation process needs to take more inspiration from how more creatively schooled designers work with sketches and ideas that they compare and relate to each other in order to find what is the best solution. These first sets of evaluations should be thought of more as ‘sanity checks’ applied early in the design face before a system have been worked through to the extent that it even runs as a mobile system possible to move from the lab. To assume that we can build a complete system embodying the overall experience without talking about the various parts of interaction is a too simplistic view on what is required to create for these kinds of experiences.

Still, we do not want to claim that expressions evaluated in the lab will provide us with a complete answer to our design questions, not even necessarily always the right answers in terms of what real use and experience will be in everyday settings. To get at those answers, real life evaluations of the com-
plete experience in the wild are necessary. These first lab tests are there to provide us with an indication whether we are working in the right direction towards the intended experience. They also make us realize obvious mistakes or possibilities in our designs.

For these first ‘sanity checks’ in the lab even some of the traditional methods used to evaluate emotions as information unities as in affective computing can make sense. It might be, for example, in order to validate a set of expressions, to see that they are not totally random in their expressivity. One such method could, for example, be Scherer’s Geneva Emotion Wheel, see figure 2.9, an instrument to obtain self-report of felt emotions elicited by events or objects (Scherer 2005). Properly used, this method can help to verify that users interpret emotional expressions approximately the same. Scherer’s Geneva Emotion Wheel is a tool based on Russell’s Circumplex Model of Affect combined with two appraisal dimensions, valence and control, that Scherer argues are the appraisal dimensions that have the strongest impact on emotion differentiation. Similarly even physiological measurements can be used in combination with users’ self-report to ‘validate’ some aspect of a design.

Figure 2.9 The Geneva Emotion Wheel (Scherer 2005)
But for evaluation of the overall experience out in the wild we, as Boehner (2006), argue for methods aimed at evoking users’ rich accounts of self-report, and methods aimed at becoming part of usage and part of users’ real life practices.

2.4.1 Methods focusing on evoking users’ rich accounts of self-report

As we will see later in this thesis, when we evaluated the eMoto system, we brought in both a group of friends but also their partner or one of their good friends to act as spectator of what the users did with our system over the course of the user study. Gaver also suggest a similar technique of using spectators but where the spectators are people whose profession is to report and comment on what people do; journalists, filmmakers and alike (2007). Gaver talks about them as cultural commentators. But Gaver is careful in pointing out how the slight subjectivity, dramatization or extrapolation in these reports can be an advantage in the design process, but can not be treated as accounts of what really happened.

Another example of a method aimed at evoking users’ rich accounts of self-report is Kaye’s logbooks that he used when evaluating his VIO system (Kaye 2006). The VIO system (as discussed above) is a single red dot placed in the taskbar that are designed for pairs to show when they are thinking about each other. In combination with this system Kaye also handed out logbooks with a set of daily open-ended questions for the participants to answer. There were three kinds of open-ended questions: questions about the technology itself, questions about the relationship the technology was meant to affect, and questions about the survey itself. A typical question would be the question of ‘How is your relationship today?’.

A third example of a method with similar aims is also Höök and colleagues’ variation of the co-discovery technique. A method they used to evaluate the Influencing Machine (Höök and Sengers et al. 2003). By inviting pairs of users instead of single users to test the system Höök and colleagues opened up for a discussion about the system, a discussion they did not themselves participate in or design, but a discussion the users were the directors of and a discussion Höök and colleagues could listen in on. Höök and colleagues used this method in the lab but with very little means it should be a very usable method in the wild as well.

The Sensual Evaluation Instruments (Isbister et al. 2006) as used by Laakso- lahti (2008) is also in a sense a method focusing on rich accounts of self-report. The Sensual Evaluation Instruments is a set of eight sculpted objects that can be picked up and held in the hand during game play as a way for users to non-verbally express how they feel or mark out a situation, see figure 2.10. Laaksolathí used this method when evaluating his interactive story
telling games. After users had played the game Laaksolathi used video sequences to remind the users about certain situations where they had used the objects and could that way evoke for users’ rich accounts of self-report. With this method Isbister and colleagues aim to get away from having to disturb the experience for users by asking them in the moment for how they feel. But also, as users afterwards tend to answer for the whole experience and not the specific events separately the idea with the Sensual Evaluation Instruments is to help users to remember the ‘flood’ of emotions they went through throughout the whole game experience.

Figure 2.10 Sensual Evaluation Instruments (Isbister et al. 2006)

Also Bardzell and colleagues (2009) use rich accounts of self-report, but what they do in addition to that is that they express the relationship between these measures and other both objective and subjective data sources. They point out the central problem in every study of emotional interaction with cultural artifacts that “any given method commits to (or at least privileges) a particular position on the relationships among artifacts, emotions, the body, hermeneutics, and culture” (p. 3). One of the examples they make is how physiological measures privilege a stimuli-response model where it is very much assumed a user’s emotional reaction is stimulated by the artifact, and that the artifact is fixed and stable and understood in the same way by all users using it. Further on, they report on a study of their own where they used physiological measures, emotional self-report measures, and personally expressive techniques, such as open-ended prose reviews to evaluate study participants engagement in a set of video clips. By looking for instances where physiological, behavioral and subjective measures of users’ engagement and emotional response pointed in the same direction Bardzell and colleagues managed to find significant results on how ratings, heart rate, and emotional tagging positively correlate but how the open-ended prose reviews are needed to “help shed light onto what is going on behind those measures.” (p. 7). How it is that it cannot be assumed that it is the artifact as the designer intended it to be used/experienced that is what the user expresses
dislike or enjoyment for. One of Bardzell and colleagues users for example say: “I was bored with the film so I concentrated on how cute the puppy was no matter how pointless the film was.” (p. 7). Bardzell and colleagues also report on how users’ anticipation for something that then was not fulfilled by the actual event in some cases led users to express even more anger or dislike than they would have if they not had expected the film to be really good. All this complexity and reasons for contradictions or sometimes unexpected emotional reactions do not appear in any quantitative data. To understand more of what actually is going on and how an emotion appear, why it happen, why it changes and more of the full story behind emotions and the emotional experiences we as researchers need to ask users’ for their rich accounts of self-report.

But, at the same time “developing an account of felt experience with technology is difficult partly because the word ‘experience’ is simultaneously rich and elusive. It is also difficult because we can never step out of experience and look at it in a detached way” (McCarthy and Wright 2004, p. 15). Therefore, in order to understand users’ rich accounts of self-report, Wright and McCarthy argue that we as researchers will have to ‘live’ the experiences we design for also ourselves in order to develop an empathic understanding for the experiences users potentially will have with the systems we build (Wright and McCarthy 2008).

The rest of the sections in this thesis will describe how we in our design team have contributed to and been inspired by the academic landscape outlined above.
3 Designing and Evaluating eMoto

To further develop the idea of Affective Loop experiences in design and to investigate whether the Affective Loop description, outlined above, could indeed be used to generate (more than one) interesting application, we first approached this task following a traditional user-centric design approach (Norman and Draper 1986). At that time, in 2003 when we started our design journey towards how to design for Affective Loop experiences, Affective Computing as introduced by Picard and colleagues (Picard 1997) was the dominating approach to emotions in HCI. There were very few actual designs at that time though, and if there were, they were not based in user needs or in what users would like. Therefore we thought a user-centered design approach would lead us to better results. A typical user-centered design model is divided into four stages: study, design, build, and evaluate, that follow after each other in an iterative fashion.

As we did not aim (and also not see it as possible) to separate the mind from the rest of the body, nor to single out users’ individual experiences from the overall experience arising in a dialogue with a friend, from previous friendship, and deep physical and emotional communication with one another, we understood this design needed to approach the full richness and complexity of communication to reflect users’ everyday life and communication needs. Designed scenarios in the lab to get users emotionally involved would never be able to capture how interaction may unfold when the communication and experience is part of people’s everyday life. Therefore, what we needed was a fairly advanced ‘product’-like application that would allow users to pretend this could be a proper product on the market. An application properly implemented to such a level that users could bring it with them into their own life and an application that would survive for at least a few weeks of usage to give the system a slight chance of becoming part of the users everyday life and practices.

This section will describe the design process and evaluation of a prototype named eMoto, see figure 3.1. eMoto is a mobile service for sending and receiving emotionally expressive text messages. The user uses a set of expressive gestures to express the emotions she wants her message to communicate. The emotional characteristics of these gestures are expressed in colors shapes and animations shown to the user while performing her gestures. When the user is satisfied with the expression, she stops doing the gestures, and the colors, shapes and animations that appear in the interface at that
time, become part of her text message. She can then send the composed message to one of her friends.

![Figure 3.1 eMoto](image)

### 3.1 Coming up with the idea

Knowing that we were to design for a new kind of communicational service and that it would include emotional experiences we started as we were taught with sending a questionnaire to 80 potential users with questions about their personality, computer and mobile phone usage and how they today (in 2003) use emotions in digital communication. Later the results of this questionnaire helped us set up a Persona (Cooper 1999) to be used in the design process for eMoto. To come up with the idea of eMoto we also used Random Words and Six thinking hats (de Bono 1985), two well-established brainstorming methods. Using the Tiny fingers method (Rettig 1994) and paper prototyping we thoroughly worked out a user scenario and the interaction steps for using eMoto.

But eMoto at this stage was only that - an idea on how to interact when sending emotional messages. To complete this idea and to later implement it we had to find a computational model of emotional body movements, as this was a key aspect of the eMoto design, and a key aspect of the idea of Affective Loop experiences in design.

### 3.2 Finding a computational model of emotional body movements

One approach to a computational model of human body language is McNeil’s approach used primarily to implement Embodied Conversational Agents, ECAs (e.g. Cassell et al. 1994). McNeil has defined five categories
for human communicative arm gestures (McNeil as described by Chi et al. 2000):

- **Iconics** are used to represent some physicality of a subject, like its shape or size
- **Metaphorics** represent some abstract feature of a subject, like the fact that it is exchangeable or emerging
- **Deictics** indicate a point in space, the most common gesture for this is probably the gesture of pointing at something
- **Beats** are used to structure the conversation, like counting gestures or gestures for turn-taking
- **Emblems** are stereotypical gestures like the ok-sign or a thumb up

McNeil’s division does not describe how various gestures feel when performed and nor does it describe emotional gestures. According to Chi and colleagues (2000) this approach will render unnatural, robotic movements when implemented in ECAs.

For eMoto our aim was to look further than categories of the shapes and commonly agreed upon symbolic/communication focused interpretations of gestures, and instead aim to find some underlying experiential characteristics of emotional body language that we could use in eMoto to evoke emotion. What we wanted was an implementable model of emotional body language that would allow for user own personal expressions and ways of expressing themselves. Experiential characteristics also refers to how the gestures users would use to express themselves with in eMoto not necessarily needed to ‘express emotion’ but evoke the experience of emotion as the gestures were intended for the user herself and were not going to be communicated to other users in that form. As we turned to dance and choreography as a potential source of inspiration, we found the work by Laban relevant and interesting.

### 3.2.1 Laban Movement Analysis

Laban, a choreographer and movement analyzer, and his successors have identified five underlying dimensions of movement; Body, Space, Shape, Effort and Relationship (Laban and Lawrence 1974, Davis 2001). In our work we have focused on shape and effort, as these best describe the emotion expression contained in gestures. Shape describes the changing forms that the body makes in space, while effort involves the dynamic qualities of the movement and the inner attitude towards use of energy.

The Laban-notation is presented in more detail in paper A, but in short, shape is described in terms of movement in three different planes: the table
plane (horizontal), the door plane (vertical) and the wheel plane, which describes sagittal movements. Horizontal movement can be somewhere in-between spreading and enclosing, vertical movement are presented on a scale from rising to descending, and sagittal movement go between advancing and retiring. (see figure 3.2)

![Figure 3.2 Shape as described by Laban](image)

The second dimension in the Laban formalism is effort, comprised of four motions factors: space, weight, time and flow. Each factor is a continuum between two extremes; direct or flexible for space, light or strong for weight, quick or sustained for time and bound or fluent for flow. (see figure 3.3)

![Figure 3.3 (a) Effort as described by Laban, (b) an example effort graph of inserting a light bulb.](image)

To get an adequate sample data to work with we invited actor and body rhetoric expert Erik Mattson to teach us more about emotional expressivity and emotional body language. Mattson works with counseling and education in human rhetoric and has for example worked with a lot of Swedish politicians teaching them what they communicate through their body and their body movements and also how they can come to better use their body to get a specific message across. The intention behind inviting a professional on body movements also came from the need to learn more about the variations in emotional expressivity and how there might be a slight difference between
the inner sensation of body movements and how we use our bodies in communication. We asked Mattson to express nine different emotional processes in body language, while we videotaped him. The nine emotion processes were picked from the results of the questionnaire concerning which emotions people most wanted to be able to express in text messages (SMS): excitement, anger, surprise-afraid, sulkiness, surprise-interested, pride, satisfaction, sadness and being in love. Where being in love actually cannot be regarded an emotion according to the definition refereed to in section two, but is from that definition more something towards an interpersonal attitude rather than an emotion. Having pointed this out we will continue to refer to these nine emotion related states in terms of emotion processes.

Figure 3.4 Effort graphs for the nine emotion processes used in our LMA; excitement, anger, surprise-afraid, sulkiness, surprise-interested, pride, satisfaction, being in love, and sadness

All of the emotion processes the actor, Erik Mattsson, was asked to perform may of course give rise to a whole range of different body movements depending on the setting, the background and previous experience of the person, personality, culture and various other factors. On occasions, Mattsson discussed and portrayed this in our videotaping of him: “this is how Swedes acts out happiness [showing restrained body, but still expressive body language] while this is what someone from Italy would do [more open, spreading movements]”. His act is only one way that these emotion processes can be expressed. Even though Mattsson was asked to perform nine distinct (sort of) emotion processes, his way of acting out those emotions was more like a process working on the concept of each given emotion, going from starting the expression to feeling it more and more, expressing it stronger, and then varying it using alternative interpretations of when this emotion process would arise. This is a method called method acting (Cohen 2008) that in the art of acting is put in relation to more ‘presentational’ acting where the actor
works more towards imitations than feeling the emotion processes in herself as Mattsson here tried to do. This complied with our focus on body movements of the felt experience, rather than simply a communicative act showing the emotions. The LMA was performed on the whole sequence of expressions for each given emotion process, although summarized into one effort graph, see figure 3.4, and one description of shape for every emotional process, see table 3.1. (Turn to paper A for a more detailed description).

<table>
<thead>
<tr>
<th>Emotion process</th>
<th>Description using Laban terminology for describing the shape of movements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excitement</td>
<td>extremely spreading, rising and advancing movements</td>
</tr>
<tr>
<td>Anger</td>
<td>somewhat spreading, rising and advancing movements</td>
</tr>
<tr>
<td>Surprise-afraid</td>
<td>enclosing, somewhat descending and retiring movements</td>
</tr>
<tr>
<td>Sulkiness</td>
<td>enclosing, somewhat rising and retiring movements</td>
</tr>
<tr>
<td>Surpriseinterested</td>
<td>somewhat spreading, neutral in the vertical plane and advancing movements</td>
</tr>
<tr>
<td>Pride</td>
<td>somewhat spreading, rising and somewhat advancing movements</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>neutral in all planes of movements</td>
</tr>
<tr>
<td>Sadness</td>
<td>enclosing, descending and retiring movements</td>
</tr>
<tr>
<td>Being in love</td>
<td>somewhat spreading, somewhat rising and somewhat advancing movements</td>
</tr>
</tbody>
</table>

Table 3.1 Nine emotion processes described using Laban terminology for describing the shape of movements

Looking back at this exercise with the experience we have now, we can see that we should also have asked potential users for their interpretations of these emotion processes. Oftentimes, actors work with extremes and caricatures of expressions (e.g. Douglas-Cowie et al. 2002) and are focusing most prominently on communication of expressions and not so much how these emotions feel. But this issue is also not as easy as that as we also as non-actors in a way are taught to express emotions in order to make them understandable to others and that communication of emotions might also very well
be the emotions we feel. From a sociologist perspective there is no such thing as emotions we express and emotions we feel, they are all the same. Then there is of course also the difference between emotions expressed in the lab and emotions expressed in a real life situation. Still, the Laban exercise was about analyzing an interpretation of movement to get a first indication for what potential underlying more general dimensions of movement there are that we could use in design to allow for personality and individual expressivity. Later, as we implemented and tested our system, we refined our initial understanding substantially.

Secondly it is important to point out that LMA is not a method aimed at capturing the emotional (positive vs negative) value of body movements. Originally it was a method Laban used to make sure factory workers were assigned to the work task in the factory that best fitted their physical capabilities (Davies 2001). Laban’s work was here motivated by the factory owners desire to make as much profit as possible out of their workforce. In spite of Laban’s original intentions though, LMA is a method that lends itself very well to the purpose of capturing the emotional value of body movements and is also used by other researcher for this purpose (e.g. Camurri 2003, 2008, Shiphorst 2009).

But in contrast to for example Camurri and colleagues, we have been looking for underlying experiential characteristics of movement. Their focus lies in the communicative powers of professional dancers improvising movement in the moment. Our focus lies in how users experience a movement, no matter how it looks or what it communicates to others around them. For example, we tend to be more tensed when experiencing negative emotions, but exactly how that tension is formed depends on the contextual setting. In a bar quarrel, the tension can result in fist fights, while in a board room, clenched jaws and tensed biceps might be the only tensions we express. By addressing the underlying experiential dimensions or characteristics of different emotion processes, we hoped to be able to capture a bigger range of emotion expressions. Camurri and colleagues have instead worked with a limited set of emotions – partly due to their focus on quite different application domains.

3.3 The Affective Gestural Plane Model

In short, we found from our Laban analysis of emotional body language a differentiating pattern in the tension and movement dynamics between emotions of positive and negative valence and between emotions of different intensity/effort. As we did not want to resort to some simplistic one-emotion-one-gesture solution that would reduce emotions to separate entities mapped to symbolic gestures, we looked for an emotional model that also could allow for the subjective and personal characteristics of emotions. Di-
dimensional models of emotions focus on the experience of emotion processes, both on a low level (as in the limbic parts of the brain and in the body), but also on a higher, cognitive, level (Scherer, 2005). In Russell’s dimensional model, named the Circumplex Model of Affect, (1980) emotions are seen as combinations of arousal and valence (figure 3.5). Since a high degree of effort brings a high degree of arousal and vice versa Russell’s analysis of emotions concurs nicely with Laban’s theories of effort. Russell’s Circumplex Model of Affect in combination with the LMA together formed the uniting framework needed to combine the various parts of the eMoto system into one complete system, we called this the affective gestural plane model, see figure 3.6.

![Figure 3.5 Russell’s Circumplex Model of Affect](image)

We took this framework and decided to alter the design of the stylus that comes with Sony Ericsson’s P800 and P900 mobile phone series (the most modern phones at that time in 2003/2004, see figure 3.1 for an example) so that it could pick up on users’ gestures. We added an accelerometer and a pressure sensor to the stylus. The negative end of the valence-scale in Russell’s model became associated with more pressure on this extended stylus. The positive end of the scale is reached by less pressure. The high arousal end is reached by moving the stylus more and more, while the low arousal end of the scale is reached by less movement of the stylus. By combining pressure and movement the user moves around in the affective gestural plane model. This means that the design not become limited to a set of particular gestural shapes that has to be performed in an exact manner, but instead the design allows different users to make the gestures with different shapes depending on their willingness to exhibit big, visible gestures or just small, less visible ones. Both will be picked up by the stylus, and in both cases, direct
the user to sort of the same area in the affective gestural plane model. Pressure and movement manage to achieve this as both can be done as either large movements, involving the whole arm, shoulder and upper torso, or through similarly energetic but smaller movement, involving only the hand or arm from elbow and out. As we shall see later, this expressive leeway allows different users to express themselves in manners that fit with their individual preferences and personality.

![Figure 3.6 The affective gestural plane model](image)

The material surface of the extended stylus is soft, using a rubber material. This allows for what Moen describes as bilateral interaction, interaction where the tangible feel of the artifact both lets the user physically express herself with it but also returns haptic feedback to those expressions (Moen, 2006).

### 3.4 The Graphical Background Circle

To design for an Affective Loop experience helping us to mirror one modality in the other the affective gestural plane model was also the foundation for the graphical feedback given by the system when performing the above mentioned gestures. Colors are used to express arousal, where red represents emotions with high arousal and blue is calm and peaceful (Ståhl 2005, Ståhl et al. 2005). The shapes of the animated objects in the areas containing high arousal are small and can therefore render animations and patterns that are energetic, quick and spreading. Moving around the circle towards less energy and calmer expression, the shapes get bigger and more connected, rendering slower and more billowing animations. Shapes placed on the positive
side of the circle are softer and more round, while shapes placed on the negative side are more angular and sharp. The emotional expressions are stronger along the outer border of the circle while weaker towards the middle; this is represented through less depth in colors and fewer animated elements. (figure 3.7)

Interaction with eMoto proceeds as follows: first a user writes the text of her message, similar to writing a normal mobile text message (SMS). She then uses the stylus, pressing and moving it while watching the screen to see how the colors, shapes and animations change. Once she reaches a part of the circle that she finds suitable to her message, she clicks on the send button and the message is sent. The receiver will see both the text and the graphical background chosen.

![Figure 3.7 The eMoto graphical background circle (where the animation unfortunately cannot be seen)](image)

3.5 Evaluating eMoto

The evaluation process of eMoto follows Höök’s two-tiered evaluation method (Höök 2004), that is, each part of the affective interaction system is evaluated on its own before combined into an overall design and evaluated against its purpose. It might be that an idea of an affective interaction system is really good but unless the expressions used in each part of that system are understood by the end-user, the overall idea will fail anyway. After each part has been evaluated on its own there should be a final evaluation conducted in a natural setting with ‘real’ usage, as not much can be said about the overall
experience and real life emotional experiences if never combined and tested as a complete system outside the lab.

For the eMoto system we first did a user study of the colors, shapes and animations (Ståhl et al. 2005) before they were combined and, in a second study, evaluated together with the affective gestures (as described in paper C). The first user study of the affective graphical expressions was performed by subjects in pairs in front of a laptop in a lab environment. Six pairs took part in this user study. In short summary, the subjects chose expressions from approximately the same area of the background circle to express the same emotions. The results confirmed that our aim to let people express themselves differently was possible and viable – without becoming completely random and confusing.

The user study of the affective gestures was a qualitative study aiming for a first indication of whether users got emotionally involved in Affective Loop experiences. 18 subjects took part in this user study, which also was conducted in a lab environment, this time as individual sessions. The study indicates from an analysis of facial expressions and the users own reports that 12 out of 18 subjects got both physically and emotionally involved in the interaction. The combination of gesture, affective expression in color, shapes and animations, and the intended emotion overall seemed to be for the most part working, even if minor adjustments were needed. Subjects did for the most part the same kinds of gestures (according to our LMA) and they picked background expressions in approximately the same area to express the emotions. Important to remember here, was our aim to create ambiguous, open-ended expressions that allow different users to pick different expressions – something that we seemed to have succeeded in doing. This is not a task-based interface where the same task always should render the same output. The subjects were also able to interpret some faked messages from other hypothetical users and assign different emotional messages to the same textual message. The results of this user study are presented in further detail in paper C.

To enhance the experience, and also make the experience better for those six users who had not been as engaged in the interaction, we after this user study worked on the timing of the various emotion processes that had been expressed by the users. It turned out that it was not enough that we had faster moving animations for emotions with higher arousal but also we had to speed up the time it takes in eMoto to reach these expressions. Emotions such as sadness or being content and relaxed seemed to take more time for users to get into and therefore benefit from a slower moving interaction model.
3.4.1 In Situ Evaluation

For our final evaluation of the eMoto system we wanted a method were we could let users have the system for at least a few weeks and without us following them around. Also we wanted users’ own descriptions of their experiences with the system rather than descriptions following a set format designed by us (as in e.g. a questionnaire, cf. the discussion by Kaye on this topic [2006]). And last we wanted a method that would capture some of the subtle, almost unnoticeable expressions we all involuntarily perform. Expressions that strangers will not see or understand, but only those who know us well. This is why we used a combination of the Experience Clips method (Isomursu 2004) and the Technology (Hutchinson 2003) and Cultural probes (Gaver et al. 1999) methods.

In their Experience Clips method Isomursu and colleagues equipped pairs of users with two mobile phones: one running a location-based mobile phone application and one to be used for filming. In Isomursu and colleagues’ user study the participants took turns in being the user and the spectator, i.e. the one filming the other when using the application. They were basically told to film their partners when they used the application but also told to focus on feelings, emotions and subjective experiences, aspects that are very hard to capture using traditional methods.

The Cultural Probes method was first introduced by Gaver and colleagues. A typical set of probes as Gaver and colleagues introduced them consists of a nicely packaged set of materials including things like a diary, a disposable camera and postcards, together with a set of provocative tasks and questions to make receivers of these packages inspired to reflect over some aspect of their life. This was a way for Gaver and colleagues to get users to collect data on their own lives, data that both is the kind of data that is hard for us as researchers to get hold of but also the kind of data users do not usually reflect on even themselves.

The Technology Probes method is a variation of Gaver and colleagues’ method. It is a method where participants are given low-fi technology applications designed to collect information around use, to explore usability issues, and ultimately provide inspiration for a new design space. A Technology Probe is not intended to be the first iteration of a prototype but a way to track how users respond to and engage with it over time. The aim is not to explicitly evaluate the technical probe itself but to gather information and knowledge that can form the basis for a range of potential systems in that direction.

In a way the Technology Probe we wanted to evaluate was our eMoto system even though this system in a way was much more finished and polished than a probe should be. We wanted users to bring eMoto into their everyday life and use the system for a period of two weeks. Not only would it be hard
for us as researchers to follow our users around during this period of time but also the users would most likely not want us to. Therefore we asked each user to introduce us to a person who knew them well and who they thought they would spend a lot of time with during these two weeks. This person we asked to in a way act as data collector during the two weeks that the study lasted for. Similar to Isomursu and colleagues we refer to them as spectators. To help users and spectators to understand what it was we wanted them to document and to inspire them to do so we on top of the system itself and a film camera also gave them material inspired by Gaver and colleagues’ Cultural Probes (1999). Our packages to users included eMoto, a disposable camera, a diary, postcards and a set of daily tasks, see figure 3.8. The daily tasks were things like “today send an emoto that expresses happiness” or “today send an emoto that shows how you feel”. Spectators got a package including a video camera, a notebook, postcards and a few directions for what to do and look for, such as “This is how other people reacted to her using eMoto”, “Now I think she is sending a message of sadness”, and “Look here how engaged she was”. The reward to users was free phone costs during the two weeks and spectators got two movie tickets for their participation.

Figure 3.8 User and Spectator equipment for the In Situ evaluation of eMoto

The extensive usage of the Cultural Probes method has later come to be criticized for using the method not as the original probes were presented as a way to get hold of the specific and the unique but as a recipe or something reproducible (Boehner and Vertesi et al. 2007). As eMoto was a service we built in order to gain more knowledge on the idea of Affective Loop experiences in design, our use of the Cultural and Technical probe methods was here a way for us to evoke users’ rich accounts of self-report, not a way for us to get any specific, easily comparable answers.

In the next section we will see how some of the results of our two-tired evaluation of eMoto came to affect the next step in our design journey to-
wards trying to learn more about the idea of Affective Loop experiences and how to design for such experiences.
4 Learnings from eMoto

The results of the evaluation of eMoto are presented in more detail in paper D, but briefly, users used eMoto in much more complex ways than we had anticipated. Not only did they use the graphics to express their emotional processes, but also aspects of their personality, what time of the day it was when they composed the message, and more. Even though the system was designed for two users at a time, emotions expressed very rarely stayed in just that narrow channel between those two users but came to affect the whole group of five friends using the system. It even affected others outside that group of friends. eMoto became a channel for our five friends of ‘doing their friendship’: being responsive to one another, such as reminding each other of their shared past, just saying hello or planning for a shared future event, but also remembering to ask each other how events turned out that one of them had expressed being nervous about.

This section presents high-level reflections on the study results, not all reported in the paper; especially there were three learnings from our work on eMoto that came to have a significant effect on our continued work on the Affective Loop. First, as indicated above, we had to deal with the clash between eMoto as a tool for the single user and eMoto as a medium for the user in the world. Second, we came to see that design for movements require a different design process. Designing for experiences of movement spurring emotional processes, cannot be derived solely from theory. Instead, we need to involve ourselves to a much larger degree during the design process. We need to feel the interaction – ‘move to get moved’ (Hummels et al. 2007) – that is move physically in order to find what it really is we want to capture. Finally, it became obvious to us that in experiential movement-based interaction, that properties of the digital and physical material (HW and SW) used to build the system needs to be much more in focus during the design process. As HCI researchers, we need to take much more inspiration from how designers work in an explorative manner, experimenting with their material, getting to know it deeply, cultivating their understanding of the material properties.
4.1 From Tool to Medium

It is not like we had not anticipated that users would appropriate the eMoto system and use its functionality in their own personal ways. On the contrary, appropriation and an openness for personality in expressivity were issues we explicitly had designed for (Höök 2006). What we not had anticipated though, were the exact effects of users’ appropriation on the Affective Loop experience as we had set it up. Looking back at the definition of the Affective Loop, given in section one (repeating it here), this is still an issue:

An Affective Loop experience is an emerging, in the moment, emotional experience where the inner emotional experience, the situation at hand and the social and physical context act together, to create for one complete embodied experience. The loop perspective comes from how this experience takes place in communication and how there is a rhythmic pattern in communication where those involved express themselves but also ever so often stand back interpreting the moment - feeling it.

To allow for Affective Loop experiences with or through a computer system, the user need to be allowed to express herself in rich personal ways involving our many ways of expressing and sensing emotions – muscles tensions, facial expressions and more. For the user to become further engaged in interaction, the computer system needs the capability to return relevant, either diminishing, enforcing or disruptive feedback to those emotions expressed by the user so that the she wants to continue express herself by either strengthen, changing or keeping her expression.

One of the driving forces behind this thesis lies in how we in our research group recognize communication as being so much more than just an information transfer, which is essentially the basic model of communication designed for today in HCI. With the idea of the Affective Loops we have wanted to direct more focus on the personal experience of communication. What we have not managed to do, is to combine the personal Affective Loop experience with the group experience in such a way that these experiences build up on each other rather than competing for users’ attention.

4.1.1 The Communicational Part of the Affective Loop

What we wanted was an interaction model where the expressions, both gestures and graphical expressions, could take on many meanings. We wanted users to feel they could use the expressions to express themselves and their identity in their own personal way. We worked hard on finding the right level of ambiguity of expressions but not leaving them too open to individual interpretation, leaving them obscure.

We also did not want to limit users to a small set of emotion expressions to play with. Instead we looked for a way to allow for a rich palette of emotions to be expressed, even some of the ones we could not foresee. Starting our work on eMoto in 2003 there were a number of services focusing on ‘mini-
mal’ emotional communication like showing presence or concern (e.g. Strong and Gaver 1996). There is a danger in these kinds of services in that they might create a need that was not there from start, in that they assume lovers or friends always are at terms with each other; all they want, is to communicate that they are thinking of each other and that they are always nice to one-another. What if a user never sees her VIO becoming bright red? Is her partner not thinking of her then or has she missed when it happened?

Furthermore, we did not want to implement a preference for some emotions. We did not want to give the message that some emotions are more suitable to express in a mobile phone media than others. With eMoto we wanted users to express rage, depression or sadness if that was what they wanted. It is interesting to see that some emotions tend to be more ‘allowed’ than others. This of course varies with the culture we live in and what situation we are in and who we are there with.

Also in communication it is not necessarily the case that what we want to communicate is how we feel in the present now, which would be the emotions that would be measured if it now were so that we could measure someone’s emotions. We might want to communicate someone else’s emotions or communicate something about the past or make plans about the future.

Further, we did not want to override basic communicational patterns like being able to exaggerate, lie or hide emotions from one another in communication. Aoki and Woodruff describe it as how we need to allow users to ‘save face’ (2005). How we sometimes even have to add limitations to the services we build when the digital material allows for more possibilities or more data storage than users want or can handle.

### 4.1.2 A Combined Experience

We also had another aim with eMoto -- to recycle some of the experience of what she is communicating back to herself. To let the user also reflect on, experience and in a way re-live the emotions she aims to communicate.

What happened though was that our two aims, an openness for expressivity and a personal experience, occasionally came in the way of each other. They blocked each other instead of building for a rich, complete, embodied experience of communication in the world.

The clash between the communication experience and the personal experience was not always an issue; whenever it was one specific emotion the user wanted to communicate, eMoto worked exactly as we had intended, allowing the user to act out and feel the emotion she wanted to express:

"When she was happy she showed that with her whole body, not just her arm was shaking but her whole body while a huge smile appeared on her lip."

(The spectator of Agnes, as referred to in the paper)
Also, there are examples of where the situation or the rest of the world did not come in the way but in fact helped and increased the individual sensation of creating an expression. An example of this is when Isabella was creating her message in harmony with the music that was playing in the room, and how Isabella in fact was dancing her message in harmony with the music, see figure 4.1. There were also situations were the whole group together brought eMoto with them to a party or a bar and where even the problematic shape and size of the extended stylus became a cool feature making the group feel special and tighter as a group (although some of this also is the case with all new technologies):

“Then I was quite smart when I at ‘Natinspuben’ changed battery on Mona’s eMoto. Then we felt as we were cool and special in front of the others” (Agnes)

“eMoto is sooooooooo cool when you show it to others” (Mona as referred to in the paper)

“Yesterday I got a few comments on the stylus looking like a dildo, which might have been due to the merry atmosphere” (Agnes describing a party she had been to)

Figure 4.1 Snap shots from one of Isabella’s experience clips

But, as mentioned above, users did not only use eMoto to express emotional processes nor did they always simply express one emotion at a time. As summarized above, users for example used eMoto to express personality:

“Green is my favorite color and my boyfriend knows that, so this is why it is green because he knows that I think that green is a lovely color, just as lovely as he is.” (Mona, see figure 4.2a)

They also used eMoto to express complex emotions and time of the day (and in this example also in combination with an excuse):

“Like this kind of ‘sorry that I nicked her’ and then we were probably about to go to bed right just about then as well, so to have like that somewhat half good night.” (Louise as referred to in the paper, see figure 4.2b)

We had to some extent through our open ‘surface’ design expected to see users appropriating the system and were pleased to see that they could use it in their own ways and for their own needs. But as this forced users to per-
form gestures that were actually designed to spur another kind of emotion process than the one they were trying to communicate, or even using emotional gestures in combination with something they themselves did not connect to any emotion whatsoever, became a problem for the Affective Loop experience – at least in the way we had set it up. What we need is to find a better way to combine these experiences, combine the personal experience with the group experience, and with the physical and social context.

Figure 4.2 (a) Mona’s emoto to her boyfriend where the graphics are used to express her personality and how she loves the color green, (b) Louise’s emoto to Susie where graphics are used to express time of the day

We found that as users felt more at home and comfortable with the communicational part of eMoto. The gestures, to some extent, became an unnecessarily complicated navigational tool for the purpose of finding the right expression to use. This could probably have been solved in a rather easy way. If the expressions had emerged more like colors/patterns do in a kaleidoscope, the users would probably not to the same extent have connected the gestures with a transportational movement in a graphical space. Obviously, we cannot know, without testing it, whether this would have led to the complete embodied experience that we are looking for.

It is probably the case that the Affective Loop experience mainly concerns the shorter more intense experience, but we need to find a way to not separate this experience from (in this case) its communicational context, but instead find a way to make the communicational part of it assist in creating the Affective Loop experience, make it richer, more intense.

4.1.3 Not an Isolated Channel

What we also found fascinating in our evaluation was how even though eMoto was designed for two exclusive users at a time the emotions that were
expressed very rarely, if ever, stayed in that isolated two-friends-channel. The emotions being expressed also affected the messages those two users sent to their other friends, which in turn also came to have an effect on the emotional flooding of emotions floating within the whole group of friends. Also what was being expressed between two friends very often involved other mutual friends and their whereabouts, concerns and emotional status. Our fascination with these matters (regarding research on friends, friendship and groups of friends) might seem slightly naive if you are from other sciences such as sociology and physiology. But in designing a digital medium for communication between friends we recognize that there is no easy mapping between theory and practice. Thus we see theory as a means of informing our perspectives, shaping how we see, but not dictating dogmatically what it is we build. A digital medium might also put the spotlight on some aspects of their friendship and cause different kinds of reflections, not only of the medium itself, but also of the participants’ personalities and how their friendship is functioning, their personal way of expressing themselves, what they want to reveal and what not. Furthermore, in HCI there is actually not much research on emotional expressivity within groups of friends. There is a whole lot on designing for supporting awareness of remote presence or activity in the workplace (eg. IJsselsteijn et al. 2003) and in the home (eg. Sellen et al. 2006). There are also several systems that are designed for romantic couples (eg. Goodman and Misilim 2003), individual reflections on your own physical, emotional status (e.g. Ferreira et al. 2008), and enhanced emotional expressivity in person-to-person communication (eg. Sengers et al. 2008). But there has been little focus on kinaesthetic expressions of emotion and closeness in communication within groups of friends.

Because of these learnings, we decided to set FriendSense up as a system for a group of users/friends, in order to further explore how emotion processes emerge, develop and changes between friends over time in the world. FriendSense was for this though only the means, not the end.

4.2 Move to get Moved

A second major issue that we learnt from the eMoto project and that came to have an effect on our work, and how we chose to set up the FriendSense system, was how we cannot merely think and plan for movement. As designers (or researchers) we must move ourselves in order to find what it is that we really want to (and can) design for.

“if one truly likes to design for movement-based interaction, one has to be or become an expert in movement, not just theoretically, by imagination or on paper, but by doing and experiencing while designing” (Hummels et al. 2007, p. 677)
Hummels and colleagues write in their paper *Move to get Moved* that we need to find “methods, tools and knowledge to design for expressive and rich movement-based interaction” (p. 677). One such method they suggest is the design movement approach, where “the product itself comes into existence in the choreography of interaction” (p. 682). The example of this method in use that Hummels and colleagues provide though, where the designer is dancing to know the shape of a vase, does not fully capture the essence of the process we came to confront. The point is not so much about moving and experiencing in order to free the mind -- to come up with new ideas for design. It is more about moving and experiencing in order to find movements and experiences of movement to design for.

Also, Höök describe how there are ‘bodily ways of knowing’ (Höök 2010). How there are aspects of movement we cannot really understand if we have not felt them ourselves.

4.2.1 Me developing my bodily ways of knowing

While LMA in different ways can help us analyze the emotional value of movement and also help us divide movement into parts that we can make a computer understand, see paper F, there are other aspects of using body movements in design that we cannot capture using LMA or other frameworks on movement. Issues regarding personality and movement and the personal feel of movements are issues that are very hard to work with and consider in design. The issues are very difficult to understand if one does not have some personal experience of these issues and also has not explicitly thought about them in relation to movement. Since we also talked of an inner experience of emotions in relation to what is communicated I, after some time working on eMoto, felt I had to take a step back and consider these issues more carefully.

During Spring 2004, I therefore attended a dance course called Physical Expressivity then given by Moen as part of her PhD studies in HCI at the Interactive Institute and KTH (Moen 2006). Moen had both an undergraduate education in engineering and is professionally trained in modern dance. The dance class was part of Moen’s empirical design work for the BodyBug system (see section two). The course was given as thirteen evening classes and was offered to engineering, Master’s and doctoral students specializing in HCI but with no previous experience of modern dance. Moen wanted to see if people with a basic knowledge of interaction design but inexperienced in dance could be taught a basic framework of movement used in modern dance and then by the end of the course be able to transfer some of that knowledge into design. Moen’s work is very interesting in itself and is referred to a number of times throughout this thesis but here I would like to summarize some of my own personal experiences from taking this dance
course. I will focus on those experience that, in turn, led to some of my design concerns related to personality, movement and design.

The perhaps strongest memory from taking this course was when we were told to ‘dance each other’s spaces’. This entailed pairing up and then moving to where our partner was not moving but still move in relation to each other, see figure 4.3a. I was paired up with one of my master students at that time who also was taking this course. Our work relationship and also the fact that we were one man and one woman came to affect my experience of this exercise immensely. Normally, I am a rather extrovert person and also a person that has no real problems with allowing people to laugh at my expense but this exercise, in combination with the hierarchal relationship we were supposed to have, made this a very uncomfortable and awkward situation. I think that if we had been strangers who simply were taking this course together I would not have had the same problems with this exercise -- the physicality and intimacy and how that was a slightly odd exercise was no problem to me (in that case the whole course would have been problematic). What happened was that even though I continued the exercise I felt as if I was somewhere else in my inner experience. It was as if I did the movements but I had distanced myself from getting emerged in the activity. This exercise taught me how embarrassing and intimate it can be to move physically to express yourself, and how easy it is to overstep someone’s boundaries in what they want to and are able to perform without closing off. As movement in interaction is still rare, compared to the mouse and keyboard interaction, we have not yet properly explored where the boundaries are – and if some of them will disappear when we get more used to moving in interaction with technology. If users are pushed too far either in terms of movements they have to do, or in what context they have to do certain movements, I believe, and we also have seen this from our results on eMoto, that users will ‘shrink away’ from the experience and we will have a much harder time to get them to engage in the experience again. This is a very important point from the perspective that Affective Loop experiences require an active user who wants to be emerged and emotionally engaged in the experience.

At the same time we need a gestural framework that directs the user, pushes her slightly, into experiences she otherwise perhaps would not have exposed herself to and therefore would not have experienced. This insight I came to partly from another exercise in the dance course. At the end of the course we were given the task of creating and performing our own solo piece. We were given a theme ‘contemporary phenomena in society’ and were told to relate this theme to our own experiences and our own everyday lives. I chose to work with demands, others were working with pain, multi-cultural abuse, the election and making a difference, just to mention a few of the other themes. For most of us it seemed (Moen 2006) this was a much harder exercise than any of the other exercises we had been given in that we were not told what to do. Even though most of the other exercises did not involve any choreo-
graphed movements they at least had a framing for us to ‘blame’ when we felt embarrassed or unused to the situation. But this solo piece was going to expose me and my own personal feelings. What happened to me in performing this exercise was that I could no longer simply feel a sensation and move according to that feeling, instead it became a set of steps that I just slavishly moved according to (see figure 4.3b), as it was I who had set them up and therefore was responsible for how they looked/how good they were. This can be compared to the exercises where I was told what to do where I could leave some of the responsibility for my actions behind and simply engage in the experience. In analyzing the effects of systems such as the Ghost in the Cave system, presented in section two, where it is a whole group of users moving together, I think if users are given some kind of framework to ‘blame’ we can slightly push users out of their own comfort zone to allow for new and perhaps richer and different experiences from what they normally set themselves up for. The blame can be how the movements are choreographed by someone else, or it can be the effect of being in a group – whatever it takes to feel less embarrassed.

Figure 4.3 (a) Dancing each other’s spaces, (b) The solo piece (Photo: Jin Moen)

But how do we find the right match between gestures and situation where users feel comfortable in engaging in slightly odd movements? How can we bring users into an arena of new, richer or (simply) different experiences? If we take it too far, it might be that users feel even less willing to express themselves even in comparison to what they ‘normally’ feel is ok, or how they under ‘normal’ circumstances express themselves. Also, the interaction model we set need to allow for more than one user to find this fine-tuned match between gestures and situation.

For Camurri and colleagues, as they work with dancers, it is probably reasonable and doable for their users to be involved in an interaction model that requires them to explore movements more freely in space. Dancers are more trained to express themselves through their bodies – and seek dancing in the
first place. But for eMoto and FriendSense we were designing for anyone, not necessarily someone as comfortable to express themselves through movement and explore movement as Camurri and colleagues’ dancers. And also the eMoto system was a system where the users had to do this expressing and exploring of movement out in public.

Sometimes during this dance course I did, despite the fact that I am not a dancer, actually came to feel a sensation of balance, harmony and fluency in moving. When the music felt in harmony with the movements we were asked to do or with the movements I chose to do and when I was capable of just ‘being there’ it actually felt quite expressive. How it then looked is not important here, what is important is that it felt expressive. This sometimes also happened when we danced without music but music definitely helped and added to the experience – but only if I could fully absorb the movement. I came to see that this happened when I had no problems performing the movements, as soon as I stopped to remind myself what movements to do next, the sensation was gone. When I could feel a fluency in the movements or when I felt they communicated something to me they became easier to remember and I could stop thinking about them and concentrate more on the feeling of doing them. This experience later helped me to better understand how the Affective Loop experience requires a ‘supple’ experience in interaction, more about suppleness as an experiential quality (Isbister and Höök 2009) required of Affective Loop Experiences in section six.

What I want to say with this rather personal experience of movement is how it made me more aware of the relationship between personality and movement (how we experience movement while in the world); and how we when becoming users of something are much more sensitive towards doing things ‘outside the box’ at least when it comes to using more of our bodies in interaction compared to more familiar interaction using the keyboard and mouse. I came to realize how we can design for richer, other or even disruptive and unusual experiences if we frame the artifacts we build as directions for sequences of movement actions that users can blame. In that sense it is not necessarily a bad thing that the eMoto pen was a rather prominent artifact, but this we will come back to in the next sub-section.

In summary, as researchers and designers of movement interactions, we need to experience movement ourselves in order to understand how we can design for movement and bodily experiences, but also in order to understand the experiences themselves and what it is in those experiences we actually aim to design for, we need to develop our bodily ways of knowing and understanding. This in order to become able to design for movement, but also in order to understand the experiences we design for and the potential experiences of our users, more on this in the next section.
4.3 A Designerly Mindset on HCI System Design

In the final, in situ, evaluation of eMoto the effects of how well (or bad) we had exploited and made use of the properties and limitations of the digital material, both hardware and software, in the formation of the system became apparent. There were a few areas where we had actually not at all considered the properties of our design material. Looking back at the design process of eMoto I can now see, what I could or even should have done differently given that my role was that of the engineer/HCI researcher in the team. Our designer, Anna Ståhl, and I should have spent more time together on becoming familiar with our design material and subsequently better able to together design for successful Affective Loop experiences. Looking back at the design process I now realize how good Ståhl was at communicating her design thinking and make me and others understand her line of thought. This was done through storyboards, inspirational pictures and design sketches (e.g. Buxton 2007). Ståhl very often presented us with a range of ideas for us to discuss together in the team. I now see how I as an engineer am taught to find the one solution I, in this case by myself, find best -- from what I think is the problem at hand. In comparing this to how designers are taught to come up with a range of possible design ideas for us in the design team to discuss, the engineering work style is a more linear process, looking for one solution to a given problem. A designer will treat the work more as an ongoing process where the problem and the solution are worked out together. What I came to understand from the results of the final evaluation of eMoto was how much the digital material and the design solutions I and other developers choose matter for the end result, for the user experience, and in this case for the Affective Loop Experience. If I had better explored and then communicated the properties of the digital material, both potentials and limitations, opening the design space from the digital material-perspective, we would have arrived at better design ideas, better fitted to what was possible to create.

Understanding the relevance of working closely with materials is nothing new in the field of design but somewhat overlooked in HCI. In HCI we underestimate the importance of exploring the digital material from an engineering point of view.

"there seems to be a misperception in our educational programs and research lab configurations/hiring philosophies that one can move as a researcher seamlessly between, for example, mobile application design and immersive 3D worlds or sensor-based interaction in games" (Isbister and Höök 2009, p. 2240)

Whether this underestimation of material in HCI has to do with the complexity of the digital material in how it unfolds over time and space (Hallnäs and Redström 2006) which makes it hard to show its properties, or whether it is because we have been taught the digital material is a very plastic material in
which we can build anything we like (Löwgren and Stolterman 2004) and therefore a material we do not have to consider in the formation of new ideas, is unclear. In some cases we work so long on the more conceptual parts of a design idea before we consider the material, we end up fighting our material to fit with the conceptual idea instead of working with it, allowing its properties to guide our design. In any case we need to devise ways of bringing the material into the thinking earlier in the design process and make it a shared resource for the whole design team.

I will in this sub-section present my own personal story for how I came to see the need to better cater for the material properties in the design process. Please note that my broad claim above is outside what I am able to validate through the empirical work presented in this thesis. Instead, I will present my own personal story and how I, so far, only have empirical support to claim that in designing for affective loop experiences, the digital material properties will be key. Nevertheless my ideas perhaps could be extended and applied to HCI design in general.

In retrospect, many of the problems that will be referred to now stand out as obvious problems when reading and writing about them afterwards. Problems that could be solved, but at the price of a lot of money and time, sometimes totally reworking or changing the material, e.g. going from Bluetooth communication to proprietary network protocols. My point though, is that it would be better to be able to experiment with the feel of the material much earlier in the design process, which would lead to:

1. Better designs – perhaps only slightly different, or perhaps even surprisingly good innovative designs
2. Saved money and time

4.3.1 A Material Analysis of eMoto

Even today when starting up the now 'aged' eMoto prototype it is striking how great this idea really was and also is. When eMoto works as it should, it works great! And when it fails, it is not a matter of the prototype being badly implemented and not working every now and then, it is more a matter of various parts of the interaction working better than others. When the stylus is connected with the system and the user performs her gestures and the background circle is moving according to those gestures the system really allows for engaging Affective Loop experiences.

The underlying framework that both the graphics and the gestures are based on allow for a coherency between the two media, see figure 4.4. Having the same combination of Russell’s Circumplex Model of Affect and the dimensions of effort and valence to relate to when working out the gestures and the graphics helped to create a more tight interaction model, allowing for the
sensation of it being one complete system, which in turn allowed for a more intense experience.

![Figure 4.4 The eMoto gestural plane model](image)

4.3.1.1 Where the material mattered: unreachable corners

To use the actual circular shape of Russell’s Circumplex Model of Affect in combination with the two variables pressure and movement for moving around in this circular shape was not as good of an idea. Having two variables of something -- the most likely and most wanted -- for combinations will probably land at the four extreme states of those two variables: both maximized; one maximized while the other is minimized and the inverse; and last both minimized. However, a circular shape (the circumplex model) used together with two variables to move around in this circle and where origo of that circle is the medium state of both those variables means that the user never can get to any of these extreme states, see figure 4.4. What will happen is that the user will get stuck at the edge of the circle and then stay there, probably thinking there is something wrong with the system, while continuing to try to maximize or minimize pressure and movement. There is nothing that tells the user when to stop (and probably should not be either), nothing more than that the system stops moving through the graphics. If the user realizes that she is navigating a circle she might realize that she will have to release or increase one of the variables in order to continue moving along the edge of the circle, but she still will never get to any of the extreme states.

A solution to this could have been (as previously mentioned) to instead have expressions taking form in a way similar to how expressions are formed in a kaleidoscope. We actually were referring to kaleidoscopes during the design.
process leading up to eMoto, but just from the perspective of how we wanted the expressions to look and take form, not from the perspective of how the user could navigate in the expression space.

4.3.1.2 Where the material mattered: size and shape of the extended stylus

But the most obvious problematic part of the eMoto design was the size and shape of the extended stylus. eMoto was implemented on Sony Ericsson’s P800 and P900 mobile phone series using the two-hand interaction model with the little toothpick stylus and we wanted to reshape this stylus and make it an embedded device equipped with sensors. An ergonomic shape that would fit in the hand was created, see figure 4.5; and also a hardware design communicating via Bluetooth and having sensors for pressure and movement. It turned out that the hardware needed more space inside the stylus for the battery and other components than we had expected and we then made the huge mistake in continuing with the revised shape. The ergonomic and slick shape we had originally seen and thought of as the size of a toothpick enlarged to a size of approximately 15 centimeters and came to resemble a dildo -- something our users also noted and a fact that they said affected their usage of eMoto in public.

![Figure 4.5 The suggested ergonomic shape that would fit in the hand](image)

In hindsight, we know we should have started by finding out what components we would need to use as well as their sizes and how they would need to be placed in relation to each other. With that knowledge we could perhaps have found a way to re-arrange the placement of these components in the mobile phone and elsewhere such that we could have implemented our design idea or at least an alternate stylus shaped more like a handle enclosing the hand. Anything but making our users carry an embarrassing ‘dildo’-like device in their handbag.
4.3.1.3 Where the material mattered: choosing Bluetooth
The second issue regarding this extended stylus that did not work as intended, was the Bluetooth connection between our eMoto-stylus and the mobile phone. In retrospect we can see how we picked the Bluetooth technique simply because of its broadly accepted status as the standard for wireless, short-range data communication. We regarded it pretty much as a closed system or black box with numerous properties taken for granted. We never investigated this technology any further. We should have tried to get more familiar with it as would have been the case in most other, perhaps more traditional, design situations, such as exploring plastic as the design material before designing a new kitchen bowl. It was only when eMoto finally was an up and running system that we saw the effects of choosing Bluetooth. It was then we learnt about Bluetooth technology’s idiosyncrasy: it follows a so-called *handshaking* process. It searches and handshakes with every device in its perimeter until it finds the correct device. Only if we were lucky, would the extended stylus be the first encountered device – if not, the user experienced an unwelcome delay/response time waiting for Bluetooth to find it. The repercussions of this delay showed up in our design. We found that the activity of a user having to first write the text of her message actually in some ways allowed the user to start thinking in terms of the emotion she aimed to communicate. A small but nevertheless important initiating step in allowing for a more intense experience later in the interaction when adding emotional value to that text message by interacting using the gestures and the emotional background circle. Now as it happened the delay in time due to the Bluetooth technology took place right in between these two events (first writing, then adding emotional value), which meant the user lost out on that first potential feeling of an emotion process starting, and instead of having an ‘emotionally prepared’ user we had an ‘emotionally annoyed’ user.

If we had known that Bluetooth performs a scan for devices and the exact procedure for how it sets up communication between two devices, we could have made our software start this connection process much earlier than it did. This would also have solved our next problem.

4.3.1.4 Where the material mattered: battery consumption
What we did know about Bluetooth technology, and what we did consider in our design, was that Bluetooth consumes a lot of battery. To do something about this we decided that the stylus should only be turned on when actually in use, when conducting the gestures with it. But to allow for an embodied sensation using the stylus we decided that this activation and deactivation of the stylus should not be achieved by some on/off button or anything else that would take the user’s attention away from the experience of the interaction. From a technical perspective we found a very clever solution to this where a small amount of pressure would activate the stylus and that the stylus would turn itself off after some time if not being active in terms of pressure. Unfor-
Fortunately, we found later when using the complete system that performing the initial pressure of the stylus disturbed the interaction. That is, it became very complicated to act out gestures that entailed very little or no pressure at all, while it was not problematic at all to do calm movements with high pressure.

If the Bluetooth connection instead would have been initiated in the background much earlier in the interaction, when the user first started writing her message, initiated by the tip of the pen touching the touch screen for example, and then turning off after a little bit of time (that is, if the sensors were not set off) both the above-mentioned problems would have been solved. Not a very neat solution perhaps but the point here is that these are things that we could have discussed together in the design team if we would have been more aware of the material and its properties.

Figure 4.6 Technical design of the extended stylus (where it is the knob in the top middle that is essential not the non-readable scribble on top of this figure)

What worked out well with this stylus was how we managed to achieve the sensation that the whole stylus was pressure sensitive even though there was really only one small pressure sensor capturing this pressure from the system perspective. Using a soft rubber to cover the area of the stylus allowed us to create a design that allowed for bi-lateral feedback (Moen 2006) to the pressure of gestures, allowing users to feel somewhat of how hard they were
pressing and so forth. Beneath this soft rubber there was a hard plastic shell connected to the mechanics of the extended stylus by a single plastic knob connecting to the pressure sensor, allowing for all pressure to the stylus to end up on this sensor, see figure 4.6.

Having realized how the material matters for the experience of Affective Loops, and from the inspiration I personally had gained from working with Anna Ståhl, I felt I wanted to take a step back and reconsider the design approach we had chosen for the eMoto-project. I wanted to see if I could find ways for an interdisciplinary design team to earlier in a design process come together to discuss design ideas -- basing their reasoning on the material properties -- as is basic procedure for a good brainstorming and continued work in the design process.

The controversy between tool and medium, how I and others say we as researchers cannot just think and plan for movements but also need to move ourselves in order to find what in movement it is that we want to design for, and last, how the material matters for the Affective Loop experience were all reasons for why I chose the strategy for FriendSense as I did – which will come in the next section.
5 FriendSense

While the eMoto design process for the most part followed a typical user-centered design process, with FriendSense we wanted to start at the other end. We wanted to stage some of the experience we were to design for from the outset and that way come to allow for more open-ended discussions on what kind of system we more exactly would build and what kind of functionality that system would hold. In designing eMoto it was not until the end of that project that we actually used the system ourselves, outside the lab, and used it as part of our own everyday lives. At that time it was too late to change the design in any drastic way – too much had already been invested in the design, implementation and HW-development of the stylus. If we had used eMoto ourselves more frequently and systematically throughout the design process, we had been more aware of and worried by the design mistakes, such as the size and shape of the stylus and how it threatened to kill the whole experience. As it now was, we were worried the stylus was becoming too big, but we never understood until the user study in fact how that size would affect the experience of using it (our only concern was to keep everything as small as possible). Perhaps being naïve researchers we never saw the ‘dildo’-effect coming. But also, we would have been able to frame the final user study and help our participants to overlook design mistakes and try and interact with the system as intended. This could have helped them to arrive at and understand any occurrences of Affective Loop experiences, instead of focusing on other functionalities or lack of functionalities in the eMoto system, such as having to open eMoto to see the actual messages and only getting notification of messages into their normal inbox.

To remedy this mistake the FriendSense system was set up more or less right from the start of the project in our lab as a Technology Probe (Hutchinson et al. 2003). We lived with versions of this probe on and off also together with our other colleagues in the lab, from Spring 2007 to Summer 2009. These early versions of FriendSense were never intended as proper systems with full functionality or perfect match to the experiences we were seeking. They were quick and dirty probe set-ups that we believed could catch aspects of the embodied experience we wanted to expose and further explore. One of the most important missions for the range of set ups of FriendSense probes, was to explore how we ‘do’ emotions in our social relationships. In eMoto we had seen how the group of friends co-constructed emotional ‘moods’ or expressions. These emotions that we ‘do’ in one context we also bring with
us, more or less strongly, casting shadows into other contexts we take part in. Vice versa, those situations and contexts affects both ourselves and all others we come in contact with. There is an ‘emotional flooding’ of emotions within a group of friends and how the users of eMoto all affected each other even though not all of them had been in explicit contact with each other. It is often impossible to tell where this flood started and who changed it and when. Therefore FriendSense was set up as a system between a group of friends and not as the eMoto system between only two friends at a time.

By setting up these probes right from the start in our group, we in a sense developed the socio-digital material through exposing ourselves both to the effects on the social processes and the effects on the choice and form of the digital material at the same time (Taylor et al. 2007). It became a parallel design process – the social interaction was altered and grew into certain forms at the same time as the FriendSense HW- and SW form was altered and took on its form. The social appropriation processes did not take place after the system design was finished (Höök 2006).

Paper E presents parts of our usage of FriendSense also compared to the usage of FriendSense in a group at TeliaSonera, and parts of what we learnt and understood from using this system as we were developing it. Our goal was never intended to gain more knowledge on how groups of friends ‘do’ friendship or how groups of friends express emotional closeness within the group. What we set the FriendSense system up for was to explore how users would do this and ways for how users could do this in the context of, and influenced by the affordances, shape and form, of a the digital material.

What we wanted with the FriendSense project were three things; first of all we wanted to explore non-verbal communication in a group of friends, second we wanted to see if we could find better ways to get to know and expose the properties of computer technology as a design material, and last we wanted to find ways for us as researchers to better understand the experiences we could design for even before we had decided the details of those experiences and before we had worked through a complete design process working out a design concept allowing for those experiences. But also as a way to see if we could work out a conceptual design idea together with users, where we aimed for the FriendSense probe to be a way for both ourselves and potential users to come to a better understanding of the overall aims with this research and not focus so much on some details of some very specific system.

5.1 Designing FriendSense

The design material we choose to work with for the FriendSense project was sensor networks as we found this to be an exciting digital material we knew
very little about from a design perspective and HCI. In the beginning of 2007 we noticed how more and more mobile phone companies started to work on mobiles including various new kinds of sensors, such as accelerometers and GPS. Unfortunately, at that time, their operating systems did not allow software developers full access to those sensors. And at that time there were also very few such phones on the market. We wanted a mobile platform, less shaped by the notion of the phone, to open up for other kinds of mobile hardware and software solutions. Sensor networks were interesting from the perspective of non-verbal communication within a group of friends. In a sensor network, each sensor node is aware of its own current state but can be made aware of all other sensor nodes’ states through connecting to and ‘gossiping’ with the other nodes. A direct contact between the nodes is not needed. We found it amusingly similar to how individuals in a group of friends communicate with each other about each other and also about other members in the group. The interconnectivity of the different groups of friends, not only affect the emotional processes in the group of friends but they are also affected by their specific contexts – similar to how each sensor node will sense their immediate context in some form.

![Figure 5.1 The development process behind the FriendSense system with several different visualizations as well as a change from one kind of sensor node to another (Graphic presentation: Anna Karlsson)](graphic)

There were in total four iterations of the FriendSense probes (see figure 5.1). All had the basic set up of a co-located group of users with individual sensor nodes that they could use to express themselves with and a public screen where all users’ expressions were shown relatively positioned to each other.
The first, second and third version of the FriendSense system made use of a sensor node from Freie Universität, Berlin. These nodes were equipped with two sensors: one picking up on temperature and one registering vibration. They were chosen from our previous experiences of how temperature and movement map very well to the emotional processes taking place in our bodies (emoto and Ståhl et al. 2009).

The first iteration of the system was a set up using this sensor node and the eMoto background circle. Vibration of this node was in this set up connected to movement and temperature to distance from origo along the x-axis, showing the intensity of users feelings. But to choose whether to move left or right of the x-axis (i.e. to show whether this was a positive or negative emotion process) users had to choose between radio buttons using a local software client they had to download to their own personal computer.

In the second iteration we took inspiration from a Russian-born painter Kandinsky (1866-1944) and his painting Farbstudie. The painting has a set of colorful squares with circles within them. In our second version of FriendSense users all had their separate square on the public screen where the vibration sensor controlled the movement of a circle within this square and the temperature sensor controlled the color of the circle within that square, going from ‘basic blue’ to ‘basic red’.

In the third probe of FriendSense we were inspired by see-through, colored, glass marbles that have objects inside them. In this probe, users had their own marble on the joint screen that they could change the color (mapped to the temperature sensor) and movement (mapped to the vibration sensor) of. They could also put a personal picture inside their marble and have it covered with the (transparent) color of the marble. We changed the color scale into a scale designed to express the physical experience of temperature (which after all was what the temperature sensor was measuring) (Ståhl 2005), going from ‘cold’ blue colors all the way to bright red ‘warm’ colors, see figure 5.2.

But the most important change in this third version was that we allowed for users to socially position themselves on the public screen by ‘far-from’ and ‘close-to’ buttons in the local software client. If users felt close to someone, they could tell the system that they wanted their marble to be close to that other person’s marble. But if that other person had explicitly said that they did not want to be close to the user (and that more times than the user had
said the opposite), their marbles would still stay away from one-another on
the screen.

In the latest version of the FriendSense system we kept the marble graphics
but changed sensor node to the Sentilla JCreate node, a sensor node that is
both more neutral in its shape than the first sensor node and also picks up on
acceleration in three dimensions and not vibration.

5.2 Our reasons for FriendSense

As FriendSense was set up in our lab, the method for continuously evaluat-
ing it and moving forward with the design relied on self-reporting. As dis-
cussed earlier in this thesis, self-reporting, or Sengers’ autobiographical de-
sign approach (Sengers 2006), is not a commonly accepted way of designing
and evaluating systems in HCI. In fact it is an approach still open for a lot of
critique, given the tradition of objectivity in HCI and other research disci-
plines. On the one hand most designers and engineers probably do use their
own systems throughout a design process, but on the other hand those pro-
fessionals do not argue they are researchers and that their self-
reporting are research results. To be a researcher and argue your own subjective self-
reporting and evaluation of your own system that that is research results is
what is debated. Our intentions were slightly different from Sengers and
Warner’s, working on the Affector system as was presented in section two.
Our overall goal was not so much to design a system for ourselves. Instead,
our main focus was to design better systems for users, where using the sys-
tem ourselves was a necessary design step in that direction. Designing for
physical and emotional experiences we cannot just think and plan for those
experiences but also we have to develop our bodily ways of knowing (Höök
2010).

In section four we discussed the three reasons we had for setting up the
FriendSense system as we did: a way for us to explore non-verbal expressiv-
ity within a group of friends; a way for us to move, in order to find what it
was in movement that we wanted to design for; and last, as a way to find
better ways to consider material earlier in the design process and as a shared
recourse for design. What we also wanted was to develop a better under-
standing of the experiences of our potential users, using a system such as
FriendSense.

5.2.1 Non-verbal expressivity within a group of friends

Paper E presents what we learnt from using the systems ourselves and from
discussions we had with other designers and potential users after they also
had used the system for a while. These insights we obtained are mainly on a
conceptual level. Paper E divides these into four groups. The first group of
insights concern group membership and the difficulties in defining what a group of friends really is, who belongs to such group and who defines the group. Who is a friend and who is not a friend in a given context? In some cases group members will disagree and define the group differently from each other.

The second group of related insights concerns how systems such as Friend-Sense mediates physical contact and how this needs to be done carefully to not override what we would be willing to do when in physical contact with each other. One of our work colleagues said the following when she found her bubble moving on top of another bubble, belonging to another of our colleagues, who she wanted to show her empathy for by positioning herself close to him on the screen and with a similar expression to his:

“I wanted to be ‘close to Jason’, but I didn’t want to ‘sit in his lap’. That feels too intimate, I want to be close but not on top.” (Hanna as referred to in the paper)

In this second set of issues, we also find how our designed expressions need to allow for the range of expressions the task and the set up requires. If we are used to hug a friend we do not want to be limited to a set of more shallow expressions where we cannot act in similar ways.

The third set of insights concern group bonding activities and how we in a group can allow ourselves to act less in harmony with the limitations and boundaries we usually set for ourselves, and instead allow ourselves to be swept away by what the group does together. Doing weird, out of character, things together can in turn tie us closer together as a group.

Finally, the fourth set of insights concern finding a balance between designing for group needs without ignoring the need for an individual expression. As we say in Paper E, “As individuals within a group we want to be seen and appreciated by the others as individuals and in terms of how we contribute to the group.” (p. 358). If we as individual do not feel that we are seen for who we are as individuals, any experiences designed for on group level are wasted. Feelings of being distant from the group or not being able to see how one as an individual can make an impact on the group will set users off and then design attempts on group level are not even reached or at all considered by the individual.

5.2.2 More of the richness of movement

The richness of movement expression is very hard to capture in design. And if releasing that the complete picture cannot be captured, it is hard to know what parts of movement that is most important to work on and how, for the experience to be as rich as possible. We found we could use Laban notation of shape and effort to break movement down into parts that we could imple-
ment and test one by one and also make the computer understand. In the end effort was mapped to how much ‘weight’ that was put into the movement, and for how long that level of effort was maintained. This measurement was then mapped to the color of the marble. The flow of movements was categorized as either smooth or jerky, and was mirrored in the movements of marbles as smooth or jerky animations. The shape of movements were calculated from the size of the gesture and mapped to how marbles move over either a small or a larger space on the public screen. This was of course not a solution we found straight away but through a long process of trial and error where we worked our way towards the feeling and sensitivities we wanted to achieve. That process is described in detail in Paper F.

5.2.3 Material as part of the design process

Paper F presents the three most important insights on how to utilize sensor networks as a design material in the FriendSense context. The first insight concerns the physical appearance of the sensor node and the choice of sensors. What we found was that the form of the first sensor node we choose to work with, a bulky form that was uncomfortable to hold in your hand, better afforded negative expressions than warm and positive movements. We therefore change the sensor node to the Sentilla JCreate node, a sensor node that is more neutral in its shape, fitting better into your hand. It also picks up on acceleration in three dimensions that would allow us to capture more of users’ own movements rather than their movements towards the object, as was the case with the vibrator that had to be banged against something to set off.

Second, in contrast to the physical aspects of the digital material, that are easily understood as limiting or liberating material properties, the immaterial aspects of computer technology, such as the specific algorithms chosen, might not be so obvious seen as material properties. Algorithms are often seen as possible to invent to fit any purpose. But, as we discuss in the paper, each algorithm will have material properties that will be part in determining users’ experiences. Therefore, the properties of the chosen algorithms must also become a tangible property that the whole design team can discuss in detail together. Otherwise, we will fail in getting at and designing for the dynamic qualities of the interactional experience. As for example seen in the previous sub-section on our efforts in trying to find the best way of mapping different movement properties (shape and effort) to the behaviors of the marbles on the screen.

Finally, we assumed that we would be able to use the radio signal strength to position ourselves in relation to each other as signal strength often is used to create indoor positioning. By placing nodes close to one another, users would position their bubbles close to one-another on the screen. This could replace the disembodied solution where you first did gestures with the sensor node and then had to press buttons in the software client on your computer to
express nearness or distance to your friends. But signal strength turned out to behave in an almost random way in our set up. There were too many signals in the small room we all sat, and the signal spread around a node is not shaped as a perfect circle. We had to take a step back and look at the affordances of our design material and debate in the design team what it was that we really wanted to express by this positioning. In our discussing, we arrived at the insight that it was emotional closeness, not physical closeness that was important. What we wanted was to allow users to emphatically feel aspects of each other’s feelings – and express those. We altered the design so that users marbles were positioned on the screen relative to the similarity of the movements they performed with their sensor nodes. If one user made jerky, angry movements, and a friend imitated this, their marbles would be placed together. In a way we went from physical positioning to emotional or expressive positioning.

While we could of course list numerous other material encounters that mattered to our socio-digital material development in FriendSense, these three are brought out in paper F as they exemplify how it is not only a matter of the limitations and possibilities in the HW. The material affordance also resides in the algorithms, computer models, wireless connectivity, choice of graphics, and all the other small and bigger implementation choices we make during a design process.

5.2.4 Empathic understanding and FriendSense as a communication tool

By living with FriendSense during our design process we did not only hope to avoid major design mistakes. The overall purpose was also to develop an empathic understanding for our users (Wright and McCarthy 2008). We wanted to live the kind of experiences we were trying to design for. That would make us more sensitive both to the material properties, but also to the stories our future users potentially would come to tell us about. Discussing your experience of a movement-based interaction is notoriously difficult (Höök 2010). Verbal descriptions may not capture the subtleties of tensing a certain muscles, raising your arm into the air, or emphatically trying to be close to a friend. We had to become more sensitive to what our future users might experience and try to tell us of. Only then could we interpret and translate their experiences into design changes of what a system like FriendSense should and could be.

But also we aimed for FriendSense to be a way for us to sit down with potential users and explain our more general research aims in a way that we hoped would open for more open-ended discussions with those users, and not so much a discussion on some experiences they would have had with a computer system, such as eMoto, specifically. For this purpose we wanted FriendSense to communicate ‘quick and dirty’-design and also the material,
the sensor nodes, in its’ pure, ‘naked’ form, and not encapsulated as in eMoto. This for us to use FriendSense as a communication tool to exemplify our thinking and research aims during and throughout a more lengthy discussion with potential users. Our hope was that FriendSense this way not only would help us explain ourselves but also act as inspiration for those users and to open up their thinking for what potentially could be. Users could after such discussion, or in between two such discussions, also be left with the system for a while to use it themselves with their own friends in a context of their own. As we then had explained to them how FriendSense only was our way to inspire them and not something we had worked on refining for a long long time our hope was that they would not be caught up with the specifics of this design but instead from the potential experiences they would have with this system come to think of things we as researchers perhaps could use as our inspiration to a future design. Thus we also wanted FriendSense to be slightly provocative and sometimes even override communication rules between friends that we normally consider in design.

One reason to why we found it hard to have such discussions with the users having used eMoto, was that eMoto appeared so ‘product’ like and polished. When being handed the eMoto system the users immediately got high expectations for what this system could do for them and when this system then in a way failed or turned out to hold a lot of bugs and a battery that quickly ran out, we had the users slightly disappointed in us as researchers. In a way they then wanted to set us straight and tell us what was to us a lot of obvious things. With eMoto we did not really manage to get users to trust us and our competence as researchers and because of that we also did not get into the more interesting discussions we had hoped for. Because of this we with FriendSense instead wanted to approach users completely differently we wanted to communicate a ‘quick and dirty’ feel to instead spur their imagination and let us in on some of their hopes and ideas for potential designs.

Dourish (2001) argumentation that the system itself is a medium for communication between designer and user is an important point but we aim to argue the system is more of a message carrier from the designer to the users than a medium for communication. With FriendSense we did not want to communicate ‘professionalism’ and an unpassionate researcher-stance, there to quietly take in and analyze what we saw. We wanted an open and in both directions fulfilling conversation between researchers and users.

As the FriendSense system was not set up as a system in the sense eMoto was, there is no final evaluation of the system. Instead the outcomes from the overall experience of living with and working on the FriendSense system constitutes design inspiration for a range of systems allowing friends to express themselves using the sensor network technology. One such system that did come out of these design insights, is the LEGA system.
5.3 A Designerly Critique of FriendSense

While we still believe in our intentions and aims with the FriendSense project, it was of course not a perfect process – there are mistakes in our set-up. The task we had set ourselves and working the digital material turned out much more difficult and complex than we expected. FriendSense ended up being a design tool to work out our own understanding of non-verbal communication within a group of friends, rather than becoming a system to explore the purpose of non-verbal communication between groups of friends in different contexts, together with users. At one occasion we moved the system to TeliaSonera to get another group of interaction designers’ understanding of these matters, but never did we actually set the system up for a group of ‘true’ users to test. And never did we actually get to use FriendSense as the communication tool we had planed for with any users outside this design group at TeliaSonera or outside our own lab.

While eMoto was an attempt to be a proof of concept, embodying the Affective Loop experience, proving that we could design for such experiences, FriendSense, on the other hand, was to begin with a quick and dirty set up for the design team to feel a hypothetical, barely existing system. My first thinking of the FriendSense system was in lines with how Personas (Cooper 1999) are used to help design teams come to a shared knowledge on who the user is. With FriendSense we aimed for a shared understanding of the dynamics of the experience we were aiming to better understand and design for. FriendSense was also a way for me and the other engineers in the project (Alina Pommeranz and Annelie Schwanecke, two master students working in the project) to right from the start of the project start become more familiar with our design material and through that process be better at sharing this knowledge with the rest of the design team. Furthermore, my idea was that FriendSense could be used to educate potential users on the complex issues we were designing for and that way allow them to take part in the early faces of our design process on more equal terms with the researchers.

What happened was instead that we pretty much ended up in a situation where we treated FriendSense as any system we regularly take months, sometimes even years, to design. We could not break with the frameset of seeing system development as something we first have got to work out in a thorough brainstorming process, perhaps some low-fi prototyping, followed by early encounters with users simply discussing the concept as such, and then a system we would set through a series of iterative user encounters and redesign.

This happened due to a number of reasons. First, the computer material is a complex and sometimes very hard material to work with. Apart from quick fixes major changes to the basic set up or to exchange parts of a system into something completely different takes time and is a very complex task. Especially so we would say is the case for designs that are as FriendSense heavy
on the hardware side. As we were only software developers in the design team we missed a HW-expert who could do changes and elaborations of the hardware. It was not until the fourth iteration of FriendSense that we actually changed into a different kind of sensor node. And the basic set up of the system we never changed.

We also lacked a strong designer, someone who is brave in her design thinking and not as strained to what is possible from the material starting point. This person could have balanced the input from the engineering team, creating the necessary give and take process between technically driven and design expression driven development. This person could have pushed us to work further away from what we first would see as possible and therefore the area we would set to move into.

If the eMoto system development process was too heavy on conceptual design side, the FriendSense process came to lack a conceptual framework and a directional design task. To elaborate this was harder than we assumed.

Still, we did learn a lot of things for how to design for emotional closeness within a group of friends and about sensor networks as design material. We managed to gain this knowledge even though we were lacking a directional framework, a strong designer and a skill set in hardware design. In paper F of this thesis we present three different kinds of material encounters, one on the more visual and haptic aspects of our material, one algorithmic and thereby more unreachable to non developers and thereby perhaps more important to talk of from the perspective of design, and last a ‘fight’ we found ourselves in when wanting to find a way to implement an idea we had. This and a range of other design insights and issues, we took with us into the design of the LEGA.

FriendSense was a brave attempt to try to do something different in terms of how we as researchers in HCI approach design. Some parts of this work, such as working so directly with the material, the digital material, have been extremely giving. In this direction our work on FriendSense has helped me together with Alex Taylor at Microsoft Research Cambridge to formulate the Inspirational Bits design approach (Sundström and Taylor 2010 and also submitted as Sundström et al. to CHI’11). This is a design approach that aims to un-blackbox some of the taken for granted properties of the digital material and explain these in a fun and inspiring way so that all members of an interdisciplinary design team understand them from the perspective of how they might affect a final design and the user experience. By doing so early in a design process we hope that what previously have been considered simply as limitations of the material now even can be seen as inspirational possibilities. The Inspirational Bits design approach is something we are working on now and that we hope will lead to a range of systems that will foster design and subsequent use of the digital material in new interesting ways.
6 The Affective Loop

The kind of experience we are aiming for with the Affective Loop design stance is an ever expanding emotionally rich experience. The aim is to engage more than just our cognitive senses and having a grounding from which we can create for intensified, fading or changing experiences. There are those who maintain that the kind of experiences we aim for are unique and inseparable from the larger context in which they occur (Boehner 2006, Boehner et al. 2008). Such a position risks ‘mystifying’ human experience, closing it off from study as ineffable and thereby beyond discussion. And even beyond making designs that build on previous experiences or learnings from other similar systems. We wholeheartedly agree with the notion of unity of experience and support the idea of letting the magic of people’s lives remain unscathed, however, we do believe that it is possible to find a middle ground where we can actually speak about qualities of experiences and knowledge on how to design for those experiences without reducing them to something less than the original. This does not in any way mean that the experiential strands, or qualities, are universal and the same for everyone. Rather, they are subjective and experienced in their own way by each user. Only by collecting a number of stories from users can we begin to form some (practical) knowledge about how certain qualities are formed and how they relate to each other. But as Dourish (2001) argues, we cannot design such experiences in interaction, only design for them to be more likely to take place. The active participating user must want to be engaged, and be open to the experience. Dewey talks of the difference between perception and recognition (1934). That there is a difference between those who simply “takes in what is there in finished form” (p. 54) and those who are being more active -- perceiving music, literature and art more as the composer, the writer or the artist herself.

Starting out this work on Affective Loop Experiences we discussed two kinds of experiences: one over a longer time making up the overall experience of use over time; and one more intensified, short, in the moment experience interacting with the system. We also talked about individual and shared experiences, as in creating a message in eMoto would be an individual shorter Affective Loop experience, and to send and receive messages together with friends building up expectations for a shared experience would in comparison be a longer lasting Affective Loop experience. This second experience would then in a way be an on and off experience in the same way
as some game experiences (such as being part of a team and planning for shared events in a game like World of Warcraft\(^5\)). While it is the shorter more intense individual experience we more explicitly design for and refer to as the Affective Loop experience, it is the longer overall experience in the world in contact with others that set the stage for the more intensified experiences.

While we cannot yet point out a direction towards a system design that fully embodies such experience, we can, from our work on eMoto and FriendSense, list a number of experiential qualities (Löwgren and Stolterman 2004) important to consider when designing for what we call Affective Loop experiences: such as *suppleness* in terms of rhythm, timing, harmony and coherency and kineastetics; a sense of *being in play*; and *depth, ambiguity* and *openness* for personality in expressivity and interpretation. This section will present those experiential qualities in some more detail, and why they are relevant to the Affective Loop experience.

Finally, we will argue for seeing the Affective Loop design stance as more than a loose framework for design. Instead, it entails a fairly detailed procedure for how to bring these experiences into design. The procedure is not necessarily unproblematic to apply and in certain way, the way we defined that procedure, it does not properly cater for the overall combined embodied experience we want to achieve. We will come back to this issue by the end of the section, but first the experiential qualities we do have found valuable to consider in designing for the physically and emotionally rich experiences we aim for with this idea of Affective Loop experiences in design.

### 6.1 Suppleness in terms of rhythm, timing, harmony, coherency and kineastetics

At several occasions in the design processes described in this thesis we can see how Affective Loop experiences require an interactional experience that is fluent. By that we mean that the interactional experience as it unfolds over time, should not entail any break ups or flaws in the rhythm of interaction; where a user’s intentions, her interaction with the system and the system’s response float together into one, *supple* experience.

According to Isbister and Höök’s description of suppleness (2009), a supple system is doing sort of a “*social/emotional ‘dance’ with the end user.*” (Isbister and Höök 2009, p. 2236). A good example of a supple system is the Wii sports game\(^6\). This game holds the kind of fluency in interaction that is

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\(^5\) [http://www.worldofwarcraft.com/index.xml](http://www.worldofwarcraft.com/index.xml)

required to create for suppleness in interaction. But to design for suppleness is not easy. So far, we have only seen, apart from our work, a few attempts to articulate and describe design processes leading to supple systems (Moen 2007, Shiphorst 2009, Wilde 2010).

Similarly to how Löwgren (2009) describes the aesthetic qualities of interaction as a combination of pliability, rhythm, dramaturgical structure and fluency, suppleness can, from our perspective, only be achieved from finding the, for the situation at hand, right combination of rhythm, timing, harmony and coherency and kineastetics. This needs to be accomplished in combination with what MaCarthy and colleagues describe as “the specific sensuousness of each particular thing” (2006, p. 373), which refers to the less dynamic, but as important, qualities of an artifact, such as its’ texture, form and so forth.

We will now go through a few examples of how we have worked on finding the right rhythm and timing in interaction, and a harmony and coherence between different modalities and designed expressions, and a kineastetics feel in interaction in our work on eMoto and FriendSense; in order to both explain them in further detail but also provide design examples for others to learn from.

Rhythm and timing are intertwined but timing is more about when a system needs to respond and for how long and rhythm is more about the pattern of interaction. Löwgren (2009) expresses it as:

“The tempo of rhythmical interaction ranges from sub-second beats in high-paced situations to several-hour cycles in more peripheral interaction settings.” (p. 7)

“On a slightly longer timescale, rhythm concerns the ebb and flow of everyday life as mediated by digital streams and artifacts.” (p. 8)

In the design process behind eMoto we learnt that the system needed to respond faster and quicker to high arousal gestures, while less arousal required a slower response. It gives the user time to get into the more calm emotions down at the bottom of the graphical circle in eMoto. The more energetic emotions towards the top of the circle turned out to be easier to move into but then users did not want to stay for very long in that extreme state. If the user has to sustain the energetic gestures for too long time it killed the experience. It became boring. In Löwgren’s terms high arousal emotional expressions require a high-paced rhythm, a flow to interaction, while low arousal expressivity require longer instances of ebbs and flow.

Even though we want users to be active in interaction, we aim for communication between the system and the user. To allow the user to comprehend and take in and hopefully be affected by the feedback a system is providing, she will have to sometimes stand back and not be so active in interaction but

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more take in what feedback she gets and how the system understands her. This allows a user to get more and more involved in the interaction by letting the system and the user work their way towards a mutual understanding. We want users to either feel that they need to change their expression because they felt the system did not understand or we want them to more strongly experience what they tried to express.

Our experiences from eMoto show that users in fact can be somewhat understanding to failures to the rhythm of interaction, most important in eMoto was that the system in some way signaled that it was at all responding to the user’s actions in first place. In eMoto users were first supposed to write their message and then use gestures to add their desired expressive background to their message. Using a Bluetooth connection between the mobile phone (where the response was given) and the stylus (with which the user was supposed to affectively interact) was, regrettably, causing a failure in the interaction. A Bluetooth connection is very reliable when it is established but slow in setting up. This slowness persists even despite the fact that two already familiar devices tend to find each other a faster than devices that never have held a connection before. The same thing happened in FriendSense, sometimes when a user wanted to change her expression on the public screen it happened that the server sensor node was interacting with another client and the user then had to ‘wait’ for the server to respond and upload the expression to be shown on the public display, a pause users did not understand and even was not aware of in the sense it happened, which made them annoyed and disturbed any potential for a supple experience. Also these dysfunctions affect the overall feel for the system in the long term. It makes it even harder when the server sensor node is answering directly, as it should in order to get users engaged in interaction, to get users engaged as they then have started to question the system.

Furthermore users seem to be extra sensitive to these matters when using their body in interaction, as they are not as used to using their body in interaction as they are to using more traditional interaction modes like the mouse and keyboard (using much less of the body in interaction), and as using more of our bodies in interaction makes us more vulnerable and exposed to others. However, we can have users become absorbed by the interaction; so absorbed that they even forget about the inconvenience and embarrassment that comes with waving a stylus pen in the air in order to create a text message as in eMoto. But if the system breaks or takes too long on some occasion, it may cause the user to fall out of the experience and becomes aware of herself being there waving a stupid pen in the air. That is, the system will become present-at-hand instead of ready-at-hand (Heidegger according to Dourish 2001). In general, a sense of having a tool present-at-hand is not necessarily negative (Sengers, Boehner and Shay et al. 2005), but when embarrassment and self-awareness follows upon such an awareness, it destroys the suppleness in the interaction.
There is a difference between a jarring ebb in the moment and a natural ebb to allow for a user to sit back and comprehend what the system is answering in response to her gestures. Dewey (1934) says it like:

"there are no holes, mechanical junctions, and dead centers when we have an experience. There are pauses, places of rest, but they punctuate and define the quality of moment." (p. 38)

But even if we have found the right rhythm of interaction and have the right timing of various expressions, the expressions performed by the user and the expressions given by the system will have to build on each other to allow for intensified, fading or changing emotional experiences. We will have to find the right harmony and coherency between the modalities used in the interaction – modalities capturing users’ intentions, how they can interact with a system and the system’s response. To allow for an Affective Loop Experience or to design for suppleness all these things need to work together as a whole and for that to happen they need to create for the same emotional experience and in similar ways. In a way this is similar to what we in design call form factor. A problem in FantasyA, as described in the first section, was that the user could express, for example, happiness but then have the game translate it as having her avatar attack an opponent – an example of an incoherency between user expression and system’s response – or as expressed by Dewey, a lack of unity between the different parts of the system. There were parts of the FantasyA interaction that were much better at achieving a coherent experience and those added to the experience. One example is when the user had to express anger by angrily shaking SenToy back and forth in her lap, in order for her avatar to attack an opponent. The angry movements mirrored the user’s intent of beating the opponent. After a successful fight the avatar would raise its arms in victory and on some occasions users would imitate this gesture in celebration together with their avatar, a physical movement that then allowed for a richer experience since large open movements open up for emotions of happiness and joy, and in this case, emotions associated with victory (Wallbott 1998). Situations where imitation and coherency in expressions act together towards the same emotional experience, together build up for an Affective Loop experience.

SenToy and FantasyA and also eMoto and FriendSense very much focus on the same set up -- some physical input in combination with a visual output. An even more compelling design could be to try to achieve a similar physical, bodily output, perhaps using haptics, rather than only graphics on a screen. Then, for example, the receivers of messages in eMoto could get a better feel for the movements and the more physical sensations of the emotions of that message. Part of this idea was of course visible in the movements of the graphics (Ståhl 2005) but not in combination with and enhanced by the actual movements themselves as when creating a message. One exception to this order is the work we in eMoto did on Kinaesthetics of move-
ment in interaction (Moen 2006). Kinaesthetics of movement refers to a more haptic response to users’ expressions. In eMoto we aimed for the material of the stylus to somewhat respond to the amount of pressure users choose for their expressions. We wanted the material to be resistant to the amount of pressure users choose to express themselves with. We wanted users to have a sensation of how hard they were pressuring on the stylus. Even though we used only one pressure sensor to measure this pressure we worked hard on achieving the sensation that the whole stylus was pressure sensitive.

Another danger is that the rhythmic pattern becomes too divided into different phases, like a dialogue, where there is too much of a separation between the user expressing something and then having to wait for the response from the system. The LEGA system is then more interesting in its set up using one device for both expressivity and feedback allowing for a more fluent interaction pattern, where users’ expressions blend into the expressions of others. Also soft(n) and the BodyBug system, as referred to in section two, are more interesting from this perspective.

6.2 A sense of being-in-play

In many ways it is a more playful usage of affect that can be said to characterize the difference between affective computing and affective interaction. While researchers in affective computing are working really hard on trying to determine ‘truths’ and free users from the burden of interaction, affective interaction instead sees emotion as something deeply interesting for users to reflect upon and get engaged with, if one likes to ‘play with’. This ‘play’ does not necessarily refer to games, it is rather a playful perspective on how we should use emotional data in design. The difference from affective computing is not so much in the techniques used to capture bio metric data or what data that is gathered but how it is used and “what authority is placed on the information collected and how transparent it is.” (Boehner 2006, p.184)

But perhaps different from Boehner and colleagues we also do not see complete transparency as playful. Our conclusion is that there needs to be somewhat of a mystery and perhaps slight modulation of data if users are going to perceive the interaction as anything else than purely navigational. In eMoto, users to some extent got more interested in finding the expression they wanted to send and did not at all times really engage with the gestures and thereby in a way missed out on some of our intentions with the Affective Loop -- to allow also for a full-body experience of communication not just an information transfer. In FriendSense we worked on a somewhat more complex relationship between gestures and the response of the system, aiming for the totality of the shape, effort and timing of gestures to create the
input. This would allow users to be more engaged with the expressions themselves rather than seeing them as signs or commands.

But also, in systems such as the Affective Diary and Affective Health we can play with slight modulations of data, not aiming to determine users’ emotions but presenting the data in a way that might be a slight provocation for users to react upon. In Gaver and colleagues’ work on ludic engagement and, in particular, the Home Health Horoscope (Gaver et al. 2009) they argue that the aim is to find the ‘sweet spot’ between the extremes of randomness and the correctness of a system’s interpretation of, in their case, the everyday events in a household. Their design aims to engage users with the system instead of thinking that the system just gets things wrong which might be the case if the system tries to modulate too much, or that the system does not know anything interesting to know if it simply is to present data as it is. But as they phrase it “establishing an intriguing middle ground between randomness and accuracy is not always a simple matter” (Gaver et al. 2009, p. 2220).

What we have wanted in eMoto and FriendSense, and what Ståhl and colleagues most likely have wanted in their work on Affective Diary and the Affective Health systems, is not so much finding the sweet spot between randomness and accuracy, but finding the intriguing middle ground between an ambiguous openness for interpretation and a provocative modulation of data. The aim is a sensation of mystery, where the user has to figure out how the system interprets her and from that, in some cases, perhaps also learn something more about herself.

A problem with adding such a mystery to the interaction is that the user may figure it out and thereby lose interest in the system. When users have it figured out they might feel that there is nothing more to explore – the sweet spot for personal reflection is gone.

6.3 Depth, ambiguity and openness for personality in expressivity and interpretation

In our work on eMoto we aimed for a kind of ‘depth’ in interaction. What we wanted was to create a sensation of never having reached the end of expressions to choose from. When designing the background graphics (Ståhl 2005) we thought of a kaleidoscopic effect as a way to keep users engaged in interaction. We wanted the background circle to be big enough in relation to the screen on the mobile phone, and by using gestures to interact with this circle, an interaction model that is not a one-to-one mapping of input to output, we hoped users would feel that the number of expressions they could choose from were unlimited. This would mean that there constantly would appear new expressions and new areas to explore when interacting with the
gestural plane model. In fact we found that this partly happened even with the limited set of expressions we provided in the background circle, see paper D.

Figure 6.1 The relationship between the size of the background circle and the screen of the mobile phone

In the end, we had to make a tradeoff between the time it takes to upload pictures on the mobile phone screen and our wish for a large amount of expressions to choose from. The final implementation had a background circle that was set to be a hundred times larger than the screen of the mobile phone, see figure 6.1. While this may seem like a sad reason to limit the circle, it exemplifies the importance of considering the properties of the material, as discussed in section five, in this case the memory limits on the mobile. Looking back at this interaction model we would probably have been more successful both in terms of experiencing the expressions (and not so much navigating them) and in terms of mystery and kaleidoscopic effect, if the expressions could have emerged, rather than been positioned in relation to each other on this circular plane.

What we probably were most successful with was the ambiguity of the expressions themselves. What we wanted was an interaction model where each expression could take on many meanings. We wanted users to feel they could use the expressions to express themselves and their personality to each other. A more simplistic relationship between expression and its emotional value would not only take the risk of being wrong but would most likely be extremely boring after a while. The users would probably not experience that the system was mediating them or the very unique relationships they have with their friends. To achieve this an ambiguous set of expressions is key,
although not too ambiguous or ambiguous in every possible way. The expressions still need to have an inspiring hint of its meaning, indicate some emotional value and they should also be to combine in various ways to express complex experiences. Users should be allowed to form something more -- of their own set of expressions -- that express them and have meaning only to someone who knows them well, such as a close friend.

But not only did we want to allow for an openness to interpretation of the graphical expressions. We also wanted the gestures to be, to some extent, shaped by users’ own choice of movements. This is why we designed both eMoto and FriendSense to look for characteristics of movement and not specifics gestures set in stone. Still both eMoto and FriendSense are designed artifacts and whatever basic measurements we use to capture characteristics of movement, and not the specifics of them, we will still be designing for a certain way of using our systems.

In eMoto differences in users’ personality affected especially the tangible design of eMoto. Users who seemed to be more extroverted in their personality were more comfortable with the physical and expressive gestures than users who seemed to be more introverted in their personality. Using gestures to express emotions is something very natural to most people. It is not so much something we are consciously aware of as something we just do as part of any conversation. However, what gestures people use are highly personal and at the same time culturally shaped. Some people are said to be more physically expressive than others. There is a difference in what people can, want to and dare to physically express to other people. To make gestures into a modality for interaction is not an easy task. The gestures needs to be both expressive enough to get users involved, but at the same time they should not challenge their personal boundaries making them retract from the experience. When designing for physical interaction it is therefore essential to know who the targeted user is.

The eMoto system was evaluated in the wild where expressive gestures were publically visible and perhaps therefore extra scary for some of our users. When starting our work on eMoto there were just a few games using full-body interaction, today this market is huge, but still there are very few systems that are not games that use large gestures or just gestures in public. All our users of eMoto commented on this in our final evaluation conducted in 2005. It would be interesting to conduct the same study today, only a few years later, but where movement-based interaction has become more spread. The social norms for what is acceptable behavior in a public environment need to be extended on if people shall be comfortable with these new interaction forms. But if we compare gestures with e.g. speaking publically in your mobile, we have seen that such a change is possible. Today it is, at least in Sweden, accepted for people speaking loudly in public as long as it is clear to those around that this person is talking into a mobile phone. People
in a mobile phone conversation physically turn away and make sure they do not have eye contact with people around them to show that they are talking to someone that is not present (Murtagh 2001). If people do not understand that it is a mobile phone conversation they might think the person is talking to herself, which is on the other hand not socially accepted. To act out gestures in public without a conversational partner is probably the same. In a few years time it might be that we all use more than hand and face in interaction in public settings without being considered strange or feeling strange about it, as long as others can see what we are interacting with someone through technology or as long as there is a technical setting of some kind to blame.

6.4 The Affective Loop is more than a framework for design

The Affective Loop idea could potentially be reduced to being a framework for design – a general direction for our design aims, pointing to certain sensitivities the design should have to allow for such an experience. We will in this sub-section though argue for why we think the Affective Loop idea in fact is more than a framework for design. This by comparing the way we have defined and presented Affective Loop experiences in this thesis, with a few other design frameworks (e.g. Larssen 2007, Shiphorst 2009, Hummels et al. 2007) aimed at the feel of movement in interaction, or leading to a better notion of the self and the human body.

The first framework we would like to compare with is by Larssen and colleagues (2007). They argue for a feel dimension in contrast to e.g. the visual dimension. They claim that the visual dimension is much better understood and explored. They do not contribute with a design method or a design but instead a set of themes that can act as conceptual tools to assist in understanding how the system can be experienced. These themes are: body-thing dialogue; potential for action; actions in space; and movement expression. A body-thing dialogue refers to a dialogue where movement is the mode of communication; orientation to, attending to and acting on and through are basic notions here. The potential for action-theme refers to how different bodies have different possible movement available to them. The action in space-theme concerns objects that are within reach and objects that are out of reach, such as a self-flushing toilet or an automatic door. The movement expression-theme refers to the way in which we execute a movement to establish a coupling in an interaction.

Shiphorst puts forth a somaesthetic framework that consists of four themes: experience, poetics, materiality, and semantics of caress (2009). Somaesthetics is a philosophical theory formulated by Shusterman (2008). A somaesthetics...
thetic perspective does not reduce the human body to a tool, putting the mind first and body second. Instead, it is a philosophical ideal that integrates the body and mind. It entails physical practices, similar to how the ideals of the old Greek philosophers. Through certain physical practices, we learn to make better use of our bodies, to know our own bodies and what can be experienced better, to train them to greater sensitivities towards experiences and movements, with the ultimate goal of living a better life. Shiphorst’s framework translates somaesthetic ideals into a design direction for HCI. She demonstrates it through designing a system named soft(n) (discussed briefly in section two above). soft(n) is an interactive art installation that explores the somaesthetics of tactile interaction. This installation is a set of ten soft objects that “exhibit emerging behavior when touched and moved about in space” (p. 2430). The experience-theme is in soft(n) demonstrated through how each object can activate vibration, light and sound in response to touch. The poetics-theme refers to how the installation includes the notion of ‘’past lives’ of objects, cherishing and memory, the notion of softness and pliability, and emotional attributes contained within objects such as forgiveness, stubbornness, resistance and glee.” (p. 2433). The materiality-theme refers to the design of the tactile interaction surface of these objects, similar to our work on sensor nodes and suppleness as presented in paper five of this thesis. Finally, the semantics of caress-theme concerns the touch-effort connection, where Shiphorst (similar to us and Camurri and colleagues) make use of Laban Movement Analysis (Davies 2001, Laban and Lawrence 1974, Zhao 2001) to connect users’ activities with the soft(n)-objects to vibration, light and sound as mentioned under the experience theme.

Hummels and colleagues framework emphasize that if we want to design for movement, we need to become experts in movement, not just theoretically but by moving and doing design through movement (2007). They list seven guidelines for how to do so: Meaning through interaction; Richness of interaction; Design by moving; Support for movement; Research by doing; Educate through and for movement; and Design for diversity. The Meaning through interaction-guideline refers to how we should move around in the world we live in to get access to the meaning that is inherently there for our bodies. The Richness of interaction-guideline points out how we should look beyond the pure tangibility of products and instead care for the richness of the interaction. By shifting focus from the things themselves to the interaction Hummels and colleagues argue for new methods in which we can design also by moving. By the Support for movement-guideline they make a case for how designers need tools to help them explore and visualize interaction. In the same line of reasoning they state that we should conduct research by doing and moving and also educate through and for movement. Lastly, they refer to how human bodies are inherently different from each other and how we therefore also need to design for diversity.
What we want to point out is that these frameworks still are very far from actual designs. The step from the principles to actual design requires interpretation and a deep knowledge of how to apply them. And even though Shiphorst exemplifies her framework in the design of soft(n), the intermediate steps required to reach the design are left out of the documentation she provides.

With the idea of the Affective Loop design stance, we have here shown how to take theoretical inspiration of affect into actual designs. With the Affective Loop description our aim is to not only provide a framework for design but also to how to translate such a framework of sensitivities to certain emotional and bodily processes into design. This is partly expressed through the affective loop pattern. The affective loop pattern explains what is required of the interaction and provides an interaction model that can be more easily instantiated with the specific goals of the application domain. On the highest level, the affective loop pattern follows the following steps: allow users to express themselves in rich emotional ways using affective gestures of full-body movements in interaction, the system then in turn answers in ways that either changes or strengthens the emotion expressions that the user’s interactions opened up for. This is a process that can be likened to a conversation with the system where the aim is for stronger emotional experiences than if it were simply a single iteration or more of a one-to-one relationship between input and output.

The interaction pattern of an affective loop experience is similar to what Benford and colleagues refer to when they describe the different trajectories that game designers create to keep the story together and build up for exciting events when building dramatic interactive narratives/games (Benford and Giannachi 2008, Benford et al. 2009). Or to how Löwgren (2009) finds a dramaturgical structure from exposition to resolution helpful when designing for aesthetic experiences in interaction. It also bears resemblance to Dewey’s (1934, also described in McCarthy and Wright 2004) description of cumulation, conservation, tension and anticipation processes that shape aesthetic experiences. A parallel can also be drawn to how interactive storytelling uses exposition, an inciting incident, rising action, a crisis and a climax, and failing action and denouement to build up an interesting story (Laaksolathi 2008). All of these prescribed interaction patterns entail specific design steps that will help to build up for emotionally engaging experiences. In that sense, they are not frameworks to make designers more sensitive to certain design aims, but provide more guidance.

6.5 A Designerly Critique on the Affective Loop

At the same time that we argue for the very specific interactional arrangement of the Affective Loop we also see how the same pattern can be hard to
apply and make use of in all contexts. It might be that we have nested ourselves into a too fixed, rigid pattern of interaction. The rhythm and the turn taking between the user and the system should not be thought of as a set of steps, but more like one, whole, supple experience. The way eMoto was set up, making it rather obvious to users how input and output were affecting each other, gestures were sometimes thought of more as a complicated navigational tool to reach some wanted expression. They were not felt as that explorative, slightly mysterious, intriguing emotionally engaging process we had in mind. While we want to design for the experience of communication and not communication as simply a transfer of information, we did not manage to make the personal experience of communication as important as the more well researched and understood communicative part.

In FriendSense we manage to make the relationship slightly more intriguing while still not being too mysterious -- but still the strong division between input and output did not allow users to be caught up in the creation of expressions.

To design for a successful Affective Loop experience it is important that we design for one complete interactional experience where the boundaries between input and output and between creating and communicating an expression becomes much more blurred. The perspective should be that it is the “changing form” that is communicated rather than the expression reached at the end of an Affective Loop experience. For that we need to continue exploring the idea of the Affective Loop in order to build further on the experiential qualities we have listed and also in order to find potential others not covered by this thesis.
7 Many Challenges Remain – Communication is Exciting!

The starting point for the work presented in this thesis was a user-centered perspective on how to design for affect in contrast to the ‘informational view on affect’ that dominated the affective computing approach (Picard 1997). But what could be refereed to, as in opposition with the almost linear user-centered design approach, this work is also about understanding the aimed for experience. For that, a more explorative and also to some extent self-lived designed process was necessary.

The user-centered perspective as it was first presented by Norman and Draper (1986) is in many ways used as an umbrella term for a range of user related approaches to design, where ergonomics, participatory design and value sensitive design are three of the most popular. The conventional user-centered design model is typically divided into four stages: study, design, build, and evaluate, that follow after each other in an iterative fashion. The HCI 2020 Forum (Harper et al. 2008) instead suggests an extended approach, which also holds a fifth stage including the aim to first understand the human values involved. This stage is thought of both as the initiating stage but also a phase that iteratively comes back throughout the design process. This fifth stage requires discussions and encounters both with users but also with other stakeholders such as philosophers, physiologists, sociologists, designers and more, and as we have seen in our work; actors and dancers and also ourselves. To avoid considering and relating a design to our own personal experiences (in combination with all the other sources) would be missing out on a very valuable resource we have right in front of us, one that is readily available to us. To miss out on this resource would be a waste of possibilities. And in most cases, a design team of practitioners, in other experientially oriented domains, such as games or social media, are using themselves as a resource in design (Hagen 2010). What is interesting is how tabu it has been to talk about this in the academic field of HCI – leading to a lack of understanding on how to do it!

In a sense, this thesis is not foremost about eMoto or FriendSense, nor even about outcomes of our work, such as the LEGA. All of the work presented in this thesis concerns how to understand and systematically work with experience-oriented design. In particular understanding more about how to design for Affective Loop experiences.
Looking back at the story introducing this thesis where a group of friends meet to hang out together, it is apparent that our bodies and emotions are key aspects of expressivity in their communication. They are key to the experience of the communication. Furthermore, looking at how digital communication to date has been studied and understood in academia, we may note how it has been focusing mainly on the information transfer - not much attention has been paid to the role of the emotional and the physical aspects of the interaction. These matters are there, but we have not been forming our digital communication tools to fit with the interesting, fuzzy, intriguing, gossiping web of interactions we in our relationships with our friends, love to spend hours and hours thinking of and trying to figure out. Emotions, up to now, have been something that is in addition to, or on top of a more “efficient” communication stream, in the shape of simplistic iconic smilies to take just one example. What this thesis and our work on the Affective Loop contributes to is a better understanding of how to consider aspects of communication and friendship that have not been much considered earlier. We regard our work as the first steps in this direction. But to take yet another step forward we need to take a step back and work on these issues more carefully, one at a time, in order to better come to understand what is really going on here. After gaining that knowledge we can approach design of communication tools in much richer, more expressive, interesting and embodied ways. eMoto, FriendSense and the LEGA system should all be regarded as probes into what kind of qualities a new expressive, experiential medium can/should have.

The reader of this thesis, might wonder why there are so many women and so few men in this thesis: all authors of the papers are women, most users are women and also many of our colleagues are women. We never aimed to make that into the focus of this thesis, but when starting this thesis, there were very few commercial and research services aimed for female users over the age of 25. There were a lot of services for teenagers and the ‘working white western man’. We wanted to develop systems that we would like to use ourselves and for women our age.

In moving forwards after completing this thesis, an issue that interests us is the relevance of making the digital material a more shared resource for all parties in the design team to get a better understanding of -- thereby making the digital material a resource for design -- and not as it is now, a resource only for those who feel they have the competence to handle and shape it (Ozenc et al. 2010). As previously mentioned, we have started working on a method that we call Inspirational Bits (Sundström and Taylor, 2010 also submitted to CHI as Sundström et al.). It is a method that aims to expose the digital material and explain its properties so that all members in an interdisciplinary design team understand how they might affect the design and in turn the user experience.
In conclusion, the work presented here should be regarded as inspiration and guidance for both ourselves and other designers when now taking the step towards designing new expressive and experiential media for whole users, embodied with the social and physical world they live in. But it needs to be said that this work will only be valuable if other designers find the results valid and important, and find ways to apply them, in their own work. What I hope to see is a range of systems for everyone, men and women, where communication is not only concerned with getting the message across but also with living the experience of communication - *feeling* it.
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Part II - The Papers
Designing Gestures for Affective Input: An Analysis of Shape, Effort and Valence

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Abstract

We discuss a user-centered approach to incorporating affective expressions in interactive applications, and argue for a design that addresses both body and mind. In particular, we have studied the problem of finding a set of affective gestures. Based on previous work in movement analysis and emotion theory [Davies, Laban and Lawrence, Russell], and a study of an actor expressing emotional states in body movements, we have identified three underlying dimensions of movements and emotions: shape, effort and valence. From these dimensions we have created a new affective interaction model, which we name the affective gestural plane model. We applied this model to the design of gestural affective input to a mobile service for affective messages.

Keywords: Affective interaction, gestures, user-centered design, mobile service

1 Introduction

By addressing human emotions explicitly in the design of interactive applications, the hope is to achieve both better and more pleasurable and expressive systems. The work presented in here is inspired by the field of affective computing [Paiva, Picard], even if our aim is to take a slightly different stance towards how to design for affect than normally taken in that field – a more user-centered approach.

Affective computing, as discussed in the literature, is computing that relates to, arises from, or deliberately influences emotions [Picard]. The most discussed and spread approach in the design of affective computing applications is to construct an individual cognitive model of affect from first principles and implement it in a system that attempts to recognize users’ emotional states through measuring biosignals. Based on the recognized emotional state of the user, the aim is to achieve an as life-like or human-like interaction as possible, seamlessly adapting to the user’s emotional state and influencing it through the use of various affective expressions [e g Ark et al., Fernandez et al.]. This model has its limitations [Höök], both in its basic need for simplification of human emotion in order to model it, and its difficult approach into how to infer the end-users emotional states through various readings of biosignals.

To get the users involved in a more active manner we would, instead, like to propose the user-centered approach to affective computing. Our aim is to have users consciously expressing their emotions rather than having their emotions interpreted or influenced by the system, while still maintaining the mystery and open interpretation of emotional interaction and expression. Inspired by the results of our previous work [Paiva et al.] we arrived at a set of four design principles, outlined in detail below: embodiment as a means to address physical and cognitive concepts in the interaction with the application [Dourish], natural but designed expressions as a means to communicate affect instead of aiming for complete naturalness, an affective loop to reach emotional involvement with both body and mind, and ambiguity of the designed expressions [Gaver et al.] to allow for open-ended interpretation by the end-users instead of simplistic, one-emotion one-expression pairs.

Our specific focus in this paper is to describe the process of finding affective gestures for interacting with a mobile service. Our idea is that gestures will address the body-part of emotions in people. When placed in an interaction that also speaks to our mind, the result may be an increased sense of actually communicating affect. Based on previous work in movement analysis [Davies, Laban and Lawrence], emotion theory building upon people’s everyday understanding of emotion states [Russell], and a study of an actor expressing emotional states in body movements, we identified three underlying dimensions of movements and emotion: shape, effort and valence.

To exemplify our design principles and our ideas of affective gestures, we approached the design of an application for a mobile setting, an affective messaging service. An important part of telephone communication is its usage to maintain intimate and close relationships between people [Castelfranchi]. In mobile phones this is done both through phone conversations but also through text messaging (e g SMS and MMS) [e g Grinter and Eldridge]. In the messaging interaction, the affective bandwidth is narrow, and most of the richness of the emotional content is lost. This also has a negative impact on the communicative bandwidth. The designed affective message application makes use of a combination of gestures and a pulse sensor as affective input, and uses emotional expressions in graphics (color, shape, animation) as output. An important goal is to mirror form and content of the gesture input in the emotional expressions added to the message.

Below we first describe our design principles in more detail, before we turn to the specific problem of designing the affective gestures. We describe our affective interaction model, which we name the affective gestural plane model. The mobile service for

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1 SMS: Short Message Service, used to send text messages between mobile phones.
2 MMS: Multi-Media Messaging Service, used to send multimedia between mobile phones.
affective messaging, which we describe last, exemplifies how our design framework and the affective gestural plane model might be applied.

2 Designing for affect

While early theories on emotions regarded emotions as discrete states [Ortony et al., Roseman et al.], later work has seen emotions more as processes and appraisal functions that regulate behavior [Paiva], not on or off singular states. As discussed by Castelfranchi, Castelfranchi, emotions are subjectively experienced states, and we all react differently depending on our background, our previous experience, our mental and physical state and other individual factors. Depending on the social setting we may also express our emotions differently. Expressing happiness during a football game will be quite different from expressing happiness at a business meeting. Thus, recognizing emotional states from biosignals or other physical or external signals is an extremely difficult task – especially in a mobile scenario with its ever-changing psychical and social contexts.

Therefore, emotions as part of human communication is better seen as a human, rich, enigmatic, complex, and ill-defined experience. This experience does not solely sit in the brain as part of a rational, cognitive reasoning process. Instead, body and mind are intimately connected [Davies, Dourish, Ekman, Laban and Lawrence, Picard], and emotions cannot be seen solely as a mental state but also a physical, bodily, state [Ekman, Picard]. Emotions can be generated through someone’s imagination without physical interaction, but they can also be generated from body movements [Ekman]. Try moving as if you are extremely happy and you will probably also experience a warm feeling that slowly grows inside you. It is quite hard to feel sad while jumping up and down and smiling.

In order to design for subjective affective experiences with a user-centered perspective that addresses both body and mind, we extracted four, interrelated design principles that we adjusted to the particular motives and needs of our design situation.

2.1 Embodiment

Dourish [Dourish], defines embodiment as “the creation, manipulation, and sharing of meaning through engaged interaction with artifacts”. By artifacts he does not only mean physical objects, but also social practice. Rather than embedding fixed notions of meaning within technologies, embodied interaction is based on the understanding that users create and communicate meaning through their interaction with the system and with each other through the system. The concept of embodiment allows Dourish to combine two trends from the human-computer interaction area; tangible interaction where interaction is distributed over the abstract digital world and objects in the physical world [Ishii and Ullmer], and social computing where social practice and the construction of meaning through social interaction is core in design [e.g. Bannon].

Designing for embodied affective interaction thus entails both looking for the physical artifact embodiment of abstract emotion concepts, as well as allowing for social practice and interpretation of meaning of the emotional expressions. The physical embodiment concurs nicely with the strong connection between body and emotion, as discussed above.

2.2 Natural but designed expressions

To get users physically involved, one approach is to build the interaction upon our previous physical and cognitive experiences of emotional processes. This approach can be applied to the design of the whole interaction, including both input and as well as output channels and the connection of the two in the application.

Human-computer interaction and human-computer-human interaction are not and should perhaps not be the same as human-human interaction. An application is a designed artifact and can therefore not build solely upon (whatever is meant by) “natural” emotional expressions. On the other hand, using mainly designed expressions bearing no relation whatsoever to the emotional experiences people have physically and cognitively in their everyday lives, would make it hard for the user to recognize and get affected by the expressions. Therefore we argue that emotional expressions should be aiming to be natural but designed expressions.

The specific focus of this paper is how to design for affective gestures. When studying the research done on gestures in computer interaction in general there are two main strands that exemplify the conflict: designed gestures [e.g. Long et al., Nishino et al.] and natural gestures [Cassell, Hummels and Stapppers]. Designed gestures can, for example, be resembled to sign language. The gestures make up a language and depending upon the complexity of the language, it may take quite some effort to learn. Natural gestures, on the other hand, aim to be easier to learn as they build upon how people tend to express themselves in various situations. Body language, posture and more conscious gestures, however, vary between individuals, cultures and situation. Thus, designers of gesture interaction often aim for designed gestures based on natural behavior, looking for the underlying dimensions giving rise to the specific movements.

2.3 Affective loop

The aim of the affective loop idea, is to couple the affective channels of users closely to those of interactive applications, so that the user’s emotions are influenced by those emotions expressed by or through the application, and vice versa. Through designing for physical expressions of the end-user (e.g. body posture, gestures, tangible input through toys, speech) that makes sense with regards to the design of the overall interaction or narrative or the system they interact with, we try to make users involved both physically and cognitively. By having users express their emotions in interacting with the system, they can be engaged in an affective loop, where their emotions are either affected or increased in intensity, either by the modality by which the emotions are submitted or as a response to output.

An example of a system that inspired and explored the affective loop idea is SenToy [Paiva et al.]. SenToy is a doll, which is used as an input device to a game. The end user interacts by acting out various emotions through movements with the doll. For example, to express anger, the user needs to shake the doll back and forth. The idea was that these body movements, together with the resulting activities appearing in the game progression would also influence users emotionally, both their body and mind.

The other part of the affective loop, the emotional output, concerns how the system in turn expresses its response to the user input. Some modalities, such as color and shape [Itten], movement, and music stand a better chance to address our physical experience. For example, according to Ryberg [Ryberg] humans have the same first instinctive reaction to colors. In movies music is used to put us in different emotional states [Bordwell and Thompson]. Bresin and colleagues [Bresin and Friberg] have produced a system, which given a piece of music can replay it to express different emotions.
2.4 Ambiguity

Most designers would probably see ambiguity as a dilemma for design. Gaver, however, looks upon it as “a resource for design that can be used to encourage close personal engagement” [Gaver et al.]. He argues that in an ambiguous situation people are forced to get involved and decide upon their own interpretation of what is happening. As affective interaction oftentimes is an invented, on-going process inside ourselves or between partners and close friends, taking on different shades and expressions in each relationship we have with others, ambiguity of the designed expressions will allow for interpretation that is personal to our needs. For example, if a system was to have buttons where each was labeled with a concrete emotion, users might feel extremely limited since they would not be able to convey the subtleties of their emotional communication to others.

Ambiguity may also follow from the ideas of embodiment, that sees meaning as arising from social practice and use of systems – not from what designers intended originally. An open-ended ambiguous design might allow for interpretation and for taking expressions into use based on individual and collective interpretations – both by sender and receiver of affective messages. Ambiguity in a system will perhaps also create a certain amount of mystery that will keep users interested. However, there needs to be a balance, since too much ambiguity might make it hard to understand the interaction and might make users frustrated [Höök et al.].

3 A model of affective gestures

While any service that attempts to instantiate the design ideas outlined above should be concerned with the whole interaction and not only one part of it, this paper will be focused mainly on the affective input side. As discussed above, we wanted to involve users physically with the application and our idea from the SenToy-work was that natural but designed gestures for affective expressions could be an interesting design alternative.

In order to find affective gestures that can express emotion, we turned to the work by Laban and his colleagues [Davies]. Laban was a famous dance choreographer, movement analyzer and inventor of a language for describing the shape and effort of different movements. His work will not lend itself to turning emotional expressions into a table with one-to-one mappings of movements to emotions – but his theories of movement can be used to understand the underlying dimensions of affective body behaviors.

To map emotional body behavior to Laban’s dimensions of movements, we invited Erik Mattsson 4, an actor, who works with counseling and education in human communication. We asked the actor to express nine different emotional processes in body language, while we videotaped him. In a questionnaire distributed to 80 SMS-users in Sweden we found the emotions they mostly wanted to communicate in mobile messages: excitement, anger, surprise-afraid, sulkiness, surprise-interested, pride, satisfaction, sadness and being in love.

Before we turn to the analysis of the movements, we need to introduce Laban’s formalism for describing movements and theories about shape and effort, at least at a shallow level, in order to understand the analysis of the actor’s expressions.

3.1 Shape and Effort according to Laban

Shape describes the changing forms that the body makes in space, while effort involve the “dynamic” qualities of the movement and the inner attitude towards use of energy [Zhao].

<table>
<thead>
<tr>
<th>Motion factor</th>
<th>Dimensions</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space attention to the surroundings</td>
<td>Indirect (flexible): spiraling, deviating, flexible, wandering, multiple focus</td>
<td>Waving away bugs, surveying a crowd of people, scanning a room for misplaced keys</td>
</tr>
<tr>
<td></td>
<td>Direct: straight, undeviating, channeled, single focus</td>
<td>Threading a needle, pointing to a particular spot, describing the exact outline of an object</td>
</tr>
<tr>
<td>Weight attitude to the movement impact</td>
<td>Light: buoyant, weightless, easily overcoming gravity, marked by decreasing pressure</td>
<td>Dabbing paint on a canvas, pulling out a splinter, describing the movement of a feather</td>
</tr>
<tr>
<td></td>
<td>Strong: powerful, forceful, vigorous, having an impact, increasing pressure into the movement</td>
<td>Punching, pushing a heavy object, wringing a towel, expressing a firmly held opinion</td>
</tr>
<tr>
<td>Time lack or sense of urgency</td>
<td>Sustained: leisurely, lingering, indulging in time</td>
<td>Stretching to yawn, striking a pet</td>
</tr>
<tr>
<td></td>
<td>Sudden (quick): hurried, urgent, quick, fleeting</td>
<td>Swatting a fly, lunging to catch a ball, grabbing a child form the path of danger, making a snap move</td>
</tr>
<tr>
<td>Flow amount of control and bodily tension</td>
<td>Free (fluent): uncontrolled, abandoned, unable to stop in the course of the movement</td>
<td>Waving wildly, shaking off water, flinging a rock into a pond</td>
</tr>
<tr>
<td></td>
<td>Bound: controlled, restrained, rigid</td>
<td>Moving in slow motion, tai chi, fighting back tears, carrying a cup of hot tea</td>
</tr>
</tbody>
</table>

Table 1: The dimensions of effort according to Laban as described by Zhao [Zhao].

Shape can be described in terms of movement in three different planes: the table plane (horizontal), the door plane (vertical) and the wheel plane, which describes sagittal movements. Horizontal moments can be somewhere in-between spreading and enclosing, vertical movements are presented on a scale from rising to descending, and sagittal movements go between advancing and retreating (Figure 1).

Effort comprises four motions factors: space, weight, time and flow. Each motion factor is a continuum between two extremes (Table 1).

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3 Laban’s theory oftentimes referred to as LMA (Laban’s Movement Analysis) is composed of five major components: body, space, effort, shape and relationship. The focus in our analysis is on effort and shape as these best describe the emotion expression contained in gestures.

4 http://www.ordrum.com/erik.html
In figure 2a we depict the graphs Laban uses to express effort. As an example, figure 2b presents an effort graph of the movement of inserting a light bulb where the movement is direct in space, light in weight, sustained in time and bound in control.

### 3.2 Analysis of emotional expressions in body movements

All of the emotions that the actor was asked to perform may of course give rise to a whole range of different body movements depending on the setting, the background and previous experience of the person, personality, culture and various other factors. This act is only one way that these emotions can be expressed.

Even though, the actor was asked to perform nine distinct emotions, his act was more like a process working on the concept of each given emotion, going from starting the expression to “feeling” it more and more, expressing it stronger, and then varying it using various alternative interpretations of when this emotion would arise. In figure 3, an example of the actor’s expression of each emotion is depicted. The analysis, however, was performed on the whole sequence of expressions for each given emotion. Two independent persons (two of the authors) did the same analysis of the videotape, after which notes were compared and discussed.

#### 3.2.1 Shape and effort

Using Laban’s theories of shape the actor’s interpretation can be described as follow:

- Excitement – extremely spreading, rising and advancing movements.
- Anger – somewhat spreading, rising and advancing movements.
- Surprise-afraid – enclosing, somewhat descending and retiring movements.
- Sulkiness – enclosing, somewhat rising and retiring movements.
- Surprise-interested – somewhat spreading, neutral in the vertical plane and advancing movements.
- Pride – somewhat spreading, rising and somewhat advancing movements.
- Satisfaction – neutral in all planes of movements.
- Sadness – enclosing, descending and retiring movements.
- Being in love – somewhat spreading, somewhat rising and somewhat advancing movements.
- Being in love – somewhat spreading, somewhat rising and somewhat advancing movements.

Figure 4 presents the corresponding effort graphs using Laban’s notation.

From looking at our analysis of emotional body language the nine emotions, presented in figure 4, can be divided into three groups with different effort levels, starting with the one with highest effort:

1) Excitement, anger, surprised-afraid
2) Sulkiness, surprised-interested, pride, satisfaction
3) Sadness, being in love

This far we had worked with two variables, shape and effort, but the different emotions are still clustered, for example excitement and anger have nearly the same shape descriptions and exactly the same effort graphs (Figure 4). Therefore, we looked for a third variable, which we found in Russell’s “circumplex model of affect” [Russell].
3.2.2 Valence

In the “circumplex model of affect” psychologist Russell looks at emotions in terms of pleasure and displeasure (here named valence) and arousal. Since a high degree of effort brings a high degree of arousal and vice versa Russell’s analysis of emotions concurs nicely with Laban’s theories of movements. Thus, valence is our third variable. In a series of studies Russell established that people have the same mental map of how emotions are distributed in a system of coordinates where the y-axis is the degree of arousal and the x-axis is the valence (Figure 5). The subjects, for example, placed angry and delighted on the same arousal level but with different valence.

3.3 Designing emotional expressions with a basis in shape, effort and valence

To conclude the above analysis it is necessary to set up a combination of shape, effort and valence to create an affective interaction were it is possible to express all kinds of emotional states without resorting to a one-to-one mapping. It is not necessary, however, to incorporate all dimensions: shape, effort and valence, into a new modality. It can likewise be a combination of the modality and emotional expressions in the interface. We will show an example of the latter in the next section.

Figure 3: Emotional body language expressed by the actor.

Figure 4: Emotional body language expressed in effort graphs.

Figure 5: Russell’s “circumplex model of affect” [Russell].

4 A mobile service for affective messaging

The goal of the affective message service is to provide users with a means to enhance their messages with emotional expressions. With today’s technology, such as MMS, users can add photos, colors, sound or animations to messages, but it is quite time-consuming, difficult to create on the fly and to get the right expression of such a messages. Instead, our idea is to build an interactive service on top of the MMS-technology that expands on the expressive power while still allowing for ambiguity and open interpretation of the affective content.

In the questionnaire (mentioned briefly above) the answers indicated that most users feel limited or alien to expressions such as smilies as a means to express emotions in text messages. Not only is the emotional content restricted but also the emotional interaction with the other party. In a phone conversation, the voice itself can be a bearer of emotional content that complements what is being said. Thus, both parties in the conversation receive too little emotional feedback and are provided with too little emotional expressive power when composing or receiving text-messages. The users in our questionnaire expressed a need for a richer medium.

Below follows a description of the mobile service and thereafter we will explain how shape, effort, valence and the four design principles are incorporated.

Our design example is an emotional text messaging service built on top of a SonyEricsson P800 mobile terminal, where the user can write a text message and then adjust it to fit the emotional expression they want to achieve. The adjustments are mainly done through affective gestures, but with a little mystery added through obscuring the input through mixing it with measurements of the users’ pulse. The affective gestures performed with the stylus used with the P800 terminal, together with the pulse will render an animated background with an emotional expression to the user’s text message. Figure 6 shows a usage scenario.
4.1 Shape, effort and valence in the interaction

We use Russell’s “circumplex model of affect” (Figure 5), as the basis for the interaction. The user will be moving around in the circular space of emotions expressing effort and valence of their emotional state through combinations of two basic movements that when combined can render an infinite amount of gestures. We call these combinations of the two movements the *circumplex affective gestures* (Figure 7):

- Moving along the valence scale towards displeasure is done through increasing the pressure on the stylus, decreasing the pressure on the pen results in higher pleasure on the valence scale.

- Shaking and making faster movements, with the hand holding the pen, requires more effort and therefore result in higher arousal, while more swinging, not so direct movements result in lower arousal.

The circumplex affective gestures are inspired by the shape, effort and valence analysis. Emotions with negative valence are associated with strain and tension, while positive emotions often involve less pressure and strain. Emotions with high effort are stronger in weight, more flexible in space and quicker in time, while emotions with less effort are less controlled, lighter and smaller in space. While the user is performing the circumplex affective gestures, the system is responding through showing the emotional expressions in color, shape and animations as indicated in figure 8. The emotional expression works like an animation in

The user starts to write a text message. At the starting point the pressure on the pen and the pulse of the user decides the emotional expression of the animated background.

While the user writes her message the background is still animated but keeps the initial expression.

When the message is written, new input from the pulse of the user influences how strong the expression of the message will be.

If the expression does not fit the message written, the user can adjust it through the affective gestures.

...until the user finds an expression that suits the message.
the background of the message, giving the writer immediate feedback on the appearance of the message (Figure 8a). The user activates this input by holding in a button on the pen. Once the user finds the expression she wants, the button on the pen is released and the expression is thereby chosen.

The animations allows the different emotions to float into each other similar to how Russell argues that emotions blend into one another and do not have any defined borders. Still, the characteristics of each emotion found in the analysis of body movements are clearly represented through the choice of colors, shapes and movements. Most of the emotions, or their position in Russell’s circular model, can be expressed through colors. Red represents, according to Ryberg, the most powerful and strong emotions. Moving along a color scale ending with blue would be moving towards calm and peaceful emotions. The strength of an emotional state could then be expressed in terms of deepening the color. In this example we are not working with the actual text in the message, neither with sound, but it is something that can be added in future work. Much can be done with different typefaces, sizes and animations of text, [Forlizzi et al.], sound and music can also convey emotional content [Bresin och Friberg ].

As an example, the characteristics of the emotion excited entail much energy, it is high in effort, and the movements are extremely spreading, rising and advancing. This can be used to create an animation and coloring as in figure 9 (where the animation cannot be shown in this paper).

The circumplex affective gestures would probably render a predictable and thereby less interesting interaction. We therefore decided to add the pulse sensor, which is integrated in the pen, measuring the user’s pulse while writing.

The model combining pulse with the pressure on the pen, as shown in the usage scenario, decides where in the circular space of emotions the user initially starts:

- If your pulse is high and you are holding the pen firmly, you will start where there is high effort and negative valence
- With high pulse and a lighter grip around the pen you will end up where there is high effort and positive valence

Figure 7: The circumplex affective gestures.

Figure 8: The affective gestural plane, a. showing how the output is expressed when interacting and b. showing how the pulse decides the width of this plane, presented in light to strong colors.
- Low pulse and a firm grip will put you where there is low effort and negative valence
- Low pulse and a lighter grip will put you where there is low effort and positive valence

On the other hand, it is also important that the interaction device does not take on any personality or emotional state in itself. It must not look like some character or carry a specific expression [Andersson et al.], but instead be bland enough to carry users’ intentions. Making a pen that is quite characterless, but still emotionally appealing will provide a suitable artifact for affective computing but still keep the user focused on the interaction. Figure 10 shows a design example.

4.2 Incorporation of design principles

The design principles introduced above, all played an important role in the design of the affective message service. **Embodiment** is realized both in terms of the actual physical interaction with the extended stylus, as well as through how the user will experience the circumplex affective gestures as such. The two taken together, embody and aid users to externalize the internal emotional states they want to convey.

The principle of **Natural but designed expressions** is incorporated through the circumplex affective gestures and the interactive feedback that are designed to resemble the shape, effort and valence of natural emotional movements. Since the design is trying to address both body and mind the emotional state of the user is reinforced not only through the gestures, but also through the response that the system generates, and therefore the interaction will involve the user in an affective loop. While not discussed in this paper, the interaction with the receiver of the affective message will also constitute another affective loop interaction.

**Ambiguity** is achieved in the affective gestural plane model as well as in the interactive feedback. The pulse sensor creates a small proportion of mystery in the interaction, thus keeps the user interested in exploring their emotional expressions further. By using circumplex affective gestures to navigate the affective gestural plane, we avoided that one gesture corresponds to one emotion, and instead created an interaction where users can create their own language and make their own interpretations of the interactive feedback.

5 Summary

We have shown how to go from a user-centered perspective, involving both body and mind, via theory of movements and emotional expressions, a study of an actor and his emotional expressions, to a specific design of a set of circumplex affective gestures for expressing emotion to a mobile messaging service.

We are aware of that this work is somewhat cultural dependent, however, we find this piece of work valid and interesting as input even if not entirely possible to generalize irrespective of culture and personality.

In particular, we have identified three underlying dimensions of bodily emotional expressions: **shape, effort and valence** that we have incorporated in the design of our mobile service both in the affective gestural plane model as well as in the interactive feedback. This frees us from design solutions that assume that users will be in discrete, well-defined emotional states, where one gesture (or input signal) corresponds to one emotion. Instead our specific design approach allows for an interpretative, interactive cycle with the emotional output that will place users, and their interpretation of emotional expressions and needs for how to express themselves, at core. This diverts from the existing trends in affective computing, where the focus is not on the emotional experience as such but on recognizing and adjusting to what the system believes that the user is feeling.
References


Paper B
Through the *eMoto* design, we intend to emotionally engage users both cognitively and physically using a tangible interface, allowing for affective gestures that are mirrored in the expressions produced by the system. A questionnaire sent to 66 potential users showed a need for richer emotional expressiveness in text messaging in mobile phones than what is available today. Emotions are expressed not only through what is said, but also through body gestures and tone of voice— mediums not available in this context.

*eMoto* is an emotional text messaging service built on top of a SonyEricsson P900 mobile terminal. The goal of this service is to provide users with means to emotionally enhance their SMS messages. The user first writes the textual content of the message and then adjusts the affective background to fit the emotional expression she wants to achieve. The adjustments are done through affective gestures (Fig. 1) that will render an animated background acting as an emotional expression to the user’s text message (Figs. 2, 3, 4, 5 and 6). The P900 terminal is used with a stylus pen. We have equipped this pen with two sensors that will recognize the affective gestures: an accelerometer and a pressure sensor. In a first prototype, the extended stylus is connected to the serial port of a stationary PC, which in turn communicates with the P900 terminal—in the final prototype, this will be a direct wireless communication channel between the stylus and P900 terminal.

In this specific design, our aim is to let users consciously express their emotions. This should not entail a simple one-to-one mapping of emotions to specific expressions. Instead, we build the interaction on the fact that emotions should not be seen as singular, discrete states, but instead as processes that blend into one another. Through creating the interaction model based on Russell’s circumplex model of affect [3] (Fig. 7), we could create a system that allows users to choose emotional expressions that best suit their messages. Without explicitly naming each emotion in the interaction, we maintain open interpretations of emotional expressions. In Russell’s model, emotions are seen as a combination of *arousal* and *valence*. By combining two basic movements that together can render an infinite amount of affective gestures (Fig. 8), the user will move around in this circumplex plane. Technically, we have made the plane 100 times larger than the screen of the mobile phone (Fig. 9). This, in combination with the affective gestures, will have the user experience a kaleidoscopic effect when choosing between the vast amounts of emotional expressions. We call this the *affective gestural plane model*. The two basic movements for construction of affective gestures are *natural but designed expressions*, extracted from an analysis of body movements [1]. The arousal of emotions is communicated through movement, where intense shaking of the stylus will increase arousal and a more swinging movement will imply lower arousal (Fig. 8). To navigate to emotions with negative valence, the user has to increase the pressure on the stylus, while less pressure will transfer the user to emotions with positive valence (Fig. 8).

The affective gestures are closely connected to the affective feedback that the user receives as visual output. The characteristics of emotional expressions found in the analysis of body movements are represented through colours, shapes and animations in the design of the affective feedback. Colours are used to express arousal, where red represents emotions with high arousal and blue is calm and peaceful [2]. The shapes of the animated objects in the areas containing high arousal are small and can, therefore, render animations and patterns that are energetic, quick and spreading. Moving around the circle towards less energy and calmer expression, the shapes get bigger and more connected, rendering slower and more billowing animations. Shapes placed on the positive side of the circle are softer and more round, while shapes placed on the negative side are more...
Fig. 1 The tangible interface; interacting through affective gestures using the stylus

Fig. 2 One way of expressing quite relaxed, through a green/yellow colour and animated objects that are quite big and connected in their shapes

Fig. 3 One way of expressing more relaxed than in Fig. 2, through deeper green colours that are closer to one another and larger animated shapes

Fig. 4 One way of expressing a little excited, through a red/orange background and a few, small, round objects with fast movements in the background

Fig. 5 One way of expressing more excited than in Fig. 4, through a deeper red colour in the background and with even larger and more animated objects

Fig. 6 One way of expressing tired/bored through dark blue colours, big, connected shapes and slow animations
angular and sharp. The emotional expressions are stronger along the outer border of the circle while weaker towards the middle; this is represented through less depth in colours and fewer animated elements (Fig. 10).

A user study of the affective output has just been completed. A few expressions need to be redesigned, for example, negative emotions with high arousal were rendered in too bright colours and some of the shapes were too depictive and thereby hindered users from reading their own interpretation into them. The big picture, however, showed a great interest in this new way of communicating emotions and that users perceived most expressions as intended.
Fig. 9 The kaleidoscopic effect of the interactive feedback when navigating the affective background circle.

Fig. 10 The affective background circle, showing how the colours, shapes and sizes of objects vary together with Russell's circumplex model of affect.
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Paper C
eMoto – Affectively Involving both Body and Mind

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ABSTRACT
It is known that emotions are experienced by both body and mind. Oftentimes, emotions are evoked by sub-symbolic stimuli, such as colors, shapes, gestures, or music. We have built eMoto, a mobile service for sending affective messages to others, with the explicit aim of addressing such sensing. Through combining affective gestures for input with affective expressions that make use of colors, shapes and animations for the background of messages, the interaction pulls the user into an embodied ‘affective loop’. We present a user study of eMoto where 12 out of 18 subjects got both physically and emotionally involved in the interaction. The study also shows that the designed ‘openness’ and ambiguity of the expressions, was appreciated and understood by our subjects.

Author Keywords: Affective interaction, gestured-based interaction, user-centered design, ambiguity

ACM Classification Keywords
H.5.2 [Information Systems]: User interfaces – graphical user interfaces (GUI), interaction styles, screen design, user-centered design.

INTRODUCTION
Research in psychology and neurology shows that both body and mind are involved when experiencing emotions [2,3]. Emotions influence somatic signals, hormones, heart rate, and body movements, and sometimes emotions become reinforced or even initiated by such bodily signals [4]. Thus, it should be possible to design for stronger affective involvement with artifacts through addressing physical, bodily interaction modalities. Tangible interaction [8], gesture-based interaction [1], and interaction through plush toys and other artifacts [9], are all examples of such physical modalities.

The feedback from the system, in turn, may also make use of a range of sub-symbolic expressions addressing our sensual emotional experience. Instead of focusing on expressing emotions through ‘labels’ of emotions or facial expressions of interactive characters, we can make use of colors, shapes, animations, sounds, or haptics.

Our approach to affective interaction differs somewhat from the goals in affective computing [10]. Instead of inferring information about users’ affective state, building computational models of affect and responding accordingly, our approach is user centered. Users should be allowed to express their own emotions rather than having their emotions interpreted by the system.

We have summarized our design aims into what we name an affective loop. In an affective loop, users may consciously express an emotion to a system that they may or may not feel at that point in time, but since they convey the emotion through their physical, bodily, behavior, they will get more and more involved with the experience as such and with their own emotional processes. If the system, in turn, responds through appropriate feedback conveyed in sensual modalities, the user might become even more involved with the expressions. Thus, step by step in the interaction cycle, the user is ‘pulled’ into an affective loop.

Our aim is to create affective loop applications for communication between people. The process of determining the meaning of a message with some emotional expression is, similar to any human communication, best characterized as a negotiation process. The message is understood from its context, who the sender is, his/her personality, the relationship between sender and receiver, and their mutual previous history. Through the sensual modalities and with somewhat ambiguous and open-ended designs such a negotiation process is possible.

To better understand whether and how it is possible to create a user-centered affective loop for communication purposes, we have designed, implemented and evaluated a mobile service named eMoto. eMoto is a mobile messaging service for sending and receiving affective messages [6].

EMOTO
eMoto is built in Personal Java and runs on P800 and P900 mobile phones, two of Sony Ericsson’s Symbian phones, both have touch-sensitive screens that the user interacts with through a stylus pen. see Figure 1. In eMoto, the user first writes a text message and then finds a suitable affective expression to add to the background of her text message. To find this expression, the user navigates in a background of colors, shapes and animations, see Figure 3, through using a set of affective gestures, see Figure 2. The gestures are picked up with an accelerometer and a pressure sensor that...
we have added to the stylus pen, see Figure 1. The colors, shapes and animations in the background of the message aim to convey more of the emotional content through the very narrow channel that a text message otherwise provides.

We aim to avoid a one-to-one mapping between emotion, gesture and expression. Instead, there is a certain level of ambiguity which allows people to express themselves in their own personal way. This is inspired by the work by Gaver et al. [7]. But where Gaver and colleagues define and make use of ambiguity to make users reflect on and appropriate technology, our aim is just to create some space for individual interpretation of the expressions.

Affective gestures
As we aim to make the user emotionally involved in a physical sense, it is important that the gestures we pick are not singular, iconic or symbolic gestures, but gestures that give rise to a physical experience that harmonizes with what the user is trying to express. An angry gesture should feel angry when performed. It needs to be sustained for a certain period of time, not too long, nor too short, in order to be experienced.

To achieve some of this naturalness both gestures and graphical expressions are designed from an analysis of emotional body language where we have used Laban-notation to extract underlying dimensions of emotional gestures [5]. However, the exact gestures of emotional body language are highly personal. In eMoto the gestures are therefore not specified in detail. Instead the system captures the underlying dimensions of emotional gestures in terms of movement and pressure. This design decision came from an analysis of emotional body language where it became apparent that even though negative and positive emotions not always differ in terms of arousal, most negative emotions have more tense expressions. Therefore the affective gestures in eMoto are set up as combinations of valence, ranging from negative to positive emotions, expressed in terms of level of pressure and amount of arousal communicated through more or less movement; see Figure 2, describing the four extreme gestures. However, in between those extremes there can be a whole range of combinations of movement and pressure.

Affective expressions
The characteristics of emotional body language were also applied on the design of graphical expressions in the background of the messages as described above. The expressions used in the background, formed as a circle, are non-symbolic and designed from what is known about the effects of colors, shapes and animations (see Figure 3).

The resulting colorful circle is a hundred times larger than the screens of the P800/P900 mobile phones. Thus only a small proportion can be seen at a time. As users can navigate freely around the entire circle and decide to stop anywhere, there is a large amount of expressions to choose from.

We first did a user study of the colors, shapes and animations before they were combined and evaluated together with the affective gestures – as described below. The results confirmed that our aim to let people express themselves differently was possible and viable – without becoming completely random and confusing.

USER STUDY
Our main aim with setting up a qualitative study of eMoto was to see if our idea of capturing the underlying dimensions of emotional gestures was enough to make users emotionally involved in the sense defined by our affective loop idea.

Figure 1: The extended stylus and a P900 running eMoto
Figure 2: The Affective Gestures
Figure 3: The Affective expressions (the animations can be seen on www.sics.se/~petra/animations)
We recruited the subjects through putting up notes around Kista, a working area outside Stockholm, asking for female subjects between 25 and 35 who were frequent mobile phone and SMS (Short Messaging Service) users. 18 subjects signed up for the user study; six master students, two PhD students, four working with PR and marketing, five software developers and one journalist, 24 < 28, 6 < 35 years old. 12 subjects had mobile phones with MMS functionality and 7 subjects had a camera on their mobile phone. Each subject was given two movie tickets in reward for the one hour they spent in the study.

The study started with a questionnaire to determine subjects’ mobile phone and computer usage, and also some of their personality. To capture users’ first intuitive ideas of what gestures to use for various emotions users’ first practical task was to perform gestures holding the modified stylus expressing the emotions angry, excited, satisfied and sad. The system did not give any feedback at this point. Then users were placed in a more realistic setting were they were presented with four scenarios, summarized in Table 1, to which they were asked to find suitable affective expressions. Finally, the subjects got to answer a second questionnaire, this time about their experiences with eMoto.

RESULTS
The results are structured into two parts. First we discuss the success of the emotional gestures as such. Second, we present the results that have to do with the affective loop, that is, the subjects’ emotional involvement when combining the gestures with the affective expressions.

Affective gestures
If we compare the characteristics of movements implemented in eMoto (see Figure 2) the gestures have nearly the same characteristics as most subjects ‘naturally’ came up with when asked to improvise with the stylus, see Table 2. Thus, our initial analysis of emotional body language seems to have led us in the right direction and the interpretation of gestures vis-à-vis the actual artifact (the extended stylus) was able to carry the same kinds of behavior.

For the more realistic task interacting with the prototype, all subjects interpreted the scenarios, ‘the racist doorman’, ‘the perfect job’, ‘the ex boyfriend’ and ‘the hammock’, as emotions very similar to respectively angry, happy, sad and content. Users got more emotionally involved with this task, probably because they were imagining actually being in that scenario. Thus, in one sense, the gestures subjects performed here (presented in Table 3) might be considered to be even more ‘natural’ than the gestures in the first task.

A difference between the gestures, as described in Table 1 and 2, is that all gestures in the latter are ‘sustained’. That is, subjects had to keep on doing the same gesture over and over in order to get the system to continue to move in the circle towards the expression they wanted. As discussed in the introduction, if users have to keep on doing a gesture for too long, we risk loosing their emotional involvement. On the other hand, the gesture must not be too fast, especially not for emotions with less arousal, such as sadness. Thus, our timing needs to be slightly altered to better capture different emotional experiences.

Emotionally involved in an affective loop
Most of the subjects got more relaxed and found the study more enjoyable when they got to do the gestures to express emotions in the scenarios. Figure 4 shows that the users not only got emotionally engaged with the gestures, but also that their whole appearance changed, in particular their facial expression. The first picture shows a subject engaged with ‘the racist doorman’ scenario. She not only had a stern facial expression and bit her teeth together really hard, but she also uttered (all citations are translated from Swedish by the authors):

“Now I’m really pissed and it’s night time and we were gonna have fun together and...”

The second picture shows a subject engaged with ‘the perfect job’ scenario. This subject waved her hand in the air and smiled. In the third picture a subject engaged in ‘the ex

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Most common gesture</th>
</tr>
</thead>
<tbody>
<tr>
<td>The racist doorman</td>
<td>Repeated hard striking</td>
</tr>
<tr>
<td>The perfect job</td>
<td>An immobile hanging arm</td>
</tr>
<tr>
<td>The ex-boyfriend</td>
<td>Wavy movement high up in the air</td>
</tr>
<tr>
<td>The hammock</td>
<td>Just holding the stylus gently</td>
</tr>
</tbody>
</table>

Table 3: Most common gestures used by the 18 subjects when interacting with the prototype
boyfriend’ scenario expressed depression both in her face and in how she just hang her arm down with a very loose grip on the stylus. Finally, in the last picture the subject was neutral and she just held the stylus in her hand for ‘the hammock’ scenario. A video analysis, based on the authors’ interpretation of the subjects’ usage, their facial expression and their general appearance, was conducted to summarize the subjects’ emotional involvement when interacting with the scenarios. 12 subjects got engaged with ‘the racist doorman’, 15 with ‘the perfect job’, 14 with ‘the ex-boyfriend’ and 16 with ‘the hammock’ scenario.

A small group of subjects (6 subjects) had a more difficult time than the rest of the subjects to relax and be engaged with the prototype and the scenarios.

In the final questionnaire the first question was about using gestures to express emotions. When comparing the answers to this question with the results from the video analysis it became even more apparent that there were two groups of users. 12 subjects felt relaxed when using their body language:

“Cool! It really feels like I’m communicating the emotions I’ve got without being aware of them.”

Six subjects were very uncomfortable in doing so:

“Hard! Partly because you have so different strength and partly because it’s basically hard.”

**SUMMARY**

The study indicates from the analysis of facial expressions and the users own reports that most of the time they got both physically and emotionally involved. Interesting is probably the need to work further on the duration for each gesture. Some emotions seem to require a fairly long, sustained gesture, while others are better expressed in a quick gesture done once. However, not all of our subjects did get involved with the gestures and affective expressions. The initial questionnaire revealed that this can partly be explained as a mismatch between their personality and the targeted user group for eMoto. In general, some users might be more open to physical, bodily expressions than others. Again, further studies are needed to disentangle whether this is the reason behind this difference.

**REFERENCES**

Paper D
IN SITU INFORMANTS EXPLORING AN EMOTIONAL MOBILE MESSAGING SYSTEM IN THEIR EVERYDAY PRACTICE

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Abstract
We have designed and built a mobile emotional messaging system named eMoto. With it, users can compose messages through using emotion-related gestures as input, rendering a background of colours, shapes and animations expressing the emotional content. The design intent behind eMoto was that it should be engaging physically, intellectually and socially, and would provide for an aesthetic experience. In here, we describe the user-centred design process that lead to the eMoto system, but focus mainly on the final study where we let five friends use eMoto for two weeks. The study method used combined Experience clips – where one user is equipped with the system and a friend acts as a spectator documenting experiences of use in situ – with Cultural probes – a set of provocative materials that users respond to and thereby document their own practice and understanding of the system. The five users and five of their friends acting as spectators were able to report and reflect on their communication patterns, their friendships, their physical, intellectual and social experience of their own emotions and reactions to the emotional messages they received. We have chosen to name the five users and their spectators \textit{in situ informants}, highlighting how this combination of user-centred study methods helped us enter and explore the subjective and distributed experiences of use, as well as how emotional communication unfolds in everyday practice when channelled through a system like eMoto.

1 INTRODUCTION
Researchers in HCI (Human-Computer Interaction) have been discussing how to move from a restricted focus on users’ cognitive understanding of interaction and instead begin to design for an integrated physical, intellectual and social experience (e.g., Boehner et al., 2005; Dourish, 2001; Fagerberg et al., 2003; Moen, 2006). It has been argued that we need to shift from the old dualistic view on mind and body as separate entities, as well as from a dualistic perspective on cognition as separate from the surrounding social and physical environment. Instead, the aim should be to design for \textit{embodied interaction}. The question is what design processes and methods that will lead to such a design? How can we involve users in the design process? And what should an artefact be like to invite for interpretation, reflection, appropriation and empowering users in the everyday lives – both physically but also in a way that harmonizes with their everyday practice? And once such a system is designed and implemented, how can we study whether and how users pick it up and integrate it with their daily practices?

The work presented here focuses on design that attempts to embody and represent the experience of an engaging and emotionally fulfilled conversation. We aim for what McCarty and Wright define as an \textit{aesthetic experience} of technology (2004). An aesthetic experience is much more than simply a
beautiful experience. It is an experience that emotionally affects the user, perhaps not immediately but after some time provides for a deeper reflection and understanding of some aspect of her life.

In here we describe how we have designed and subsequently deployed a mobile service, eMoto, to explore how a small group of friends communicate. Communication of emotions seen from this perspective is not simply an information transfer problem; it is about physically and intellectually experiencing the whole range of emotions that make up a conversation. We name them affective loop experiences, experiences where it is not possible to separate the intellectual from sensual experiences, nor to single out what is my individual experience from the overall experience arising in a dialogue with a friend, from previous friendship, and deep physical and emotional communication with one-another.

This means that we cannot evaluate our system in a laboratory setting where the user is separated from her friends, distanced from her everyday practices and everyday environment, and where the system is not integrated with all the other tools, artefacts, practices, routines and daily activities that we all engage in – the continuous improvisation that life is made up of (Suchman, 1987). We therefore turned to and combined three methods that all focus on entering people’s lives as they occur in situ. First, Cultural probes (Gaver et al., 1999) a method where people are given means to report on personal and subjective experiences themselves. Second, Experience clips (Isomursu et al., 2004), which is a method that relies on a friend, a spectator; to help obtain data on how some recently designed artefact is used. Finally, the system is regarded as a partly unfinished, provocative artefact where parts of the design are intentionally left open-ended and ambiguous for the users to fill with their interpretation and meaning through their use over time. Placing eMoto in real use, is similar to what is intended by the Technology probe method (Hutchinson et al. 2003), where partly unfinished designed artefacts are entered into people’s everyday lives to make them explore, experience and then reflect on how they would like a similar or new medium to be designed.

2 THEORETICAL BACKGROUND AND DESIGN INSPIRATION

Our long-term goal is to design artefacts that provides for affective loop experiences (Fagerberg et al., 2003). In order to figure out what such a design should look like and to create a system that users are willing to integrate with their everyday lives, we took ideas of embodiment as our theoretical home and starting point. Dourish describes embodiment as a process of designing from a basis in the familiarity we all have with the everyday world that we live in (Dourish, 2001). By this, we do not mean some simplistic notion of “naturalness” or imitation of, for example, bodily gestures expressing emotion. Anything we build will always be a designed artefact affording certain behaviours that we design for and that people learn to make use of to express themselves. But the basis for the design process is to look for those aspects of communication that feel familiar to us and that fulfil the kinds of communication needs we have in our everyday lives. As emotional experiences are not limited to our conscious, intellectual processing, but also to the entire body, the approach is to build the interaction
upon our previous physical and intellectual experiences of emotional communication processes, where
the expressions are to be natural but designed. But what is natural for some user is not always natural
for another. The physical and intellectual emotional experiences people have are highly individual and
dependant of the specific context. Some users might need a lot more expressiveness to become
affected, while others might be uncomfortable with too overtly displayed or expressed emotions.
Therefore ‘natural but designed’ expressions should be open enough in their appearance for users to
put in their own interpretation of the meaning and allow for many different variants of behaviour. The
design must be such that it balances the need for individuality in expression while at the same not
being completely random and thereby cause confusion.

The way we see an affective loop is as an interaction where the user first expresses her emotions
through some physical expression, for example, through gestures or manipulations of an artefact. The
system (or another user through the system) then responds through generating an affective expression,
for example, colours, animations, haptics, or some other sensual feedback. This in turn affects the user
(both intellectually and physically) making the user respond and step-by-step feel more and more
involved with the system. A successful tool for expressing emotions should for the most part be
experienced as an extension of our aim to communicate emotions to a friend in the sense as what
Heidegger refers to as ready-to-hand (Heidegger according to Dourish 2001). As soon as the tool does
not work as an extension and the user will have to shift her attention to the actual tool, it becomes
present-at-hand, and then stops the user from being emotionally engaged in an affective loop
experience.

According to Dourish (2001) embodied interaction focuses not only on what is being done but also on
how something is being done. The concept of embodiment allows Dourish to combine two trends from
the HCI area: tangible interaction where interaction is distributed over the abstract digital world and
objects in the physical world (Ishii and Ullmer, 1997), and social computing where social practice and
the construction of meaning through social interaction is core in design (e.g. Höök et al., 2003). But
when embodiment has been used to design computer artefacts, the focus has not been on the actual
bodily experiences of interaction.

Moen (2006) focuses on bodily experiences in her work on kinaesthetic movement interaction. What
Moen wants is to make use of the human kinaesthetic senses and use movement both as input and
output to some technical artefact. One can argue that she in a way has taken the other extreme of a
dualistic mindset, focusing entirely on the bodily interaction and not at all on the intellectual aspects of
the interaction. This provocation might be needed to more concretely incorporate bodily experiences
in interaction design. Moen points to the fact that we in the western world today mainly use our bodies
to accomplish various tasks, but we very rarely reflect over naturalness of the movements or how they
physically affect us.

Thus, design should be rooted in an understanding of everyday practices not only in terms of social
and tangible interaction processes, but as one that involves the physical human body in ways that
makes us experience, in this case, our emotions through movement. An affective loop design should allow for a powerful emotional experience while communicating with and through the system. Through the ideas of an affective loop we want users to also reflect more on what emotional communication actually involves, in terms of both physical and intellectual experiences. We also wanted to provide for a communication channel between friends that would be emotionally expressive and could be integrated, embodied, with its social and contextual setting. According to Sengers and colleagues (2005) reflection is about bringing unconscious aspects of experience to conscious awareness. Sengers and colleagues argue that the way Heidegger has been understood in HCI means that reflection is put in opposite to usability. Instead they argue for reflection as part of a holistic experience. While we do not think users want to be reflective in every single situation and we do not either wish to require such activity, reflection can arise as a consequence of use over time. A method they use and also a method that Hutchinson and colleagues (2003) have been using to explore users’ reflection is to give users technology probes to encourage them to see things in their lives that are there but perhaps aspects they do not normally think of or discuss much. After using these probes for some time, users start, step by step, to reflect. In the study discussed in this paper, we hoped to see a similar, slowly arising reflective process, where users would become increasingly aware of their inner, physical experiences of emotions as well as their social role in their communication with their friends. Similar to Sengers and colleagues, we aim for our technology probe to open for appropriation and personal interpretation by the users and thereby we would see the traces of their reflection on their own communication.

3 DESIGNING EMOTO

Our overall aim is to design for emotional communication. However, for us to know anything of how such activities take place and evolve in everyday practice we need to reach into the everyday lives of our users. Our approach has therefore been a user-centred, iterative design process where we have involved users throughout the design process. Following on Dourish’ ideas of designing from familiarity we first of all conducted an analysis of emotional body language (Fagerberg et al., 2003). This was followed by iterative user encounters in the laboratory to verify that each part of eMoto worked as intended (Höök, 2004) before eMoto could be tested in situ.

3.1 An Analysis of Emotional Body Language

To capture the familiarity of emotional body language and the underlying experience dimensions of movement, we used Laban Movement Analysis (LMA) to extract the shape and effort in movements (Davies, 2001; Laban and Lawrence, 1974). The Laban notation is presented in more detail in an earlier paper (Fagerberg et al., 2003), but, in short, shape describes the changing forms that the body makes in space, while effort involves the dynamic qualities of the movement and the inner attitude towards use of energy.
The analysis was performed on nine different emotions (excitement, anger, surprise-afraid, sulkiness, surprise-interested, pride, satisfaction, sadness and being in love) as expressed by an actor. Even though the actor was asked to perform nine distinct emotions, his way of acting out those emotions was more like a process working on the concept of each given emotion, going from starting the expression to feeling it more and more, expressing it stronger, and then varying it using various alternative interpretations of when this emotion would arise. The LMA was performed on the whole sequence of expressions for each given emotion, although summarized into one effort graph and one description of shape for every emotional process.

As we did not want to resort to some simplistic one-emotion-one-gesture solution that would reduce emotions to separate entities mapped to symbolic gestures, we looked for an emotional model that also could hold the subjective and personal characteristics of emotions. Dimensional models of emotions focus on the experience of emotion processes, both on a low level (as in the limbic parts of the brain and in the body), but also on a higher, cognitive, level (Scherer, 2002). In psychologist Russell’s dimensional model, named the circumplex model of affect, (1980) emotions are seen as combinations of arousal and valence (Figure 1). Since a high degree of effort brings a high degree of arousal and vice versa Russell’s analysis of emotions concurs nicely with Laban’s theories of effort.

![Figure 1: Russell’s dimensional model, named the circumplex model of affect.](image)

### 3.2 eMoto

We therefore took the results from the LMA and decided to alter the design of the stylus that come with Sony Ericsson’s P800 and P900 mobile phone series so that it could pick up on users’ gestures. We added an acerolometer and a pressure sensor to the stylus, ending up with the design that can be seen in Figure 2. The negative end of the valence-scale in Russell’s model became associated with more pressure on this extended stylus. The positive end could be reached by less pressure. The high

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1 eMoto is built in Personal Java and runs on Sony Ericsson’s P800 and P900 mobile phone series.
arousal end is reached by moving the stylus more and more, while the low arousal end of the scale is reached by less movement of the stylus. By combining pressure and movement the user moves around in Russell’s circumplex model of affect. This meant that the design is not limited to use of the actual visual shape of the gestures but instead make the design so that different users can make the gesture with different shapes depending on their willingness to exhibit big, visible gestures or just small, less visible ones. In both cases, the same inner experience of the gesture in terms of effort and shape should be possible. Pressure and movement manage to achieve this as both can be done either visibly, violently, or through smaller movements. (Figure 3)

![Figure 2: eMoto – The Technology Probe.](image1)

![Figure 3: The eMoto gestures.](image2)

But in order to provide for an affective loop, the system needs to respond, preferably in some sensual modality that reflects and reinforces users’ experience of what they are trying to express. We decided to create combinations of colours, shapes and animations that are added to the background of users’ text messages. The colourful, animated background was designed with a basis in the same LMA and Russell’s dimensional model as the gestures – aiming to mirror one modality in the other. Colours are used to express arousal, where red represents emotions with high arousal and blue is calm and peaceful (Ittens, 1971). The shapes of the animated objects in the areas containing high arousal are small and can therefore render animations and patterns that are energetic, quick and spreading. Moving around the circle towards less energy and calmer expression, the shapes get bigger and more
connected, rendering slower and more billowing animations. Shapes placed on the positive side of the circle are softer and more round, while shapes placed on the negative side are more angular and sharp. The emotional expressions are stronger along the outer border of the circle while weaker towards the middle; this is represented through less depth in colours and fewer animated elements. (Figure 4)

![Figure 4 – The eMoto-circle (the animations can be seen on emoto.sics.se/animations/).](image)

Neither the gestures nor the graphical expressions should be mapped to any specific emotion in a one-to-one mapping. The graphical expressions and the range of possible gestures blend into one another and are designed in an open-ended way to allow for many different interpretations. Thus, we believe users must experience what Moen describes as a *bilateral interaction*, interaction where the tangible both lets the user physically express herself with it but also returns haptic feedback to those expressions (Moen, 2006). In the eMoto case, this is communicated through a feeling of softness in the material of the stylus.

Interaction with eMoto proceeds as follows: first users write the text of their message, similar to a SMS. They then use the stylus, pressing and moving it while watching the screen to see how the colours, shapes and animations change. Once they reach a part of the circle that they find suitable to their message, they click on the send button and the message is sent. The receiver will see both the text but also the graphical background if they have eMoto installed on their phone. If not, they can look it up by a specific web-address.

### 3.3 Iterative User Encounters

Through the whole design process we used a Persona to focus both the design process but also to help us choose the informants to our studies (Cooper, 1999). According to Cooper the Persona method is the opposite of designing for the *elastic user* that tends to make the user adapt to the system rather than the other way around. In the Persona method the design team makes use of a very specific individual, a persona, who is given a name, a picture and a precise description of her goals and needs. This helps the team to resolve design issues when they arise during the design process.

The Persona set up for eMoto is named *Sandra* (Figure 5). In short she is a confident 29 year old woman who likes to spend time with her friends and family. Sandra does not care much of how things
work technically, but she likes new cool “techy” features and she is very happy with her new mobile phone that has camera and MMS functionality. Sandra’s main aim with her mobile phone is to keep in touch with family and friends.

Figure 5: Sandra, the persona for the eMoto project.

Besides bringing in a few potential users here and there during our design process, we also needed to perform a couple of more organised studies where we “staged lived experiences” (Iaccuci and Kuutti, 2002). We needed to check whether the gestures and the graphical expressions were understandable and usable in the way we intended to them to be. This followed Höök’s two-tiered evaluation method (2004), which emphasises the need to first make sure that any emotional input or output to a system is indeed interpreted correctly by end-users before evaluating the overall aims with the system. Thus, before we conducted the real life evaluation presented here, we performed two separate user studies of the two parts of the eMoto system: the graphical expressions and the gestures. While these studies were done in a lab environment, we tried to stage the setting through using scenarios that we hope the users could relate to.

The first validation focused on the graphical expressions and was conducted in a lab environment with 12 users working in pairs, using the co-discovery method (Dumas and Redish, 1994). The results are presented in more detail in (Ståhl et al., 2005) but in short we found that the users described properties of the graphical expressions that could be mapped to what we had found in the LMA. While the graphical expressions are abstract and ambiguous, users were still able to recognise them and relate to them. The expressions felt familiar and users could relate them to physical, sensual, emotional, experiences. They were also ambiguous and open-ended enough to let the users choose different expressions depending on the context of use and users’ individual preferences and personality. When asked to point out where in the circle which emotion was most prevalent, users for the most part choose places in approximately the same area. But some parts of the expression circle had to be redesigned. The expressions aimed to portray negative emotions with high arousal were contradictory in their appearance, the colours expressed more positive valence than aimed for while the shapes and the animation expressed the intended negative stance. There were also some parts of the expressions that contained shapes that were too depictive in their appearance. For example, one shape in the
negative valence part of the background could be interpreted as a rose, which in our culture is symbol for love. The graphical expressions were subsequently redesigned and the new expressions were used together with the gestures in a second user study.

In this second user study 18 users, this time brought in individually, got to try the redesigned graphical expressions together with the gestures. The results are presented in (Sundström et al., 2005), but in summary the study showed that most users got both physically and emotionally involved in the interaction. The combination of gestures, graphical expressions, and the intended emotions overall seemed to be harmonizing, even if minor adjustments were needed. The extended stylus was able to carry movements that resembled and reminded our users of their sensual experiences of emotions. Users performed, for the most part, the same kind of gestures (despite not being told which gestures to use) and they picked background expressions in approximately the same areas to express similar emotions related to the scenario we placed them in. Users who were more similar to the targeted user group, who were similar to our persona Sandra, seemed to like Moto better and more easily got engaged with the gestures and the interaction.

One conclusion from this study was the importance of explicitly designing the technology to concern also the duration of gestures. Gestures for low arousal and negative valence need to be sustained for a longer time in order for users to experience them as negative, while expressions for high arousal and positive valence need to be quick and performed in intervals. If the latter is pro-longed for too long, users feel dis-embodied and loose their sense of being inside the physical experience. This design problem was solved through letting the timing between gestures and graphical response become different for different parts of the eMoto-circle.

4 IN SITU EXPLORATION

Given that we had tested the usability aspects of eMoto’s in the lab, we could now move on and give the eMoto-probe to a small group of friends to be used as part of their everyday practice and everyday experiences. By giving it to a group of friends who already had strong relationships to one-another we hoped to see how eMoto would be picked up and integrated with their communication needs and how well it would allow them to express their feelings in personal yet interpretable ways. Through this in situ exploration, we hoped to move beyond the simplistic scenarios we had imagined for its usage.

Isomursu and colleagues have proposed a method they name Experience clips (Isomursu et al., 2004), to be used when evaluating mobile services. The mobile service is given to a user and a friend of the user, the spectator, who is provided with a camera and other documentation facilities and asked to send back feedback on how the user is experiencing the system. In Isomursu and colleagues’ study users took turns in being the user and the spectator. Users got to use mobile phone applications and they were asked to focus on feelings, emotions and subjective experiences, aspects that are very hard to capture with traditional methods. As we were hoping to get insights on how friends engage emotionally with one-another and in a sense with themselves through the engagement with the eMoto-
gestures, the spectator should be someone who knows the user well. Emotional body language can be highly individual and hard to interpret unless you know someone well. In addition to the Experience Clip method, we added the Cultural and Technical probes methods. In a Cultural probe method, participants are typically given a range of materials, such as a diary, a disposable camera and postcards, together with a set of provocative tasks and questions that makes participants reflect over some aspect of their life (Gaver et al., 1999). The obtained data from such a study are then used exclusively as design inspiration and should therefore not be seen as a method for gathering data to prove some particular point in a scientific sense. Variants of the method have made use of digital equipment, using for example mobile phones and text messages to prompt participants with questions (Hulkko et al., 2004). Technology probes were proposed by Hutchinson and colleagues (2003). Their idea was to place partly unfinished technology in people’s homes and then study how participants made sense of it.

Kaye and colleagues have made use of a combination of a cultural probe and a technology probe as a method for exploring how to design for intimacy (Kaye et al., 2005). Their aim was to make users reflect more on their relationships and communication of intimacy and thereby gain insights into the role that minimalistic communication channels can play in helping to keep partners close. They gave users both a tool, the VIO system, serving as a technical probe, and at the same time cultural probe material that they could use to document their experiences of the VIO system.

For the eMoto-system, we have a similar purpose to that of Kaye and colleagues. We want our users to reflect over their emotional experiences and how they are shaped and communicated in dialogues with their friends and in this case with and through the eMoto system. We therefore also made use of eMoto as our technical probe, some cultural probe materials to help the user document and reflect on their own experience of communication through eMoto, and finally, we made use of the Experience Clip method to obtain data from a spectator on our users experiences.

### 4.2 Procedure

The two weeks of usage by the five users took place in September 2005. The five users were each given probe material consisted of a notebook, postcards, a disposable camera and the technology probe, eMoto. That is, we let them borrow a Sony Ericsson P910 mobile phone that was wirelessly connected to the extended eMoto-stylus we had built. The five users’ spectators each got another set of probes material: a notebook, some postcards and a small video camera, see Figure 6. The probes also contained letters indicating what kinds of issues we were interested in, e.g. signs of physical engagement and emotional expressions, and suggestions for some tasks they could perform in order to document their initial and later experiences of the eMoto-usage. For example, they were given the task “send an happy emoto to someone today”.

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After the two weeks we quickly went through the material from both users and spectators grouping it with our log data and from that created a first, draft analysis of each user’s experiences. This served as a basis for individual interviews with the five users.

During the interviews the users were also asked to go through all emotos they had sent and received and divide them into two groups; *authentic emotos* that expressed some emotional value and *tests* that were sent either to explore the service or simply because they felt obliged to since they were participants in a study.

### 4.3 The Five Users

<table>
<thead>
<tr>
<th>Users</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agnes</td>
<td>A 25 years old behavioural scientist living in Uppsala (a city, 70 km outside Stockholm), but at the time of the exploration she still took a few courses and worked extra in the support office at one of Sweden’s larger phone companies. She had her boyfriend as spectator and she was the only one who knew all the other women in the group.</td>
</tr>
<tr>
<td>Isabella</td>
<td>A 26 years old Consultant in the energy sector living in Stockholm. Isabella lived a busy working life in Stockholm and since she did not live with anyone she had two spectators, her cousin and one of her friends. Isabella is an old friend of Agnes and she did not know any of the others in the user group from before.</td>
</tr>
<tr>
<td>Louise</td>
<td>A 25 year old student, writing her master thesis in Technical Biology at the Royal Institute of Technology (KTH) in Stockholm. Louise lived alone and therefore she asked one of the other participant’s (Susie’s) spectator to be her as well. Louise knew and still only knows only Agnes and Susie.</td>
</tr>
<tr>
<td>Susie</td>
<td>24 years old, wrote her master thesis in Technical Biology, in Uppsala where she lived. Her roommate worked as her spectator and they meet up with Louise a couple of times during the weekends. Before the exploration Susie knew primarily Louise but also Agnes. During the two weeks she not only spent more time than she had done before with Agnes she also became good friends with Mona.</td>
</tr>
<tr>
<td>Mona</td>
<td>A 25 years old School of Economics graduate from Uppsalas, as Agnes, she still took a few courses and worked extra in the support office at one of Sweden’s larger phone companies. Living together with a few of her friends, she had her roommate as spectator.</td>
</tr>
</tbody>
</table>

Table 1: Description of the five users.

We found the five users through contacting one of the participants, Agnes\(^2\), from one of the previous studies of eMoto (Sundström et al., 2005). She fitted well with the persona *Sandra* (see above) and she had indicated that she really liked eMoto. As we wanted eMoto to be used by a group of friends, Agnes in turn asked four of her friends to participate. The five women who took part in this user study were *Agnes, Isabella, Louise, Susie* and *Mona* (see Table 1).

\(^2\) All users’ names are fictional.
5 RESULTS

Below we have divided the results into three categories: first *emotional communication through eMoto* where we focus on what was being communicated, how it was received and interpreted, second *experiences of the sensual aspects of eMoto* concerning how we with eMoto in some ways managed to provoke the users to reflect more on the physical and perhaps more unconscious aspects of emotional communication, and finally *experience of an In Situ Exploration* reporting on the method as such and whether we were able to reach into the everyday lives of our users and their everyday practices and experiences.

Let us first provide a brief summary of the data we obtained; in total 96 emotos were sent with the eMoto service during the two weeks; 53 of those were sent as *authentic emotos*, messages the users said they sent in order to express an emotional value while 43 emotos were sent in order to test and explore the functionality of the service. Table 2 shows how much of the probes that we returned from the in situ informants.

<table>
<thead>
<tr>
<th>Log data and returned probes</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agnes 33 sent emotos and 28 received, 38 SMS left in memory, 5 postcards, ~8 minutes of experience clips, her and her spectator’s notebooks</td>
<td></td>
</tr>
<tr>
<td>Isabella 16 sent emotos and 10 received, 0 SMS (she unfortunately had to carry also her regular phone), 2 postcards, ~7 minutes of experience clips, her and her spectator’s notebooks</td>
<td></td>
</tr>
<tr>
<td>Louise 11 sent emotos and 10 received, 2 SMS left in memory, no postcards, no experience clips and no notebooks</td>
<td></td>
</tr>
<tr>
<td>Susie 13 sent emotos and 13 received, 13 SMS left in memory, 2 postcards, ~10 minutes of experience clips, her notebook but not her spectator’s</td>
<td></td>
</tr>
<tr>
<td>Mona 23 sent emotos and 17 received, 11 SMS left in memory, 3 postcards, ~11 minutes of experience clips, her notebook but not her spectator’s</td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Log data and returned probes from the in situ informants.

5.1 Emotional Communication through eMoto

eMoto entered into an already existing web of friendships where some were stronger and others weaker, some were unbalanced where one party needed the relationship more than the other, or where one party was more expressive and responsive than the other. The way eMoto was picked up reveals some of what is communicated in a circle of friends. For the participants, the introduction of eMoto also put the spotlight on some aspects of their friendships and caused different kinds of reflections, not only of eMoto, but also of the participants’ personalities and how their friendship was functioning, their personal way of expressing yourself, what they want to reveal and what not.

5.1.1 Reinforcing friendships: past, present, and future

As discussed by Vetere and colleagues (2005), in intimate relationships people use small signs of affection, like a special gentle stroke or keeping gifts from your partner that can then be used as proxies, in order to maintain their mutual contact. In the use of eMoto, we found that there was a
special “rhythm of friendship” that needs to be maintained in order to keep it alive. It involved talking about past events, planning for future events, repeating special, meaningless jokes known only by the two friends, or in general just showing some presence – I am here, I still remember you, we are friends (or when communicating with a boyfriend outside the eMoto-study: expressing love). In figure 7 we see five examples of such messages.

In the first message, Agnes expresses her love for her boyfriend. This is probably not news to her boyfriend – no new information is conveyed – she just feels the urge to express it. The background she has picked for her message comes from a part of the circle that we had intended to be somewhere in between angry and happy, but Agnes interprets it in her own way:

“This looks almost angry, but it is not, really. It is like, but oh... […] It looks somewhat edgy but at the same time as it is feels like it could be some kind of warm streams with like love like this. But it is somewhat too edgy for me to interpret it as love. I would have had somewhat more round, soft, maybe somewhat pulsating or something […] It was this one that I felt fitted best to it.”

Thus, she puts her own interpretation of what the love between her and her boyfriend looks like into this picture. When Mona communicated her love to her boyfriend (message two in figure 7), she instead used her favourite colour, green, to express love to her boyfriend:

“Green is my favourite colour and my boyfriend knows that, so this is why it is green because he knows that I think that green is a lovely colour, just as lovely as he is.”

Both these messages are examples of the need to express those intimate “I am still here for you”-messages in styles that makes sense to the sender and receiver. There is a potential here for developing an intimate “gesture” that can be used and re-used by the couple (or two friends) to repeatedly communicate their closeness for no other purpose than maintaining the relationship when apart.

The third emoto presented in figure 7 is an example that does not make sense to anyone else but the two friends. This message was written by Louise and sent to Susie. In the interview after the study, Louise explained how she and Susie both liked a Swedish song by a musical artist named Timbuktu where one of the lines in the lyrics is “hej hej hallâl”. This was a standing joke between them,

Figure 7: Five example emotos of reinforcing friendships.
expressing irony in a way that we still think only Louise and Susie understands. The background of this message is the centre of the eMoto-circle. Often this part of the eMoto-circle was chosen because it had bits and pieces of all emotions and still none in particular. Here it is probably used to emphasise the ironic use of this joke between the two friends.

The fourth message in figure 7 is an example of the second most common tempus used between friends – expressing hopes about future experiences. Here the friendship is re-instated by talking about future events when they will connect again and do things together. They often used emotos to explain how they were looking forward to something or preparing for a mutual future. Planning for and showing that you remember the plans you make with your friend is an important part of the rhythm that keeps the friendship alive.

The last emoto in figure 7 shows how the users often express several moments in time in the same message – relating to events of the present, the past as well as the future. This specific message was sent by Louise to Susie and expressed how Louise was sorry for “stealing” Susie’s roommate Suss. Suss is Susie’s roommate in Uppsala but when visiting Stockholm she stayed overnight at Louise’s place. During Louise’s and Susie’s interviews we got to know that this message, between the lines, also dealt with an issue that had become a problem to Louise. Louise had a hard time finding a spectator to the eMoto-study. Our interpretation is that she is a somewhat shy and reserved person and therefore avoided the task of finding someone who would be willing to document her interactions with the eMoto system. Susie had chosen Suss as her spectator and Louise now took the chance and asked Suss to act as her spectator as well (something which in the end did not really happen). In her message she is apologizing for “stealing” Susie’s spectator for a while. Apart from this, the message also re-instates the relationship to Susie through the question about whether she was having fun. Finally, Louise talks about her expectations for their upcoming party the following Saturday. Regarding the choice of the background expression for this rather complex message, Louise said the following:

“Like this kind of ‘sorry that I nicked her’ and then we were probably about to go to bed right just about then as well, so to have like that somewhat half good night.”

Our interpretation is that she both wanted to express gratefulness for borrowing Suss and the choice to make it perhaps darker than we would expect came from wanting to express something that resembled the darkness of the night. This, in itself is an interesting way that the eMoto-expressions may be used. The graphical expression is used to resemble the surroundings, the night, and not only the inner experience of emotions. Below we will continue to show how eMoto in many ways manage to embody much more of a communicational setting, such as the environmental and social setting, and not simply be a channel for transfer of information of emotional states.
5.1.2 Balancing friendships – being responsive

Friendships are not necessarily easily maintained. Sometimes they are unbalanced in the sense that one friend is putting more effort into the relationship than the other, or needs the other more. The communication patterns between friends have to be handled delicately in order to not overstep the invisible border lines to where you feel intruded or neglected by the other. eMoto sometimes put a spotlight on those processes, perhaps making those imbalances more visible than otherwise. While this might be seen as a worrying aspect of the eMoto-design, this is an unavoidable part of friendships and one that people worry about, discuss and brood over a lot in their lives. If eMoto cannot be used to make such processes accessible, we argue that the design would be a failure.

Figure 8: Three example emotos of imbalances in friendships.

In the first message in figure 8 Isabella is sending a message to Agnes that Agnes feels compelled to reply to. It was sent at a time when Isabella was stressed and tired due to her situation at work, which Agnes knew about and understood. But Agnes was also disturbed by this message. She explained afterwards during the interview that she felt unpleasantly pushed by this message. She did not like to have messages that demanded her reply and she in some ways did not feel so close to Isabella. Agnes herself avoided sending any negative messages where an encouraging reply is required by the other party. This rule of behaviour she took for granted as a norm. Looking at the distribution of each user’s authentic emotos (Figure 9) it became apparent that Agnes did not use the negative side of the eMoto-circle. She simply avoided sending messages that would require consolation or empathy return messages. As can be seen in figure 9, the rest of the friends’ emotos were distributed over the whole eMoto-circle.

Figure 9: Distribution of the authentic emotos that were sent, presented separately for each user from left to right: Agnes’, Isabella’s, Louise’s, Mona’s and Susie’s.
Also Agnes’ spectator commented on Agnes’ more cheerful nature:

“Most emotos that she sent seemed happy, only on a few occasions did she do restrained movements with the pen. This is probably because Agnes seldom sends depressed SMS anyway.”

Agnes feels that Isabella is overstepping a line here in their friendship, at least a line that needs to be drawn in this particular communication media. The second emoto in figure 8 shows Agnes’ reply to Isabella, where she obviously, in spite of what she said above, has been affected by Isabella’s emotional state. If we look careful at figure 9 we can see that this is the only time Agnes went outside the first, positive, quadrant of the eMoto-circle. What Agnes does in her reply is that she tries to cheer Isabella up by both showing empathy with Isabella’s working situation but also by congratulating her on her name day. Agnes explained how she this time simply wanted her emoto to look beautiful, and she was not so concerned of what emotions the expressions she had chosen actually communicated:

“I was trying to kind of put together something nicely looking as well sometimes [...] I knew what kind of background as I wanted in order for it to become a good-looking emoto and it kind of communicated that which I wanted it to communicate, then that there might not be any emotion behind it but instead it is... yes, it is simply a congratulation”.

The third message in figure 8 was in fact sent by Agnes to herself but from Louise’ phone. After having sent and received emotos during a few days Agnes started to reflect on what relationships she actually had with her friends, something she probably already were aware of at some level, but that the introduction of eMoto made more overtly visible. According to Agnes, Mona ‘impersonated eMoto’. By that she was attempting to express how she more and more came to enjoy Mona’s expressions and ways of using eMoto. She also saw Mona as a person very similar to herself. Louise, on the other hand, was not responding to the eMoto-communication and was not sending any emotos. Agnes was getting more and more annoyed by this fact:

“Louise is kind of funny anyway. She could have totally wrong mappings against mine kind of [...] She probably cannot express her emotions.”

Having these thoughts Agnes, at a party that Louise hosted, essentially stole Louise’ phone for a while and, as she said, “helped” Louise to express herself. She basically took Louise’ phone and sent an emoto to herself. During the interview Agnes said:

“Since I am rather full of myself, I sent a ‘you are so good’ message to myself”.

Every new communication medium requires time to develop its own communication patterns and norms, but these examples show how a new medium introduced into an existing practice of communication between a group of friends may well make one of those invisible boarders we draw in our relationships to others unpleasantly visible, even requiring action. Agnes has to reply to Isabella’s
request – otherwise she would harm their relationship – and so she does, even if reluctantly. The choice of background and the contents of the message to some degree communicate this duality. She does not dwell on the work situation but just briefly tries to cheer up Isabella. Regarding the message sent by Agnes from Louise’s phone, Agnes’ explanation to this message came after we had met with Louise so unfortunately we never got Louise’ perspective on how she felt about this rather ‘blatant’ action of Agnes. Having all the messages in front of her, Louise during her interview simply did not remember sending this message and was actually a bit confused about it. Thus, she never really got the provocation that Agnes put out there for her to react to. The lesson learnt from eMoto compared to many other intimate communication technologies (e.g. Gaver, 2002), is that only providing for simple, positive reinforcements of intimacy will not create for a rich enough communication channel. Close friendships must also allow for negative, unbalanced, messy relationships – this is life – not Hollywood.

5.2 Experiences of the Sensual Aspects of eMoto

Throughout the examples above, we can see that the eMoto-circle is not used in a simplistic one-emotion-one-expression manner mapping emotions directly to what you are experiencing at the time of sending an emoto. Instead the graphical expressions are appropriated and used innovatively to convey mixed emotions, empathy, irony, expectations on future experiences, surrounding environment (the darkness of the night) and in general a mixture of their total embodied experiences of life and in particular, their friendship.

But eMoto was also designed to create physical, sensual experiences and our design aim was to make that aspect well-integrated with the overall experiences. We hoped that the physical side would, after some training, become an unreflected, embodied part of the interaction, ‘ready-to-hand’ (Heidegger according to Dourish 2001) – something that only happened to some extent. With eMoto we wanted to provoke users to reflect more on the total experience of how they communicate emotions. Sensual and more personal experiences are most often thought of as second to the aim of getting some information across, this while these experiences are important both to how we learn about ourselves but also to how we see and understand others.

Whilst being inside the interaction experience, it is hard to reflect on the physical aspects of the interaction, especially in those instances when it works well because then the interaction disappears into the activity. But as we came back to them and interviewed them afterwards, such a reflection could take place as they could see the experience clips of themselves using eMoto and also look back at the emotos they had sent.

These more sensual aspects of the experience clips are however hard to retell in textual form in this report, and also most experience clips were more spectators interviewing the users than users actually being filmed emotionally engaged with the system. An example though, is an experience clip of Isabella when she constructs an emoto being emotionally engaged in the gestures and the emoto she is
in the process of creating, but also by the loud music she is listening to at the same time. In Figure 10 we provide a series of snap shots from this clip where one sees her body dancing to the music, singing along at the same time as she is gesturing with the eMoto-pen.

Figure 10: Snap shots from one of Isabella’s experience clips

In the spectators’ notebooks we have been able to find textual comments from a more observing perspective, on how users got emotionally engaged with eMoto:

Agnes’ spectator: “When she was happy she showed that with her whole body, not just her arm was shaking but her whole body while a huge smile appeared on her lip.”

Isabella’s spectator: “Uses more expressions when using eMoto than when using SMS.”

In the users’ notebooks and afterwards during the interviews we could see that the users after a while started to reflect more on these sensual aspects of communication. First though, the users seemed to have been mostly annoyed with the gestures. They quickly became fond of the graphical expressions and liked using those to express themselves, but they did not really understand why they had to find those expressions by the use of gestures, an interaction model they initially thought simply made things more complicated. The wireless Bluetooth connection between the stylus and the mobile phone out in “the wild” seemed to again have introduced delays between gestures and feedback that we previously had worked with in the laboratory. For a while it looked as if this obstacle would stop the users from incorporating our technology probe into their everyday lives, but as it turned out, it seemed to be what really triggered them to reflect on these more sensual aspects of communication:

Mona: “I leave out things I think are implicit due to the colour… the advantage is that you don’t have to write as much, it is like a body language. Like when you meet someone you don’t say ‘I’m sulky’ or something like that, because that shows, I don’t need to say that. And it’s the same here, but here it’s colour.”

Mona: “It is nice to be able to express an emotion, and it feels good to be able to do it purely physically.”

Both Agnes and Mona discussed how there might be different reasons to express emotions physically depending on whether they are negative or positive. They wanted to reinforce happy feelings and
relive those again and again through physical movements. But for the negative feelings, the need is different, perhaps instead to get rid of them through physical movement:

Agnes: “Do one really wants to reinforce the expression through movements? Presumably if one is happy, but not if one is sad… or not I anyway. Angry perhaps works fine. To relief one’s anger. […] I mean, most often when one gets pissed one wants to kick and perhaps throw things.”

Mona: “When one says ‘now I’m f**king irritated’ then one stops a little bit being so irritated, and it becomes a little bit the same thing here, if one shook it off it disappeared a little bit.”

As mentioned above, eMoto in a good way addresses “the rhythm of maintaining a friendship” and thus, our users found that the gestures perhaps would have made much more sense if the receiver had experienced the physicality of what the sender had gestured. The mirroring of the gesture in the animations of the eMoto-circle was not enough for them to warrant the gesturing. Agnes, for example, proposed some ideas for how we could work with more physicality on the receiver end by using haptics and thereby make the gestures more important in the interaction at the sender end. She also told us of how it works when Harry Potter’s mum wants to yell at him and then sends him a digital scream. Her idea was that sounds could enhance a more physical experience on the receiver side.

Another issue with the gestures was that they in this (in situ) study, were exposing the users’ interaction to others in public environments. Similar to the laboratory studies there were of course situations in which our users were not exposed to strangers, like when composing emotos in their home or alone walking in the woods. But bringing the technology to an everyday use context also involves more public spaces were the gestures have to be performed in front of other people, something Isabella commented upon in her diary:

“Used eMoto ‘publicly’ today, in the middle of the town. Noticed that I was restrictive in my movements. I was going to show a buddy how it works. But [I] shook it only discreetly, through [I] put more pressure on it. Somewhat interesting to think about that afterwards. At home I shake it violently, but out there I don’t. Must use eMoto more often in public environment to see if my behaviour is changed, that is, will I feel more comfortable with it after a while?”

eMoto needs to be redesigned so that it makes use of less visible movements in order to meet the needs for privacy in public spaces. On the other hand, many mobile phones have gestural interaction (for example, the SPH-S4000 and SCH-S400 Samsung phones in Korea), and so such behaviour might become more socially accepted with time (similar to how we now accept that people speak in their ear-pieces while walking around in grocery stores – sounding as if they are speaking to themselves).

While we might speculate that the design problems with the eMoto-pen on some occasions might have created disembodied experiences, and this prevented a complete aesthetic experience, we can from the informants’ comments and activities see that eMoto still was able to provoke the users to reflection and that there were several embodied, successful interactions.
5.3 Experience of an In Situ Exploration

The combination of experience clips and a cultural probe that we made use of in this study, proved to be very successful in documenting the effects of our technical probe. We got insights into our users’ everyday life, the social roles they took on in their friendship group, and their uptake, use and interpretation of eMoto that none of our previous laboratory-based studies had been able to capture. For example, in our laboratory studies, we saw that scenarios were very important for how our subjects could interact with eMoto, but writing scenarios is not an easy task (Iacucci and Kuutti, 2002). The scenarios we put into that study we can, in retrospect, see had very little to do with our subjects real use of eMoto in their daily life. We used scenarios such as “I was stopped in the door because of a racist doorman” and “I got the job I applied for out of a thousand applicants” which involved very extreme emotions experienced at the time of sending the emoto. What our circle of friends actually communicated about when using eMoto for real was more on a level of constantly establishing and re-establishing their relationships.

Through involving users in the process of documenting and interpreting their own activities with eMoto, it was also possible to deal with and understand some of the more creative usages of eMoto. For example, stealing Louise’ phone and creating a message from it, arranging an eMoto-pub-get-together in order to explore eMoto in a public space together, were activities that we could not have envisioned or re-created in a laboratory setting.

Since users were able to use eMoto in their daily lives for as long as two weeks we think we received data on a more analytic level than for example comments on usability and first impression. It was notable that problems the users found also did not stop them in their investigation. Instead they thought of ways for us to solve these problems and how and when a service such as eMoto would be useful. All, except for Louise, explicitly stated they wanted to keep eMoto after the two weeks were over.

Having a spectator for two weeks was on the other hand a bit difficult. The spectator could of course not be there all the time and was perhaps not there when the most exciting experiences occurred. From the spectators point of view it became a problem that they were not users themselves. For a similar user study in the future we would have to work more on the incentives of spectators. Perhaps we should take inspiration from Isomursu and colleagues’ work where the participants took turns in being user and spectator.

But not everyone will be willing to enter study like the one described here. Our experiences with Louise, who did not make use of eMoto extensively, points not only to the importance of finding the right user group for an application like eMoto, but also how important it is that subjects feel at ease with the study method itself. In that sense, this method might not be useful to reach a representative selection of the intended user group if it includes users who are more ‘private’.
If we bring our technology probes out in situ they will also be exposed to greater expectations than in a user study taking place in a more staged environment, such as the laboratory. The further we take our prototypes towards being experienced as products the further we have to bring them to a level of actually being products. All informants in this in situ exploration of eMoto, for example had problems with the form factor of the extended stylus:

Mona: “The stick is too big & tall & looks like a dildo. I know I shall try to look beyond the technical, but it undeniably restrains usage.”

Still, we could see that the methodology encouraged the users to find solutions to the problems they saw instead of simply complaining about them. Agnes for example suggested how we instead of the stylus could work with the new trend of having gadgets attached to the mobile phones, she suggested a ball that the users could press, move and squeeze as they wish, a ball that would be attached to the mobile phone and both play the part of a mobile phone decoration and a tangible for interaction.

6 CONCLUSIONS

First of all, the results confirm that emotional communication must not only support some simplistic notion of transferring ‘information plus emotion’ from one friend to another. Instead, it must provide ways to maintain the sometimes fragile communication rhythm that friendships require. It also needs to provide users with open-ended ‘surfaces’ that allow for their own personal ways of expressing themselves to one-another. An important lesson was how an emotion does not belong to one individual alone, but is something that permeates the total situation, changing and drifting as a process between the two friends communicating, based on their previous encounters and knowledge of each other, the particular social and physical setting they are in when they communicate, their intimate, well-known gestures, and their own personal needs for communication.

We also gained insights into the under-estimated but still important physical, sensual aspects of emotional communication. We learnt that the physical expressions used by the sender should be experienced as physical by the receiver as well. That would make it possible for these behaviours to develop into the kinds of familiar gestures between friends that fulfil their communication needs. The particular design we choose for the physical, sensual aspect of emotional communication involved gestures that are not as private as other modalities. The results show that users limit their gestural interaction in public settings. But we also noted that a greater physical expressivity in some situations was what really got them emotionally engaged – providing for an aesthetic affective loop experience. Through this and the previous user studies of eMoto we think we have found ways of designing for personality in the gestures but perhaps we need to work more on how they can be adapted to different public settings.

It is also apparent how sensitive these bodily expressions are to aspects of novelty and privacy. While our users seemed to have an easier time to expose themselves and their inner feelings through the
graphical expressions, the gestures exposed them in ways that made them want to hide in their shell. Obviously, the public aspect of the gestures is part of this, but on the other hand we express ourselves physically all the time through our body language, body posture and facial expressions. It might be that a future design needs a tighter connection to what we are familiar with from our everyday practices and experiences – a design that will not expose users so publicly.

On the methodological side the user-centred design process and final study of eMoto provides some important lessons to be learnt by the field of affective interactive design research. Designing artefacts aiming to embody a richer experience of communication is not possible from some abstract emotion theory only and it will not be achievable in a laboratory setting. A more ethnographic approach probably could have come closer to the same results as we did in this study, but we believe that the combination of a technical probe and the *in situ informants* made it possible for us as outsiders to reach further into the everyday, private lives of our users and better understand the communication needs of their intimate friendship. The methods we used helped us provoke our users to reflect upon the more unconscious and subjective experiences of everyday life and their embodied experiences of emotions.

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Probing the Potential of Non-Verbal Group Communication

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ABSTRACT
Designing for non-verbal communication using e.g. gestures and other bodily expressions is difficult. Hardware and software need to be co-designed and harmonize in order to not throw users out of their embodied experience. We aim to design for kinaesthetic expressions of emotion in communication between friends – in this case, colleagues at work. A probe was built using sensor node technology designed to let users express themselves and their emotional state to a public and shared display where the expressions together formed a collective art piece expressing the individuals but also the group as a whole. Two groups of colleagues used the probe during two weeks. It came to serve as a channel in which some conflicts and expressions of social relations were acted out which were not openly discussed in the office. It exposed different roles and balances in relationships in the group. Finally, the probe taught us the importance of balancing the design for joint group expression and individual, personal expressions. The study also allowed the participants to experience the sensor node-‘material’ – enabling a participatory design process.

Categories and Subject Descriptors
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design

Keywords
Richer expressiveness, friends at work, technology probe, autobiographical design.

1. INTRODUCTION
A subfield of Human-Computer Interaction (HCI) has focused on designing for supporting awareness of remote presence or activity in the workplace [5, 12] and in the home [3, 21]. Most of these systems aim to increase efficiency of work tasks or to manage family activities, but recently there has been a shift from more information oriented systems to keep track of co-workers or family members, to those that try to embody a general sense of presence of others to provide comfort, a sense of togetherness or strengthening the ties between people [20]. Aspects of those ties are, in some systems, designed to be expressed in terms of kinaesthetic, gestural expressions. There are several systems that are designed for romantic couples [7, 27], individual reflections on your own physical, emotional status [25], and enhanced emotional expressivity in person-to-person communication [23, 26]. But there has been little focus on kinaesthetic expressions of emotion and closeness in communication within groups of users, in particular for colleagues at work.

The boom of sensor-technologies offers new materials that can potentially be used to create for embodied, physical presence of others. Some sensor-technologies are spread in the environment, as in sensor networks, and some we strap onto our bodies for sports- and health applications. These sensor technologies allow for gestural interaction [2, 24], picking up on bodily, emotional signs and signals [18, 26] and together with actuators, such as haptics or interactive plush toys [17] they create for a new exciting design arena. We can use all these new interaction opportunities to capture and build upon more of what the richness of body language and gestures entails. However, it is not trivial to design for what Isbister and Höök name supple experiences [13]. In short, a supple system is a hardware device that uses custom-built hardware, sensors, and wireless communication, to interact with end users and create a physical, emotional, and highly involving interaction. Supple systems rely on subtle signals; rich human communication and interpretation strategies such as emotion, social ritual, nonverbal communication, and kinaesthetic engagement; and emergent dynamics, to provide for a moment-to-moment experience. To create a supple system, hardware and software need to be co-designed [28] and made to perfectly harmonize in order to not throw users out of their embodied experience [26].

It is in the intersection between the issue of designing for kinaesthetic expression of emotion in communication in sociable relations and co-designing hardware/software taking its material qualities into consideration that our work can be placed. We are aiming to design for non-verbal communication in groups of colleagues or groups of friends, making use of the new materials offered by, in particular, sensor-technologies. Each individual would be equipped with a tangible, sensor-enabled device, possibly integrated with their mobile phone or with their wrist watch. The device would allow them to express themselves and communicate with the group and its members using gestures. Our idea is that their expression would not be a one-way communication from one individual to another, but instead creating a joint expression by two or more users together. Our idea is that this joint expression would portray both individual moods but also interrelationships, between individuals in the group, and in general, allow for playful creation of expressions.
Inspired by autobiographical design [22], we used a technology probe [9] to let both ourselves and potential other users live the experience of non-verbal communication within a group. By this, we started to uncover some of the sensitivities, practices and fragilities in how groups express themselves, or rather, how we do relationships. Creating expressions together using the probe we provided, to some extent, created joint moods, served to act out conflicts, reinforced closeness between colleagues and uncovered imbalances and issues between them. The probe became an arena for some of the efforts that we do in order to create for relationships. Most importantly, it gave us the design input we need to take the next step in the design process.

2. EXPOSING EXPERIENCES

Given the development of games, everyday use of technology as part of our lives, mobile technology, and ubiquitous technology, in the third wave of HCI [9] user experience has been put at core. Desired qualities include designing for aesthetic experiences [15], affect [18], emotional experiences [16], fun [1], affective loop experiences [11, 27, 28], or embodiment [4].

However, we cannot design for such qualities in void – first we need to understand how they interact with the requirements of the specific design case. In this case, we needed to understand what goes on in people’s daily social, emotional and bodily interactions with people they spend time together with. This entails digging deeply personal, subjective, physical experiences that are hard to express. On top of that, new materials, such as the sensor technologies we used here, may enable new ways of mediating communication between friends. We needed to become emphatically involved with our users’ lived experience of interacting physically with such an imagined system [11, 28].

There is a small, but growing, body of methods for aiming to capture non-symbolic experiences without forcing users to reduce their experiences to their constituent parts, such as cultural probes [6], autobiographical design [22] or the Sensual Evaluation Instrument [14]. Sengers and colleagues reintroduced the idea of autobiographical design, that is, designers designing for themselves and their own needs rather than someone else’s [23]. They thereby circumvent the problem of trying to understand others and their physical, emotional and social experiences. We decided to pick up on some ideas from autobiographical design and expose ourselves and others to a technical probe.

3. BEING CLOSE

Our starting point was from our previous research where we had identified some design qualities that are important when designing for communication and reflection between friends [26]. In short summary, we already knew:

- Friendships require a careful ‘rhythm’ of communication to be kept alive – we have to be there for one-another and keep the bond alive
- Using gestures in interaction is very sensitive to users’ personality, body language and the way the technology is designed – the smallest mistake in e.g. timing between physical expression and response from the system will throw users out of their embodied experience and they will withdraw from the overall experience
- Crude mappings of users’ gestures to expressions in some one-to-one-manner to e.g. emotions will fail to cater for the subtle, dynamic nature of their communication. Instead, we have to design open surfaces where users can inscribe meaning themselves. But these surfaces should not be completely empty to start with – they have to feel familiar to our bodily experiences of communicating

We have also performed a study of very long term friendships (not yet published). Important findings from this work were:

- A group of friends is not a set of pair-relationships of equal strengths, but a complex organism with many different roles, changing over time – it needs to be ‘managed’ to survive. A group has many relations and constitutes a unity
- Conflicts may be a threat to the nature of friendship, but they are also an essential part of it. When they occur, they test the strength and quality of the relationship and changes it
- A system designed for friends need to include collaborative, strengthening activities (compare to e.g. choir singing, which need the whole group to make sense) that everyone enjoys and where everyone has a role, and allow for richer expressiveness by involving also bodily and subtle communication cues to compose a unity

All these findings points to the necessity of seeing friendship as something we do, rather than something that is simply there and can be expressed in a system. Friendships in groups prosper when we create together, when the whole group is needed, something we come back to below. While colleagues at work are not always friends, there are some similarities between the relationships we build at work and our friendships (and, as we know, work mates sometimes do become friends).

4. THE PROBE

A technology probe is a fairly simple but fully working technical system designed to uncover and learn from real life practices and experiences [9]. The idea is to place the system with potential users to be used in their everyday environment in order to get outside the laboratory and away from some of the obstacles of a staged set-up. It is a way to get initiated user feedback early in a design process.

A probe needs to be partly unfinished but still detailed enough that it provides for rich experiences in the direction of a certain area for design. If a probe looks too beautiful and finished, it becomes hard for study participants to brainstorm about alternative looks and feels. It is more difficult to think of alternative designs if you like the one design you have been using for a while and got used to. The aim is to let users feel competent as designers and to minimize feelings of insufficiency in front of a research team.

A probe is a mean to expose/uncover qualities that otherwise might be neglected. That is why a probe might well include provocations and clearly unwanted functionalities in order to force users, as well as designers, to reflect on their own practice and creatively invent new ways of interacting.
A technical probe is not an early prototype of a future system. It is a way to open up and to get hands on experience of a future design field and new design materials. It is after a technical probe experience that brainstorming sessions on specific design solutions take place. It is a fruitful but rather time consuming method to spur new ideas, since also a technical probe needs little of a design process to evoke rich enough experiences.

4.1 The FriendSense Probe
FriendSense was the technical probe we created to find out more about the relationships and activities that constitutes a group of work colleagues or friends at work. This probe works as follows: each user is given a sensor node (from Freie Universität, Berlin) that picks up on temperature and vibration, see Figure 1. The visual expression consists of a sphere-shaped object resembling a marble or soap bubble. Users first create their expression locally on their own PC and then upload it to a public and shared display where a collective expression of all users’ expressions is formed. The shared display was placed so that all users could see it from their desk when sitting in an open office landscape, but also visible to non-users passing by.

![Figure 1. The probe: sensor node, software client, interaction with the sensor node, and an expression on the public display](image1)

The motion of the marble on the screen is determined by the vibration sensor, and its color is determined by the temperature sensor. To change the movement of the marble the vibration sensor must be set off through bouncing the node package against some other surface, for example the other hand or the surface of users’ desk. The color of the marble is changed by heating or cooling the temperature sensor. The movement and color of the marble were chosen to in a very rough form resemble the bodily experience of manipulating the sensor node. Our intention was also that the possible colors and movements would be varied and expressive enough for users to express their experiences – their mood, emotion, or some other experience relevant to their friends to see. It turned out that the nodes were individually sensitive to stimuli (i.e. each node responded differently to temperature and vibration) and the changes in colors in the graphical representations were continuous. This, in combination with the possibility to also add a picture to be placed inside their marble, made each expression close to unique, and allowed the users to express themselves and, potentially, distinguish the identity of each expression on the public display, see Figure 1. Our design was deliberately ambiguous, allowing for appropriation and interpretation.

As discussed above, we knew that friendships are on-going processes where conflicts sometimes arise. In our first trials of the FriendSense probe, we had seen that it mattered to users exactly where their marble ended up on the big display, or rather, who’s marbles were close to one-another. We therefore redesigned the probe so that users could try to affect the positioning on the public display. The exact placement of the marble was a combination of what all users wanted. Depending on individuals’ choices and the number of times they were uploaded, an algorithm in the system managed the positioning and relations of the marbles on the screen, a functionality illustrating the ‘silent negotiation’ going on in social contexts. Since the probe set-up, with a stationary public display in the open office space, forced people to use the probe while co-located, this functionality holds the potential of making this usually silent negotiation not so silent. Here it could be visible to everyone that someone is not wanted or perhaps that someone is wanted more than the others, a consciously designed probe functionality there to provoke and expose and spur delicate experiences. One would probably not want to put this much focus on such sensitive matters if this was not a probe but instead designed to be an early prototype of a future system.

![Figure 2. (details) Preceding expressions transform to smaller spheres on the edge on the latest uploads, “history bubbles”](image2)

Once a user puts a marble on the joint display, it was left there until the next time the user uploaded a new expression. The old marble would then be turned into a small sphere sitting on the edge of the marble, see Figure 2. These smaller spheres thereby represent the history of expressions used. These history cues fade over time, allowing the users to see the latest uploaded expression as originating in a process. The uploaded expressions were, in this sense, holding more information than just the latest (individual) upload and contributed to the composition created by the group as a whole over time.

5. LIVED EXPERIENCES
The technology probe was deployed in our own workgroup at the Mobile Life centre (that all the authors belonged to) and in a workgroup at TeliaSonera (that none of the authors belonged to). The selection of these two groups was deliberate; being inspired by autobiographical design we wanted to get personal experience enabling an empathic understanding of the other user group and the design area as such but we also wanted the fresh ideas and feedback from another user group as in a more traditional user study. This combination of our own group and an external group, were we had limited prior insights to their emotional and social relations, made it possible to collect a rich material and capture some of the non-verbal communication within a group of friends at work. Below we use fictional names for the participants in the two groups.
5.1 Set-up and collected data
The two groups used the probe system at their respective work places for two weeks each. They were introduced to the intentions of the probe – that is, to enable discussions about emotions, relations, self-expressions, interpretation, and affective experiences taking place in a group of individuals. We asked them to use the system in parallel with their regular work, as much or little they wanted. We provided them with documentation material in forms of diary books and disposable cameras. They could also send us comments directly through the Friend-Sense software, or email us.

After the two weeks of use we performed semi-structured individual interviews that took about one hour each. In those interviews, we asked the participants to reflect on the usage of the probe, on their relations in the group as well as on other group relations that they had experienced. We discussed the collected data together with the user showing them their own comments, number of interactions, and screen shots of the joint screen from different points in time. We asked the users to share their reflections on how the (both individual and composite) expressions had emerged and how they had interpreted them, and finally, whether they had been affected by them. The quotes in the material below originates both from comments during usage and from these interviews.

5.2 Participants
The TeliaSonera group of six users sit closely together in an open office space, but they are almost never there at the same time; they have assignments in external projects, travel, and spend a lot of time in their lab space which is located on a separate floor in the office building. As some are recently employed, and others have been there for two years, their sense of the group differs. They see each other as workmates who sometimes take a beer after work, but not really as close friends.

The Mobile Life group consists of nine researchers who also share an open work space. Some of them have worked together for many years, but the group also has new members. They are most often not at the office at the same time; they work irregular hours and have assignments also outside the lab office. However, during the two weeks of this particular user study, the group spent quite a lot of time together. This group regards themselves as friends.

6. EXPERIENCING THE PROBE
Below, our findings are presented as stories. In particular, we emphasise situations that illustrate four important themes in the data; individual expressive needs; effects on the mood or activities of the whole group by the public display; using expressions to deliberately influence the whole work group, and finally, various examples of group collaboration and co-creation on the public display. The stories also describe how the users physically handled the nodes and their experiences of the material as such.

6.1 Usage in the TeliaSonera group
The TeliaSonera group seemed to be more of a traditional work group. The social norms within the group did not seem to allow for expressive emotional outbursts. For example, they did not want to disturb the others by making too much noise banging the sensor nodes, or to negatively influence the group by showing their own bad mood overtly on the joint screen. In this group, users picked a picture to place in their marble that acted as their alias or avatar. They often chose a character which they liked or felt empathic with. Erica, for example, picked a picture of a lonely penguin, which she wanted to be placed in the cluster of expressions:

Erica: “I took my penguin because I like it and also it is actually a picture called ‘alone’, so it is a little lonely penguin and I thought he could get to join this.”

Allan, who was new to the group, used a picture of Ralph, his favourite character from the Simpsons (the TV-series show). He wanted to show the others who he was through this choice. Unfortunately, most members of the group did not figure out who was who of the marbles during the two weeks. They also said that they cared more for their own expressions than trying to figure out the others’. Allan was the only one who actually knew that, for example, Erica ‘was’ the penguin.

The group used the social positioning feature to express actual physical relation in the room or who they currently were project partners with. They rarely used it to express social or emotional relations to the others. Since they all mapped closeness between marbles on the screen to physical placement in the room, they frequently became annoyed with the fact that marbles stayed on the public display even when people were not there. In the Probe design, we had incorrectly assumed that users would turn off their computer or the probe system by the end of the day or when leaving the office for a longer period in time. This was not always the case which made the marbles linger on the screen.

The users expressed problems with the ‘balkiness’ of the sensor nodes They felt that it was easier to use them to express aggressive and negative emotions and had problems to express softer and more gentle emotions, since the interaction provided, especially the vibration sensor, was not affording what they wanted to express.

6.2 A few days in the TeliaSonera group
Erica is annoyed. Anger is an emotion she feels that she easily can express with the sensor node. She puts her marble ‘far away from everyone’, so that she will not disturb anyone else with her anger. She feels that it is improper to “unload” negative emotions on the others. She then hurries to a meeting and her angry, lonely marble is left on the public display in a corner.

When Allan arrives, he manipulates the distance to the others on the screen, trying to make the public display mirror the physical workplace as much as he can. This day he places himself far from John who he knows is sitting somewhere else today.

Later Erica comes back from her meeting and sees that her marble is separated from the others. She sees her penguin inside the marble is someone else, not “herself”, and feels empathic with the penguin, wanting to cheer it up. She tries to create a cheerful expression and places it among the others on the public display. In doing so, she finds it hard to manipulate the sensor node in a way that feels cheerful. The limited range of manipulation offered by the sensor node forces her to perform similar gestures as if she had been angry (the expression she is trying to achieve is red and jumping), and that evokes annoyance and, ironically, angry feelings. The result of her interaction, the expression on the public display, the noise, and the sensation in the hand are also almost identical to anger. After a while she gives up, disappointed that she could not get the expression she wanted.
Another day Marcus comes to the office in a terrible mood (because he hates commuting) and he is, actually, looking forward to being unpleasant to the others and to share his negative mood, but gets very disappointed when he realizes that the office space is empty. When he looks at the shared display, it looks like they are all there, though. As a matter of fact, Carl has had the same expression for several days. Marcus is not entirely sure of who is who on the public display; he only perceives “a bunch of bubbles”. He picks the same picture as yesterday (a picture which he has chosen because it has graphical qualities making it looking good inside the marble) and chooses to be ‘close to Carl’, this to see where he ends up. Carl and him are involved in the same project and will work together later that day and they also physically sit closest to each other, so Marcus thinks that should be shown also on the public display. During the day, when his mood changes to be more sociable: “OK, now I am on it again!”, he also felt it was important to change the colour to something warmer, make the marble appear more active (i.e. vibrate), and move away from the corner on the display, towards the centre, reflecting the change in mood.

**Present when absent.** Even though this group mapped physical presence and proximity with the marbles on the public display, and, in fact, often got confused when the virtual did not agree with the physical, they sometimes used the probe to get a sense of connectedness, when away.

Erica: “[I] sit in another room [today] and usually sit close to Maria. I’ll put my marble close to her, so that I feel a little bit like “home” anyway, in a sense”. See Figure 3.

**Reflections on the group through the probe.** When up-loading their individual expressions they most often wanted to express their individual mood and position the marbles in line with actual, physical positions in the real world. This group rarely purposely used the public display as an arena for acting out interpersonal or (social or emotional) group relations. However, sometimes, they were happily surprised by the results on the screen, and translated it into real world interaction: the closeness and movements of the marbles changed the perception of the group in the real world:

Maria (looking at the public display): “Wow! We are really close, really cosy, we are even touching each other, we really are a whole group here. [laugh] ‘Oops, what happened here?’”

**Work friends vs. close friends.** The probe made the users reflect on also other, closer, relations. Maria and Erica both were very careful to not expose too personal information, especially anger, frustration, and sadness to their colleagues at work.

Maria: “[the sensor could well have (somehow) been automatically capturing my emotional state.] But... that would be rather scary in this context, where you don’t want to show. In friendships that is much easier, and you can be more informal. But here, at work, if I’ve had a bad morning, I might not want everyone to know. I mean, if it went ice-blue and ended up in the corner. ‘Oh, how is she?’ but if the same thing happened in close relations, I might get that call from a close friend ‘How are you, my dear?’”

**6.3 Usage in the Mobile Life group**
The Mobile Life group sometimes managed to act out both conflicts and to support each other through the probe. They also used it to actively influence the group mood. The group used pictures inside their marbles extensively to express a whole range of matters, such as empathy, understanding, personality, specific emotions, and memories. It is hard to know whether this use started by chance or for some other reason in one group but not in the other. It might have been because the Mobile Life group knew each other better and therefore were more willing to communicate more personal matters and emotions through their pictures. They also used the positioning on the public display far more for emotional purposes and interpreted position on the screen as a dynamic social reflection rather than physical placement of group members. The closeness of the these colleagues is also visible in how openly they are willing to share their emotional states, instead of withdrawing as Erica at TeliaSonera did to spare the group of her bad mood. The Mobile Life users also expressed more emotional reactions to what was going on in the display.

**6.4 A few days in the Mobile Life group**
When Astrid, Eva, and Turid arrive at the office, Phyllis has been alone for a while which is also apparent at the public display; showing a single marble (which Phyllis describes as neutral and awaiting): a green-yellowish marble that is not moving at all. Turid does not feel social today, and wants to wait before getting too engaged in the group. The others upload their expressions right away. Their marbles are moving cheerfully in orange and yellow colours. They seem to be in a good mood, all clustered together. Turid wants to be left alone, not that she dislikes anyone; she simply wants to keep her distance. Hence, she places her marble ‘far from everyone’. She also wants to look calm, so she puts her sensor node outside the window to cool it down and acquire a blue colour. She has a photo of herself that stirs sentimental and sad memories, and she puts it into her marble to see what it looks like on her private screen. She becomes satisfied when she is convinced that the picture is distorted and blurred enough to make it impossible for the others to really see how sad she looks in the photo:

Turid: “It was perfect to have inside my bubble. I knew the picture and what it meant to me, but I was pretty sure that others couldn’t read it. It was a little bit thrilling.”

During the day Turid keeps the picture and calm expression, but moves closer to the rest of the group, as she wants to be more sociable. When Karen arrives, all the marble-bubbles are gathered in a pulsing heap, a happy, bumpy cluster of friends at work.
Karen thinks it looks nice, as if the group is in a good mood and is really comfortable. Karen gets in a good mood by this sight.

**Expressing support.** Jason’s thesis defence is getting closer. Many years of struggle and hard research work will now be publically examined and Jason is over-worked and nervous about the defence. Karen has felt a strong need to be close to him lately, sometimes she rolls her office chair closer to his and peeks over his shoulders while he is writing his dissertation, to show him her support and presence. Friday morning, right before Jason’s defence seminar, Karen and Phyllis have placed pictures of Jason into their bubbles and moved them very close to him on the public display to show him their support and empathy, see Figure 4.

**Acting out a conflict.** Astrid feels the need to be on her own today. She tries to be far away from everyone else on the public display. To strengthen her expression she chooses to use a picture of a very dark evil-looking vampire and uses her sensor node to make her marble vibrate a lot and become orange. At one point during the day there were only two marbles left on the public display; Phyllis’s and hers, see Figure 5, left.

**Influencing the whole group.** One Friday afternoon, Karen tried to get everyone into a cocktail party mood. She chooses a picture of a cocktail bar, and has heated and pounded her node so that her marble is red and jumpy. She is a little bit disappointed that her marble is placed at the edge of the public display and feels that she fails to express what she wants: come over here and join me in my lounge mood. But then she notices that both Jason and Phyllis have joined her in her party mood (see Figure 6). Jason had moved closer to her, and Phyllis has changed her picture to a disco ball, expressing that she is up for whatever Karen has in mind for the evening.

**PARTICIPATORY BRAINSTORMING**

Apart from the interviews conducted, we also performed a brainstorming workshop (one for each user group) following the interviews held after the two weeks of usage. We let the groups act out how a system similar to the visionary future system described in the introduction, would behave and be designed. We provided the participants with some props, and asked them to imagine that they had a device with sensors of their choice and then act out how this would be used in a social group, co-located or not. The participants produced a range of gestures, possible locations of sensing technology, and suggestions on what kinds of behaviours the solutions must be able to carry/afford. They extensively discussed how to allow for both gentle gestures, such as stroking or patting, and for more negative expressions. Their solutions in many cases involved integrating input and output into one – making the input feel like the output – thereby also getting stressed [...] and felt that fixing minor bugs in the prototype was rather secondary. To reveal that to others, and especially her, I repeatedly chose ‘far from Phyllis’.

At a second occasion, Astrid explicitly wanted to make a point to Phyllis, see Figure 4, right. Phyllis correctly interpreted this as anger but she was in a teasing mood and decided to “battle” with Astrid, by choosing ‘close to Astrid’ many, many times. This action after some time overrides Astrid’s attempts to keep the distance and Astrid and Phyllis’s marbles ended up close together. Astrid then decided to leave things as they were instead of “fighting” back. She did not like the fact that she had to upload so many new marbles in a short time in order to move away from Phyllis. She felt that it made her marble look boring with a lot of similarly colored smaller marbles attached to her larger marble.

**Figure 4.** Friday morning before Jason’s thesis defence. Everyone is gathering around Jason’s vibrating and red marble.

**Figure 5.** Two similar screen shots but with different meanings. The left picture makes Phyllis mistakenly assume that Astrid is angry with her. In the right picture Astrid is angry.

The two marbles were far apart, which might be interpreted as a conflict between them, which is what Phyllis assumed: “I am not sure, but I think that Astrid is a little bit bitter at me at this point.”. This time Phyllis misinterprets the causes for the appearance of the display. However, probably this was because there have been other days when Astrid actually had been very angry at Phyllis:

Astrid: “She (Phyllis) was supervising me, [...] which led to tensions sometimes. I remember one day [when Phyllis’s demands annoyed me] it distracted me from my work. I was already

**Figure 6.** Karen’s (upper right) tries to work up a Friday party feeling and the others (except for Astrid) joined the “party”. Astrid’s marble lingers on the screen from Valentines day, the day before this day.
8. DESIGNING FOR GROUPS

In short summary, the probe was successful in exposing some of the sensitivities of group communication as well as uncovering aspects of the physical, emotional experiences we were interested in. This whole activity with the probe and the interviews and brainstorming sessions held after the two weeks of usage helped us to extract four key challenges when designing for this kind of non-verbal group communication.

8.1 Group Membership

In real life, we act according to contexts and rules explicitly or implicitly stated in the different communities we belong to. However, it can sometimes be complicated to determine who is included or not in a group and which rules of conduct should be applied. The technology probe we deployed in the two groups in some sense made the social network within these two groups more apparent to its’ individuals and exposed some of their practices, or lack of closeness.

In the Mobile Life group it became even more apparent than before how some members of that group are closer to one another than others and how it can be hard to be a newcomer in such a group.

A problem for any group system is the assumption that our friends can be lumped into one group. Erica, for example, (when she was describing her relations to her closest friends, outside work), reflected upon how it was hard for her to even sort those friends into a group constellation:

Erica: “My friends are not really a group and they have no interest in getting to know each other either and I have no such interest either. If you are part of a group it might be different”

Both the TeliaSonera and the Mobile Life groups went through thorough discussions on group membership; how it could be more dynamically defined in the system by allowing for individual definitions and set-ups, or how each individual could have their own list of friends. As we can see in the stories above the users compensated for the crudeness of the probe and how it revealed the different ties or lack of ties in the group. They often did so by hiding behind the ambiguity of the expressions of the marble.

Since others, outside the group, could see the public display, it could potentially be embarrassing to show what was going on inside the group to others. But none of the participants said they had hesitated to express themselves on a public display visible also to outsiders passing by:

Maria: “To them (the outsiders) it was more of a picture, kind of, a nice picture and it might have been animated but then they would not have any clue to what that was really.”

This points to the importance of designing for the group ties in such a way that the meaning-making processes are privileged to those who take part in the group and relationships rather than making crude simplifications and labelling of emotions or relationships within the group that other can interpret. It must also be possible for the group members to send signals between themselves that not everyone in the group necessarily understands in all detail. Overall, we must be aware of and allow for the fact that groups of friends will not be perfectly balanced – some are more central to the group than the others. We need to carefully deal with the fact that this is potentially very sensitive to the group members:

Astrid: “The moment I remember best happened on the very first day when I placed my bubble first on the display, so the position was kind of random. Then everyone else up-loaded theirs and for some reason everyone ended up far from me. Even though I am aware how the algorithm works and it... probably was a coincidence... it affected me a lot.”

8.2 Mediated Physical Contact

An important insight from our probe experience is that the system mediated a parallel universe of interaction to that going on in the office anyway. By sitting together in an open office space, we were already communicating a whole range of non-verbal cues. The way you sit on your chair, your facial expression, your sighing, or body posture all reveal aspects of what you are doing and what you are feeling. But the probe did not mediate exactly the same signs and signals as your body does. In the office we do not really physically show who we presently feel socially and emotionally close to or far from, but in the probe this was bluntly expressed. Sometimes these possibilities added to the interpretation of what was going on – as in the ‘click’ war between Astrid and Phyllis.

Emotional closeness, conflicts, and bodily experiences as expressed in the office were transferred, transformed and juxtapositioned against participants’ virtual presence and positioning on the public display. What was going on inside the probe was sometimes equally important as what was going on in the office in terms of expressing emotional, physical closeness. It was therefore important to the participants that the system did not portray this in the wrong way. On the public display the individual expressions sometimes ended up on top of each other if wanting to be close to someone, which made both Maria at TeliaSonera above and Hanna at Mobile Life to reflect:

Hanna: “I wanted to be ‘close to Jason’, but I didn’t want to ‘sit in his lap’. That feels too intimate, I want to be close but not on top”

Physical contact is a sensitive phenomena, it is ‘magically’ negotiated within a group, of friends, family, colleagues and strangers. There are usually small cues that determine when we can touch another person. By touching another person, you are crossing a border. Designing to allow for touch through a tangible system; i.e. to pet, stroke, pinch, hit, or just being in physical contact, must be designed carefully.

John: “Some friends you throw yourself at when you meet, and others you don’t”

The conclusion we draw is that while we are designing an alternative universe that might not be based on physical interpersonal expressions, we are still mediating and creating for strong physical experiences. We are opening a new channel for interaction. And within this channel, it must be possible to regulate/negotiate your behaviour so that you do not embarrass others and so that we can express what we really mean. A system
like this should also not limit users’ expressiveness. Again, by leaving quite a lot of power into the hands of our users, they will figure out ways to negotiate and repair relationships – without necessarily avoiding expressing neither closeness nor conflicts. The probe did not have enough expressive powers in that sense, but it gave us clues to start working on the next step.

### 8.3 Physical Bonding Activities
As mentioned above, mediating physical expressions of emotion through technology is very sensitive to users’ personality and body language. Sometimes, it becomes too embarrassing to use a technology that throws users out of their comfort zone and they withdraw from the overall experience. For example, a new interaction style that involves gesturing can appear as ridiculous and even disturbing to by-standers, and makes the user too self-aware and possibly embarrassed. However, if you are part of a group, some of the embarrassment can be removed. If everyone else around you is doing the same weird gestures or noise, such activities can even act to strengthen the feeling of being part of a group. In a group of friends, a family, a sport team, etc. it is quite common to find more or less ridiculous physical rituals. It can be doing high fives, specific gestures, coordinated movements when scoring, or “funny faces”. These rituals can be expressions of excitement and emotional group experiences but they also act to strengthen the group. The ridiculousness of the rituals is an act of trust within the group and act to tear down facades and distances. We even believe it is possible to lure similar behaviour in a group that will help to create for stronger emotional ties.

Simply by being part of the study reported here, using those weird-looking sensor nodes, handling them, making noise with them, and having inside information on what it was all about and being able to better than outsiders make sense of the public display, the two groups both expressed how that in itself strengthen their feeling of belonging. Many of them got questions from outsiders about the activity and the expressions on the public display, the participants also said they sometimes felt that colleagues outside the study were envious.

It might be that we need to pull users slightly out of their comfort zone to create for new ways of interacting, and spur closer relationships. At the same time this does not take away our responsibility to design for an interaction that makes sense to users and respects their personality and body language. This brings us to our next key challenges for mediation of non-verbal communication in a group.

### 8.4 Individual Experience is Key
While our focus is on group experience and sharing in a group of colleagues at work, it became clear to us that expressing ourselves individually is key in what it means to be a member of a group. As individuals within a group we want to be seen and appreciated by the others as individuals and in terms of how we contribute to the group. But it is not only important that other’s note the effort you have put into your expression on the public display, it is also important exactly how you, as an individual, is allowed to arrive at your expression. The physical expressivity through the manipulation of the nodes and how well that maps to you as an individual needs to be carefully considered in the design.

When interacting with a physical object the affordance of the interface have effect on the expressions that will be created with that object. If the interface is too sharp and edgy, expressions of anger and frustration will come easier to hand. On the other hand, if the interface invites to stroking, patting, or other “soft” interaction behaviours, it may exclude the repertoire of harsh, negative, and frustrated expressions.

Erica: “I found it became difficult because… since you had to bounce this way… it generated movement and whether that was an angry or happy expression was very hard to express. And the bouncing movement, to me, was really a pretty aggressive movement and not like ‘jihoo I am so happy’. If so, I would have liked to shake it more. This made it hard to translate some kind of emotion into it. I tried a bit, but it became the same whether you were annoyed or just happy.”

This means that it is not only in the interpretation of the group ties that are expressed on the public display that we need to allow for different ways of creating meaning. The same expressive leeway must be included in the choice and design of the physical expressions with the sensor nodes. They must be able to engage in different meanings. If you feel happy, you should be able to express happiness and also be encouraged by the form of the interaction device to do so. Happiness should also be the response you get to see on the display (or whatever output means the system has) to strengthen the feeling of happiness and so forth. This is why we need to aim for express leeway instead of specifically labelled expressions in a crude one-to-one mapping. We do not want users to have to formulate what they want to express and then try to consciously translate that into gestures with the device, but instead express how that sensation feels. The aim is for interaction to allow users to do as they feel and not force new physical interaction patterns onto our users that make them disengaged with their experience. As discussed above, the probe was consciously designed to be a bit rough – definitely not providing for a supple experience along the lines of Isbister and Höök’s definition above – but suppleness is what we need to consider here.

### 9. REVISITING THE DESIGN SPACE
Designing for non-verbal expressiveness is difficult, and it is even more difficult to involve users in a productive way where they can understand what is possible and contribute their own understanding and creativity. Our technology probe experience showed us that a fairly rough implementation was successful in involving both ourselves and the other participants in living and experiencing the possibilities. The slight provocations we included did help us uncover sensitivities in group communication. It allowed us to experience the material that can be created from a combination of sensor node interaction and group communication. The simplicity of the probe allowed for creative and fruitful discussions between researchers and users.

However, some of the roughness or “non-decisions” in the FriendSense probe affected the interaction and user experience. For instance, the closeness between users’ marbles had to be expressed through a client on each user's computer. This effectively broke the connection between gestures and expression on the screen as users had to let go of the node and click in menus to say who they wanted to be far/close to. A more subtle design would have given us more rich and better ideas for design. Even though a technical probe is a method during the design process to get to ideas of a future system, a more carefully designed probe allows for more insightful ideas. A technical probe needs its own...
design process but it can most often be kept rather small and simple.

The design process of the FriendSense probe involved a few iterations in finding the best “translation” of the sensor data into the graphics on the screen. We were a little held back by the rough hardware technology we used for the FriendSense probe to get a quick start in implementing a working system. The idea was that vibrations would translate into “marble-movement” expressing arousal [26] and temperature would map to colour made to somewhat resonate with Western culture mapping of temperature to colours and indirectly from colour to value (pos – neg) of expression. This was the most minimal design we could imagine that still had enough expressive power for the given purpose and that would provide for a clear mapping. In the study, we discovered that the nodes only allowed for the more negative expressions – a disappointment. We had assumed that light shaking or light touch of the temperature sensor would afford caressing movements.

The ultimate goal is to produce a system that much more gracefully and subtly translates physical expressions with/through the sensor nodes into expressions – preferably not on a screen but existing on/in the sensor node itself and between the users’ nodes, using other interaction modalities such as for example haptics. Most important to us were the experiences of expressing ourselves non-verbally to one-another. In particular, we need to consider the need for both expressive leeway to fit with individual taste and personality, and at the same time making sure that the physical act properly corresponds to the inner experience of what we want to express. A design challenge lies in integrating input and output into one – making the input feel like the output – as expressed in the brainstorming workshops.

We learnt a lot about the work we all do in keeping a group alive and healthy. Overall connectedness and emotional closeness have been treated too much from the perspective that we should only design for the positive aspects of friendships [3, 7, 20, 21, 27] in the HCI literature – sometimes in stark contrast to what people actually use the systems for. With a rather blunt probe we opened up for conflicts and tensions to be acted out, thereby providing a less naïve perspective of friendship and emotional closeness.

We found that a jointly created expression provided an arena for the group to express itself, acting out both conflicts and closeness. The expressions in turn influenced the group and its individuals. It was even used as a tool to deliberately try to influence the group. Risks involved excluding members of the group or misinterpreting what was going on, however, activities that also are part of relationships and what makes them so interesting and engaging. Relationships are sometimes both strong and fragile and needs careful attention.

Commercial systems, like Kareokee, Dance Dance Revolution, Sing Star, Guitar Hero, Rock Band, and Wii, are in some ways relevant to what we are aiming for here. They do force users out of their comfort zones, they allow for groups of friends to have fun together, and their physical form is carefully designed to harmonise with the experience of the system, though none of them explicitly deals with presence and awareness of friends’ activities.

In summary, our probe allowed us to uncover what is needed to design for an interesting physical, emotional expressive channel that can serve as a parallel, somewhat different, universe, able to strengthen group ties by allowing for individual, physical, emotional expressions contributing to a joint group-created, aesthetically pleasing whole.

10. ACKNOWLEDGMENTS
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11. REFERENCES


Hand in Hand with the Material: Designing for Suppleness

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ABSTRACT
Designing for a supple interaction, involving users bodily and emotionally into a ‘dance’ with a system is a challenging task. Any break-ups in interaction become fatal to the sensual, fluent, bodily and social experience sought. A user-centered, iterative design cycle is therefore required.

But getting to know the affordances of the digital material used to build the application plays an equally important role in the design process. The ‘feel’ of the digital material properties sometimes even determines what the design should be. We describe three situations in which the properties and affordances of sensor network technologies guided our design process of FriendSense – a system for expressing friendship and emotional closeness through movement. We show how the sensor node look and feel, choice of sensors, limitations of the radio signal strength and coverage, as well as iterative prototyping to properly exploit the software/algorithmic possibilities guided our design process.

Author Keywords
Computer Material, Design, Suppleness, Sensor network, Sensor node, Movement Interaction, Friends, Emotions

ACM Classification Keywords
Emotion and Affective User Interface, Handheld Devices and Mobile Computing, Prototyping, User Experience Design / Experience Design

General Terms
Design

INTRODUCTION
Isbister and Höök introduced a use quality they named suppleness [5, 6]. According to Löwgren and Stolterman, use qualities arise in the interaction with a digital artifact creating for particular experiences of the interaction as such. Use qualities are not to be confused with usability qualities or seen as a checklist for design, but as articulated values that can help steer the design process. [10]

Isbister and Höök sees suppleness as an interaction that relies on subtle social signals, emergent dynamics and moment-to-moment experiences: “a supple system is doing sort of a social/emotional ‘dance’ with the end user.” [5, page 2236]. They though point to the difficulties in designing for suppleness. So far, we have only seen a few attempts to articulate and describe design processes leading to supple systems [12, 14, 21]. In the following, we aim to describe one such design process and the struggle to get the supple experience in place. The system we designed, named FriendSense, allows a group of friends to express their friendship and emotional closeness through gesture-based interaction.

As pointed out by Isbister and Höök, it is particularly important to respect and cultivate deep knowledge of the material in which the system is being built when designing for suppleness. “The more hands-on experience one has with working with particular affordances of particular materials and contexts, the more likely one is to produce a supple design. Suppleness is in the details of the moment-to-moment unfolding of the experience—something hard to understand without tinkering with it for a while.” [5, page 2240]

In our design team we have long experience of designing for physical and emotional interaction in various settings [e.g. 13, 15, 18]. We have gained more and more experience of the necessity to keep a very tight design process to achieve these kinds of experiences in interaction. We have seen how using the body and gestures in interaction tend to be far more vulnerable to slightest delay or mistake in interaction compared to more traditional interaction where the physical body is not as involved. This may be because we are less used to interacting bodily, but also since this kind of interaction is publicly visible and thereby a potential source of embarrassment. We become more aware of ourselves and may fall out of a potential flow experience. A supple system is a system where there are no, or very few, such ‘breaks’ between users’ emotional engagement, the interaction and system response.

Below, we will not report the full story of the design and evaluation of the FriendSense system, but focus on how we have worked hand in hand with the unfolding of the socio-digital material and how that improved our ability to design for a supple experience (turn to [17] for a more
complete picture of the FriendSense design process. The socio-digital material is the material that arises from the combination of the digital material and how it in the end become understood and ‘lived’ by people using it [19]. We will bring out three example situations where the properties of the material, in this case sensor networks, had to be experienced by the design team in order to create for a supple experience in the FriendSense system:

- Sensor node look and feel and choice of sensors
- Algorithmic concerns in mapping from gesture dimension via sensor signals to expressions
- Properties of the radio signal strength and coverage

While any design process has to consider the affordance of the material, we argue that designing for supple experiences require that the design team share a hands-on, experientially grounded, understanding of the material. The experience and meaning of the interaction is understood in and through the emotional and bodily acts themselves – we have to perform them (or to use a phenomenological terminology ‘live them’) during the design process.

Important to point out is that FriendSense in itself is not meant to be a full-fledged system, but a so-called technical probe [4]. Designing FriendSense has been about gaining a better understanding of suppleness. As with (almost) any design work, it is not a step-wise rational, simple waterfall design process, but a complex mess of understanding the material, how users make use of the system, and trying to achieve the use quality of suppleness.

HAND IN HAND WITH THE MATERIAL

It has been argued that HCI researchers should look more closely at the practices of architects and industrial designers and be inspired by how they design by building artifacts that can be discussed, criticized, redesigned, tested and so forth both by people within the design team but also together with potential users. As Greenberg and Buxton [2] put it: “getting the right design vs. getting the design right”. If we adopt this perspective on the design process of computer systems, we must start to carefully consider the properties of our material, the digital material, in similar ways to how these practitioners explore their concrete, iron, brick or plastic materials. By the term ‘digital material’ we refer to technology that can sustain an interaction over time with a user (creating for a dynamic gestalt [9]); thus it includes both hardware and software, and is manifest in both complex artifacts such as mobile phones or computers, but also in the different parts they are made from, such as sensors, network communication, radio or touch screens, all the way down to the programming languages themselves such as C, Java, or Flash.

On the one hand, the digital material is very plastic – we can design almost anything in our material. This has lead researchers such as Löwgren and Stolterman to talk about it as “the material without properties” [11]. But given particular digital materials, such as sensor networks, that include both hardware (sensors and antennas) and software (programming in Contiki, an operating system for embedded smart objects, www.sics.se/contiki/), abiding to the laws of physics (radio strength and coverage); the material is not really without properties. We are not the first to criticize Löwgren and Stolterman’s position, to cite Vallgårda and Redström “Such a perspective, however, makes it difficult to understand how this material relates to other materials we use in design, as it almost seems to exist in isolation on its own premises.” [20, 514]. By creating composites of digital technology and other materials, such as wood or paper, Vallgårda and Redström try to answer the question of how we can characterize, and work with the properties of the digital material. In short, by creating composites they expose properties of the digital material as well as putting the material into a physical form that can be handled. While their work is very insightful, we want to go further and argue that even the pure software components and the programming language hold properties that are important from an experience perspective and therefore have to be put into a form that can be experienced by the design team.

In our previous work, we often spent too much time developing the design idea before starting to consider the digital materials and their affordance in realizing our design. For example we at one time treated Bluetooth simply as a means to connect two devices and did not consider the time it takes to actually achieve such a connection. Moreover overlooked the potential to be inspired by the properties of the materials we wanted to use. Our point is not that we should abandon user-driven design processes and work entirely technology-driven, but perhaps we need to find a balance between the two. We need to let the material become yet another driving force in our design process, alongside with contextual or ethnographic studies, users’ input and all other sources of information and inspiration we make use of.

Sensor networks were, to us, a new material we had to become acquainted with. In getting to know its properties, such as the range and shape of the radio signal or the reactivity of the sensors, we run into both limitations to what we can design, but also novel affordances that would not have arisen if we had created the design without getting to test and ‘feel’ the inherent properties of the material during the design cycle. Building several experiential prototypes that we could test ourselves (as well as bring in outsiders), ‘feeling’ the interaction was essential in directing the design process as well as exploring the material properties.

DESIGNING FOR THE FEEL DIMENSION: LMA

The particular system we aimed to design here, FriendSense, builds upon a series of experiments we have done on how to build for emotional and bodily mirroring, engagement and expression [e.g. 13, 15, 18]. We are par-
particularly interested in designing for bodily movement – be it the whole body, through gestures or bodily bio-signals.

As discussed by Larssen and colleagues [8] when dealing with movement and body we are designing for a feel dimension rather than the more commonly visual dimension that most web and computer applications rely on. Users become involved in a body-artifact dialogue where movement is the basis for interaction and meaning-making. In addition, we are addressing movement not as a modality for performing task-oriented, functional input to a system, but as an aesthetic, experiential activity.

Others who have attempted to address aesthetics of movement include Schiphorst and Moen [14, 12]. Schiphorst has constructed an interactive tangible art installation called soft(n), where she has used conductive multi-touch fabrics to capture differences in touch. Moen has taken inspiration from modern dance in her work on the BodyBug system. BodyBug is a small ‘robot’ moving on a wire that users strap on to their body. BodyBug moves in response to users’ movements. It can be seen as a game, a dance partner, or jewelry depending on how users appropriate it.

In Schiphorst, Moen and our design processes, we have all made use of a movement analysis tool named Laban Movement Analysis (LMA), in order to get at the experiential aspects of movement. As we will make use of LMA below, we need to provide a brief introduction here.

Laban Movement Analysis – LMA

Rudolf Laban was a famous dance choreographer, movement analyzer and inventor of a language for describing the shape and effort of different movements [1,7].

Shape describes the changing forms the body makes in space, while effort involves the ‘dynamic’ qualities of the movement and the inner attitude towards use of energy [23].

Shape can be described in terms of movement in three different planes: the table plane (horizontal), the door plane (vertical) and the wheel plane, which describes sagittal movements. Horizontal moments can be somewhere in-between spreading and enclosing, vertical movements are presented on a scale from rising to descending, and sagittal movements go between advancing and retiring.

Effort comprises four motions factors: space, weight, time and flow. Each motion factor is a continuum between two extremes. Space attends to the surrounding, and is either direct to its’ goal as in inserting a light bulb or more indirect as in waving away bugs. Weight is related to the amount of power required and is set between light and strong. Light would be the weight required to lift a feather while the weight required moving an elephant would be strong. Time is the duration of movements and is measured from sudden to sustained. Catching a fly is most often a sudden movement while stroking a pet is a more sustained movement. Flow is related to the control of movements and is set somewhere between free and bound, similar to how people most often are more ‘free’ in disco dancing compared to doing yoga.

As we will show below, this kind of analysis can help not only to describe characteristics of movement and body posture, but to some extent capture the experience of conducting them. Also this analysis helps us to model movements in forms we can make a computer understand and respond to. But obviously the inner, subjective experience of movement cannot be reduced to only these dimensions – as often pointed out by Laban himself.

DESIGNING FRIENDSENSE

The overall aim behind FriendSense was to design for the physical sensations of emotional closeness between friends. The design task we set ourselves was to allow small groups of friends, say 3 – 10 friends, to communicate with one-another using bodily gestures through a sensor network. A set of radio-enabled sensor nodes can only communicate when in reasonable range from one-another (depending on sensor solution and the environment it might be anything from centimeters to hundreds of meters). Our idea was that the system would allow a group of co-located friends to communicate in a ‘virtual universe’ in parallel to their verbal or facial communication. When their sensor nodes come into range of one-another, they will be connected in an ad-hoc local network and can start expressing and experiencing each others’ interactions with the sensor nodes.

As we will not go into each and every step in our design cycle here (some more detail can be found in [17]) and Figure 1 presents some sort of a timeline for this design process) we will only provide a brief presentation of the four main versions of the system and two example situations of how the FriendSense system was used. This before we go through the three examples of where the properties of the digital material came to have a decisive role in the design process. We would like to point out that all four versions of the system were intentionally left rough in certain ways – partly because we tried to go through a faster experiential prototyping cycle, and partly to make our friends more willing to comment on the design.

Four experiential prototypes

The basic interaction of the FriendSense system consists of sensor nodes given to a group of friends so that they can express themselves. The results of their expressions are displayed on a public screen. The idea is that you may want to express your mood/emotion/closeness to others through expressive gestures with the node, mapping to colorful, animated expressions on the screen.

1 LMA is composed of five major components: body, space, effort, shape and relationship. The focus in our analysis is on effort and shape as these best describe the emotion expression contained in gestures.
First version: colors, shapes and animations

The first, second and third version of the FriendSense system made use of a sensor node from Freie Universität, Berlin, see Figure 1. These nodes were equipped with two sensors: one picking up on temperature and one registering vibration. They were chosen from our previous experiences of how temperature and movement map very well to the emotional processes taking place in the human body [15, 18]. When our friends/colleagues made gestures with the sensor node – banging the nodes against some surface or holding it in their palm to heat it – a colorful animated expression (based on [18]) was shown on a screen that all the other friends could see, see eMoto-inspired screen dump in Figure 1. Through manipulating the sensor node, users would move around in the colorful circle:

- vibration would move them along the y-axis, portraying the energy of their expression – the lower on the y-axis the calmer expressions and animations, the higher the more wildly animated
- higher temperature would move them out from origo along the x-axis, showing the intensity of their feeling – higher temperature rendered the more red intensive colors while lower temperature rendered more blue, cool colors. But to choose whether to move left or right of the x-axis, we had to use radio buttons on our local computers. The left-hand-side of the circle portrays negative expressions – ranging from depressed, non-energetic states, all the way up to intense, angry, high-energy states. The right-hand-side portrays positive states, all the way from calm, low-energy, states, to high-energy happy states.

Second version: Kandinsky

In sense, the first FriendSense prototype turned out to force us to express singular, individual emotions rather than group-oriented expressions such as empathy or closeness to others. From the ethnography performed before the design process started (not yet published), we also knew that friends often attempt to create ‘experiences’ together, be concrete joint experiences as singing or dancing together or more ephemeral experiences as co-creating a particular mood. We therefore moved to a second version where we took inspiration from a Russian-born painter Kandinsky (1866-1944) and his painting Farbstudie. Here friends’ individual expressions on the public screen were given one ‘square’ each, thereby allowing each friend to describe their own mood/emotion, as can be seen in Figure 1. But as a group they were dynamically creating the whole screen together. The color, a scale going from ‘basic blue’ to ‘basic red’, was mapped to the temperature sensor. The vibration sensor controlled
the animation of a circle-shaped object in ‘their’ square of the Kandinsky drawing, see Figure 1.

This version and the third version forced users to create their expression locally before uploading it to the public screen, thus putting, in a sense, a layer between them and the result on the screen.

Third version: marbles
Another problem with the second version was that we could not make out who was who amongst the different Kandinsky squares on the public screen. In our third version, we therefore altered the graphical expressions again. We were inspired by marbles and how marbles can have objects inside, under a see-through but sometimes colored surface. In the system, each friend has their own marble that they can change the color (mapped to the temperature sensor) and animation (mapped to the vibration sensor) of. They can also put a personal picture inside their marble and have it covered with the (transparent) color of the marble.

On the surface of each marble, previous states are portrayed as old smaller marbles attached to their big, current marble, see Figure 1. We also changed the color scale into a scale designed to express more of the physical experience of temperature (which after all was what the temperature sensor was measuring) [16], going from ‘cold’ blue colors all the way to bright red ‘warm’ colors, see Figure 2.

But the most important change in this third version was that the friends could socially position themselves on the public screen by ‘far-from’ and ‘close-to’ buttons in the client software on their computer. If you feel close to one of your friends, you could tell the system that you wanted your marble to be close to that friend’s marble. But if your friend had explicitly said that s/he did not want to be close to you (and that more times than you had said the opposite), your marbles would still stay away from one-another on the screen.

Fourth version: marbles with Sentilla nodes
In the latest version of the FriendSense system each user is given a sensor node (The Sentilla JCreate node) equipped with an accelerometer that picks up on acceleration in all three dimensions. We map this to characteristics of gestures, in Laban-terms the shape and effort of movements. Effort is mapped to how much ‘weight’ a user puts into the movement, and for how long the effort is maintained. This measurement is then mapped to the color of the marble. The flow of movements is categories as either smooth or jerky, and is mirrored in the movements of marbles as smooth or jerky animations. The shape of users’ movements are calculated from the size of the gesture and mapped to how marbles move over either a small or a larger space on the public screen. In a sense, this became a more holistic ways for users to express themselves through movement – an issue that we come back to and explain below.

FRIENDSENSE IN USE
To make the overall picture of the FriendSense system a little more comprehensive we will present two example situations of FriendSense in use. Both these examples are from using the third version of the FriendSense system, the marble version. Figure 3 presents screen dumps of the public screen by the end of these two situations.

The first example comes from when one of our colleagues was close to defending his thesis and the rest of us wanted to show him our support without disturbing him in his stressful situation. As we know, users tend to forget about updating their status in social systems when being engaged elsewhere. The same happened to this colleague, who had left a very stressed and annoyed expression of himself on the screen for several days. What happened was that the rest of us, who had a little more time to interact with the FriendSense system, fiddled with our expressions to look equally stressed, placing ourselves close to his expression on the screen. Some of us also filled our expression with photographs of our colleague. We wanted
to express our support for him in his very stressful situation. But not only was this situation about a group formation of a collective empathic expression on the public screen. To form these stressed expressions we had to move our sensor nodes and thereby ourselves in a stressed manner, which meant that we also physically and emotionally experienced reminiscent of the same stress he experienced.

Another example illustrative use example was when two of our colleagues were in conflict with each other. In a workplace emotions such as anger and annoyance needs to be controlled and most often, we spend quite some energy on finding less harmful ways of expressing them. Our intention was not to implement a system that would expose purposefully hidden emotional processes, but we also did not want our system to prohibit showing aspects of sensitive or even destructive actions. In this situation one of the two colleagues was supervising the other and they had become good friends. The differences in their relationships to each other sometimes made the situation a little bit tense, especially during stressful parts of their joint work. In FriendSense they sometimes allowed themselves to reveal some of their current, perhaps more negative, emotions towards each other, emotions that at the time were too sensitive for them to explicitly talk about as it could have harmed their work relationship. The way this was acted out in FriendSense was different from how it perhaps would have been acted out in real life: it became a ‘game’ where the supervisor teased her student by challenging her ‘sulky’ mood. Figure 3b shows how the student reveals her sulky/angry mood towards her friend/supervisor by putting an angry picture inside her marble, make it orange/red and moving it far away from the supervisor’s marble. The supervisor responds to this by repetitively trying to place herself close to the student’s marble - not to calm her down but instead to tease her and perhaps upset her even more, in a sense to take the edge off the quarrel. This ‘hunting’ across the screen through repeatedly positioning themselves relative to one another continues silently in parallel to their actual work together where the situation is still tense.

THREE EXAMPLES OF WHEN MATERIAL PROPERTIES MATTED SUPPLENNESS
Given the description of the development of the FriendSense experiential prototypes, some of the reasons why we progressed from one version to the other, and a few example of usage, let us now turn to three of the most significant design insights on suppleness that arose from the properties of the digital material itself.

I. Sensor node look and feel
Our design aim is that the gestures should not feel like symbols or functions – they should be involving, experiential gestures, resembling our emotional and social ways of being in the world. When we perform them, they should pull us into an involving loop, an emotional dance, a supple experience between the gesture and the rendered expression on the public screen, resembling the emotion or social messages we aim to express.

**Encounter with digital material properties**
The first sensor nodes we used picked up on temperature and vibration but that did not, despite what we assumed, properly afford expressions such as moving, warming or cooling the node. To really make the animation on the public screen lively, we had to bounce the sensor node against our hands or some more or less hard surface, such as the desk or a bunch of papers. This activity became way too focused on the requirements of the node rather than moving and expressing yourself freely and letting the system pick up on that. Likewise, heating or cooling your temperature sensor turned out to be a harder task than expected since the battery on the back of the circuit board emitted heat and the placing of this sensor varied between the nodes. This resulted in differences in how hard it was for users to have an affect on temperature and thereby the color of their expression on the screen. Some could not make their sensor cool down at all. Occasionally we had to place our nodes on the windowsill outside a window to cool it down (which requires living in a cold climate zone). These activities distracted our attention from trying to express ourselves to instead focus on the physicalities of the nodes. The interaction became to cite Heidegger ‘present at hand’ rather than ‘ready at hand’ [3].

The bulkiness of the node also better afforded negative gestures, noise and frustration, and not the more pleasant, warm or cheerful gestures. One of our colleagues even dressed her node to make it both look nicer but also more comfortable to hold and thereby potentially affording more positive gestures, see Figure 4.

**Our solution: bringing in richer materials**
It became clear to us that the limitations of the Freie Universität sensor nodes were too big to overcome. We needed different sensors and a different look and feel of the node itself.

The Sentilla JCreate sensor node is covered with a smooth plastic surface, it is smaller and the look of it is more neutral (see Figure 1) than our previous sensor node. This made it more comfortable to hold and therefore we hoped it could allow us to be more expressive. But more importantly (since we also could have designed a cover for the node itself.

Figure 4. One user dressed her sensor node.
first sensor node), instead of a sensor capturing vibration, it came with an accelerometer that could capture acceleration in all three planes. From that we could calculate the energy/effort of movements (see Laban-dimensions above) and together with its progression over time we could also calculate distance in all three planes. That in turn allowed us to look for the size of movements and if they are smooth or jerky in terms of flow. Even though we had previous experience of capturing emotional movement [e.g. 15, 18] we had not in detail understood how different motion sensors will pick up on different properties of movements relevant to users’ experience. While some sensors, such as the vibration sensor used here, will force users to move the sensor in ways that makes sense to the sensor, but not to the user, the accelerometer picking up on movement in three planes allowed users to move freely, in ways that made sense to them – in this particular application scenario.

To verify this in the FriendSense setting and also to get more experience of what movements users wanted to express if not hindered by the sensor properties, we organized a workshop with some of the friends/colleagues who had been using the previous versions of the system. They were given the sensor nodes to try out, but there was no functioning system in place. This allowed them to show us expressions and interactions they wanted to perform, based on their prior understanding of the material qualities, thereby making them realistic to implement.

During the workshop, it was fairly easy for us to brainstorm and a range of expressive gestures was performed. For example, one participant brought her sensor node close to her heart to show empathy with another participant who had bad luck with his employment situation. He thanked her by moving his sensor node in a big circle. Then when another participant told the group about his despair over employment, another participant moved the sensor node gently round in a big circle.

For example, another participant who had bad luck with employment situation. He thanked her by moving his sensor node in a big circle. Then when another participant told the group about his despair over employment, another participant moved the sensor node gently round in a big circle.

But this brought us to the second material encounter example: how could we map these dimensions to expressions on the public screen?

II. Finding the algorithm that extends feel

We now had a sensor node that felt nice to touch, and that could afford a richer set of expressions. But we needed to map from the sensor data, via the Laban-description of the dimensions shape and effort, to the expression on the screen. But what mapping should we choose?

Encounter with digital material properties

Different people may have quite different body language, and so we could not map the gestures in a one-to-one manner to some specific expression on the screen. Not could we require users to perform one specific movement to get one particular expression, as that might not harmonize with how they want to express themselves.

We also needed quite some liberty to express a whole range of experiences – not be forced to choose among a limited set of possible states.

Our solution: mapping through iterative testing

Here the properties of the software material – the algorithm for mapping from gesture to public screen expression – became prominent in our design process. Through

<table>
<thead>
<tr>
<th>Emotion user/users wanted to express</th>
<th>Gestures used to express this</th>
<th>Shape in terms of Laban</th>
<th>Effort in terms of Laban</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expressing her empathy</td>
<td>Bringing sensor node to heart</td>
<td>Enclosing, retiring</td>
<td>Light, bound, direct, sustained (in that she repeated the movement)</td>
</tr>
<tr>
<td>“Thank you” for support, but still sad on the inside</td>
<td>Moving the sensor node softly round in a big circle</td>
<td>Rising, descending and spreading</td>
<td>Light, fluent, flexible, sustained</td>
</tr>
<tr>
<td>Mixed feelings of happiness for one and sadness for another, both being present in the room</td>
<td>Moving sensor node slowly and fluently up and down</td>
<td>Rising and descending, and a little bit spreading</td>
<td>Light, fluent, flexible, sustained</td>
</tr>
<tr>
<td>Playfully annoyed by someone talking too loud</td>
<td>Making loud sounds by banging sensor node on the table</td>
<td>Rising and descending</td>
<td>Strong, bound, direct, quick</td>
</tr>
</tbody>
</table>

Table 1. LMA conducted on the gestures the Sentilla sensor node opened up for and that users wanted to express.
repeated experimentation, we found one set of mappings that ‘felt’ close to the richness of individual differences and need for expressivity. In the algorithm, the effort expenditure over time was mapped to the color of the marbles. The underlying argument was that if you put a lot of effort into a gesture you get warmer, it feels more ‘red’, while if you put less effort in, it feels cooler, a ‘blue’ feeling. Through focusing only on the effort dimension, different people can exert effort in different ways – it does not require one particular shape of the movement.

The flow of movements (smooth or jerky movement) was reflected in how your marble on the screen was animated. Here we aimed for, more or less, a direct mirror of the movement. The marbles should be in sync with your own body – making them part of your own expression. We wanted to allow for the feeling that the expressions extended upon your own movements and that they were mirroring you rather than that you had to consciously affect certain aspects of them.

Finally, the shape of movements was only analyzed in terms of their size. We mapped this size to how the marbles were animated as moving over either a small or a larger space of the public screen.

It may sound as if this mapping from movements with the sensor node to expressions on the screen was easy to find – or that we claim that this is the optimal and only possible mapping. This is not the truth. The Laban-analysis helped us in that we knew what characteristics of movements we were to capture and create a coherent expression for on the screen, such as flow, size and effort of movements rather than the complete picture of movements. We could also work with these dimensions one at a time and make sure we got each part of an expression right before we combined it into one. But still, it was a complicated, iterative process to fine-tune the graphical expressions to harmonize in terms of timing and ‘character’ of users’ movements. For example, to capture the flow of movements we had to decide on an algorithm that felt as if it could exhibit the diversity required by users’ different personality in bodily behaviours. It was a matter of finding the characteristics of movement rather than a choice of graphics. The only way to get this right was to repeatedly test it – ‘feeling’ the interaction and thereby finding the right mapping algorithm.

III. Signal Strength ▶ Closeness to Friends
As discussed above, the ultimate design goal for FriendSense is to embody some of the more bodily aspects of emotional closeness and the bonds of friendship that hold a group of friends together. But in a group of friends, we are not equally close to everyone, and over time, we may want to express more or less closeness to our friends (as in the examples above), due to the everyday dynamics of empathizing, quarrelling, longing for or even getting bored with our friends. And sometimes, we want to be alone, despite being physically amongst our friends.

In our long-term use of the third FriendSense prototype, the possibility to make your marble close or far away from someone else’s marble, became one of the more important expressions [17]. The system mediated a ‘parallel universe’ of interaction to that going on in the ‘real world’. The way you sit on your chair, your facial expression, your sighing, or body posture all reveal aspects of what you are doing and what you are feeling. But the probe did not mediate exactly the same signs and signals as your physical body does. Emotional closeness, conflicts, and bodily experiences as expressed in the office were transferred, transformed and juxtaposed against participants’ virtual presence and positioning on the public display. What was going on inside the probe was sometimes equally important as what was going on in the office in terms of expressing emotional, physical closeness or distance.

Encounter with digital material properties
In our second and third implementations of the FriendSense system there was a software client running on users’ PCs where friends first created their expression using their sensor node and then uploaded it to the public screen. For the marbles version this software client also allowed users to position their marble in relation to other marbles by clicking on ‘far-from’ or ‘close-to’ buttons.

In the fourth prototype, we wanted to remove the software client to strengthen the physical experience of expressing oneself using only the sensor node directly mapping to the big screen. The software client had been an annoying layer of interaction, hindering a direct relationship between us and our expressions on the public screen. But how could we use the sensor nodes to express whom we wanted to be close to or far from?

One suggestion we had got from one of our users was that users move their nodes physically closer to/farther away from their friend’s nodes to express distance. Her idea was to use the radio-signal strength to solve this technically, as radio-signal strength is oftentimes used for indoor positioning (even if it is not intended for that usage).

But, as it turns out, in a technically ‘noisy’ environment the radio on the nodes will not map distance very well and especially not at the granularity level we needed. To understand how radio in sensor nodes functions, we need to explain some of its digital-material properties. One node is often set to be the host and collects communication packets sent from the other sensor nodes. In such a host-set up, a packet from one node, is not only sent directly in a straight line to the host. Instead there is a broadcast of packages sent in all directions from each and every node. (We are referring to the simplest set up of sensor networks where no computational package takes the way thru any other sensor node in communication with the host, a set up where all nodes communicate directly with the host.) Under ideal circumstances with only one node and one server, and no other physical objects, walls or
people around, we could calculate where the nodes are in relation to one-another using the nodes’ signal strength. But, unfortunately, this ideal scenario does not exist for several reasons. First, all nodes are sending packages at the same time and they are also broadcasting which leads to multiple, ambiguous packets and changes in signal strength. Second, there are other wireless communicating units in the room, such as mobile phones or Bluetooth units, which together with walls, furniture and people in the environment make some packets get lost or be stopped on route to the server. In summary, using radio for positioning may render more or less random results.

Our solution: look for what the material affords

We had to go back to the drawing board and think carefully about what it was that we really wanted to achieve with the idea of ‘social positioning’ and friends being close or afar from one-another. The problems with sensing distance made us ask ourselves whether social position should be linked to physical closeness of the nodes? Perhaps more important was emotional proximity – having the same mood or showing empathy through trying to have the same expression as a friend (as in the example of expressing support to the colleague defending his thesis above)? From what we and other friends actually did with the system, we saw the potential of basing closeness on likeness of expression – ‘expressive likeness positioning’. Two friends with the same expression could be moved close to one-another. Expressive likeness positioning also allows for mimicking and letting users note the effort others have put into an expression. But while this approach opened up for these other interesting aspects of emotional closeness expressed as empathy, it did not solve the original problem. Properties of the material prohibited a perfect match with our design aims. But instead of ‘fighting’ the material to fit the design aim, we used the properties of what the material afforded, and what we had seen unfolding in the socio-digital material.

DISCUSSION

In this design process we put ourselves in an extreme starting position: without a clear and detailed idea of the purpose of the system (more than the aim that it should support a group of friends), without a clear context of use, and with only minimal input on how friends create their and sustain their friendships [17]. Instead, we immediately dived into the lived experience of the material thereby finding out why, how and where friends could make use of this kind of system. This extreme position allowed us to see how the socio-digital material unfolded in dialogue with the technological possibilities. In retrospect, after having worked through this complicated and messy design task the lessons learnt were crucial for the next step in the design process where we moved from our probe-approach to creating a more realistic system, ArtSense. With ArtSense, we returned back to a more structured user-centered design process: studying friends in a museum to find a relevant context, working through the purpose of the system in a structured way, pinpointing the intended user group, and iteratively designing prototypes bringing in users (and ourselves) to test versions of the system. There is not space enough to describe ArtSense here, but in short, it allows friends visiting a museum to express themselves physically, through gestures, leaving traces or co-created expressions for their friends to pick up on as they pass through the museum (see Figure 1 for a picture of what the system looks like). ArtSense does not rely on any screen, but uses leds and vibrations as feedback – all integrated into the egg-shaped artifact.

But the purpose of designing the FriendSense-probe was not only to work out the overall set up or possible functionality of a potential future system. Our main purpose was to learn more about supple interaction based on a better, richer and deeper understanding of the material. We had to figure out the affordances of the sensors and the sensor network technology in order to know how to create for “an emotional and social ‘dance with the system’” where expressing yourself also makes you feel bodily and physically involved in what you are expressing. We needed to know what kinds of movements and expressions users would want to express in various situations – but perhaps more importantly, how those would arise from their dialogue with the material and what that would feel like. This why FriendSense was permanently installed and used in our own lab. Some readers will probably object to the idea that colleagues at work are friends. Others might object to the method of letting designers base the design decisions solely on their own experience of the system they are designing. But to us, this was a crucial step in living our own design and experiencing exactly how the different design decisions and choices of technology we brought in changed our experiences of the system. Obviously, this does not remove the need to bring in outside users (as we also did during our design process), to empathize with future users [222], or to find a relevant context and study it as input to the design (as we have later done with ArtSense).

By exposing some of our design process and the importance of considering the material properties we have started to uncover some of what Isbister and Höök discussed in their paper at CHI 2009 – partly from living with our design throughout the design process but also from truly getting to know our material. Our emphasis has been on how the design processes can be shaped by the materials being used; to design with sensor networks is not the same as designing with some other digital material. As can be seen from our three examples of material encounters, the look and feel of the sensor node, choice of sensors, limitations of the radio signal strength and coverage, as well as iterative prototyping to properly exploit the software/algorimic possibilities guided our design process.

We would even like to claim that the ‘meaning’ of a gesture can only be understood in the context of the application, as experienced inside the interaction as it unfolds.
with the material, in the context of the particular group of friends. The possible expressive gestures must therefore co-evolve with the exploration of the affordance of the digital material.

It is also interesting to note how the expressions of friendship inside FriendSense were different from their expressions ‘in real life’. There is no way we could have jumped from the initial ethnographic study of long-term friends directly to designing the final version of FriendSense. FriendSense is not a simple mapping from how people touch, quarrel, co-create mood, confide or have fun in real life. We first had to live with the experiential prototypes in and through the socio-digital material enabled. It is only when our groups of friends start expressing themselves in and through the digital material that the ‘alternative universe’ of expression that the material enabled. It is only when our groups of friends start expressing themselves in and through the experiential prototypes that the socio-digital material takes shape for us as designers. Only then can we mould the interaction into meaningful gestures and interactions between the friends.

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