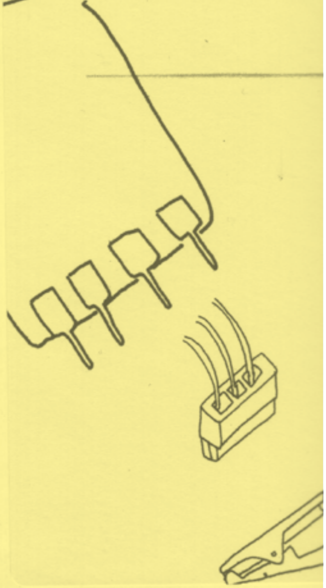
IT +
Textiles



IT + Textiles

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IT+Textiles

Johan Redström

Introduction

It might seem as if 'computers' have remained largely the same since the introduction of the personal computer and the graphical user interface some decades ago, but this is far from true. Now that we are beginning to understand how to use – and live with – these large square boxes interfaced through screens, keyboards and a multitude of accessories, chances are that this understanding of what a computational thing is like will be fundamentally challenged by current technological advances.

Perhaps without even thinking of them as 'computational things', we incorporate mobile phones, MP3 players, and digital cameras in the way we relate to each other, to communication, and to information. Though a digital camera might look and even sound like a traditional camera, just consider differences in behavior that they bring – how we hold the camera to take a picture, use the display on the camera to share the results, and archive digital memories as opposed to paper artifacts. Similarly, our mobile phone might resemble a traditional, stationary phone, but there is little that remains in terms of how we use it – with a shift from devices associated with places to devices carried around by people, the social protocols of telephone use have transformed.

As computation is embedded into things, environments and perhaps even people, what might once have appeared as discrete, rather limited objects becomes a 'ubiquitous' resource, an 'ambient intelligence'.

Introduction

It might seem as if ‘textiles’ have remained largely the same since the dramatic changes that came with the industrial revolution and mechanization of production, but this is far from true. Although textile is one the oldest and most important materials we use in our everyday lives, the things we wear and to furnish our surroundings, chances are that our understanding will be significantly transformed given the implications of current technological advances.

Perhaps without even thinking of them as ‘textiles’, we experience new textile materials applied as reinforcement materials, as medical implants, or as electronic components. While innovations such as ‘non-woven’ materials certainly challenge the way most of us may think about how textiles are made, the real challenge will come from new areas such as ‘smart textiles’. In this area, the creation of materials with the ability to sense, react and change points towards a future of uses, expressions and design possibilities not previously associated with textiles. While much of this development is currently targeted towards military, medical or industrial sectors, it is clear that these new materials will soon be entering into our own everyday lives.

As textiles expand beyond traditional textile design, art, craft and fashion into electronics, computation and even nanotechnology, what might once have seemed a rather ‘traditional’ material transforms one of the most innovative areas of new design materials.

IT+Textiles

In light of the imminent arrival of ambient intelligence and smart textiles, the design of computational and textile things are rapidly converging. While substantial attention is directed towards the technical possibilities of these new materials, much less effort seems to be put into the challenging task of re-thinking the use of textiles and computational technology in design on the basis of a rather complex mixture of traditions, perspectives, concepts, methods and materials resulting from such a convergence.

We might, for instance, ask questions about the expressions of technology as it gets a textile surface we can relate to – while the textile things we use everyday are often soft, warm, memorable and close to our bodies, technological devices often feel quite the opposite, as harsh and rigid, cold and distant. What happens as we combine them? On the opposite side of the coin, we might ask questions about what happens to textile design, traditionally focused on techniques to create static graphical patterns, as computational power makes it possible to work with dynamic patterns and change visual, sonic, and even tactile properties. Although it is easy to see strong relations with respect to technical development, it is less clear what it would mean to approach technology design on the basis of traditions that exist in the area of textiles, or vice versa.

Such challenges and opportunities are what originally inspired the IT+Textiles research program. To explore the potential design space around IT and textiles, we combined perspectives and methods from fashion, textile and interaction design, textile and electrical engineering, philosophy and behavioral science.

Research structure and outcomes

The IT+Textiles research program has been funded by VINNOVA, the Swedish Agency for Innovation Systems, mainly through two granted research applications called ‘Emotional Broadband’ and ‘Textiles and Computational Technology’. The objective of ‘Emotional Broadband’ has been to develop new IT-based devices for interpersonal communication with a focus on aesthetical, social and emotional aspects of use. The term ‘emotional broadband’ refers to a way of approaching the design of communication systems where it is not just the technical bandwidth but *what* and *how* we communicate that is in focus. In comparison, ‘Textiles and Computational Technology’ approached the same general area from a more technical point of view – how networked computational technology and textiles could work together to make new ‘pervasive’ computational resources present to people in meaningful ways.

Partners and collaborators in the research program brought a div-erse range of interests, competences, and knowledge into the project, representing the traditional textile industry, research and education, technology and service development, design and design research, and commercial consultancy. Thus, desired outcomes ranged from product concepts and even new companies to papers and articles in established research forums, from artistic exhibitions and public seminars to the development of new educational curricula.

In many ways, the program was set up more as an open meeting-place for collaboration than a narrow effort towards a single objective. Having had much experience working in so-called ‘interdisciplinary’ settings where it is an ongoing challenge to establish mutual understanding, much less consensus, we structured IT+Textiles around an open exploration of diverse practices and complementary understandings. As applied to project work, this meant that we worked with two types of structures: smaller projects done by one to three people that were open-ended and experimental, typically focused studies of some material, situation or method, and; larger projects typically involving more than five people in developing a prototype or a concept based on combinations of findings from the smaller ones.

The notion of combining smaller, experimental projects into a foundation for larger, more developed ones also relates to traditional models of research work. In our approach to design research, we explore existing or emerging technologies on the edge of, or slightly outside, their current use context, to create more or less (un-)expected combinations and interpretations. We do not develop much basic technology or materials, rather we work with what might be considered 'applictions' for such things. Some time ago, such an approach might have been likened to Levi-Strauss' notion of 'bricolage' – these days more Post-Modern notions of 're-appropriation' are perhaps more popular. Regardless, processes of recombination and reinterpretation are central to much practical research work, and IT+Textiles explored whether such ideas could also be a basis for structuring a three-year research project. Of course, with such an open approach and loose structure, predictability of results was neither possible nor desirable – our intention was to create a format where free and creative experimentation was not only possible but even a driving force for an expedition into a largely unknown design space.

In this book, we present results that represent a diversity of thinking and working that made up the program as a whole. Beginning with a theoretical framework, we present some of the conceptual and methodological issues essential to the project. Then, there are examples of larger projects, including discussion of the smaller ones that fed into them. For instance, the Interactive Pillows developed out of work on experimental textile displays and a study made for the development of new communication services for the home; Tic-Tac-Textiles evolved out of a study of acts of waiting and experimental work on the (dys)functionality of tablecloths. There are also examples of smaller projects that produced scenarios and design sketches and still others that resulted in functional prototypes. Lastly, on a very practical level, we describe some of the materials developed and applied during the research program.

This book describes what we did and learned from this interdisciplinary research program. As such, it can be read in two different ways. On one hand, it can be read as an attempt to frame and carry out an investigation of such a design space, as an illustration of the range of issues we have encountered, of our approach to this research area, and of its results. But it also allows for second kind of reading – as a practical example of what might come out of such a mixture of backgrounds, perspectives, methods and materials. Thus, this book documents an expedition into an emerging design space, illustrating both the inspiring and the occasionally frustrating complexity faced in combining two such different traditions as textiles and information technology in design.

On Technology as Material in Design

Johan Redström

Materials have a central role in design, in our understanding of form, and of what it means to craft an object.[1] Not only are many design disciplines defined, even named, in relation to certain materials, new materials have also played a central role in the development of design movements since they challenge existing notions of form, expressions, aesthetics and what sorts of objects can be created.

There seems, however, to be a significant difference between how we describe and relate to the materials important in, say, the Modern movement and how we relate to the computational technology, information and communication systems that are currently making their way into most areas of design. Whereas we refer to reinforced concrete and plywood as 'materials', we refer to electronics and computers as 'technologies'.

In what follows, we shall raise questions concerning technology in design. It is not technology per se, as social or scientific phenomena or as a tool to support design activity, that is our concern. Rather, our question is how to think of technology in design as a means to craft objects – how we think, or might begin to think, of it as design material and how such a perspective could provide a complement to thinking about technology design as the implementation of functionality.

Background

As it seems, many technologies end up being used in ways not originally intended by its designers.[2] Examples of reinterpretation of objects where a new use has become more important and influential than the original one include the telephone, the typewriter and the computer. Everyday life is filled with examples of local re-appropriation of technology, and subcultures seem particularly creative in this respect – the use of the turntable as a musical instrument in hip-hop could serve as an interesting example. Given the importance of interpretation and re-appropriation of objects in use, technology design as merely the implementation of functions seems problematic. Some 15 years ago, Jones wrote:

> But there is a hidden cost, a severe one, which has only recently become evident. It is that of inflexibility, over-specialization, the realization that this 'plastic world' of homogenized, cost-reduced products is increasingly unalterable, un-repairable, and imposes upon us (from its stabilization of the larger scale of functions) a life, an obligatory way of *using* what is made, that is felt as coercive, not satisfying, with decreasing outlets for individuality. The lesson is obvious, though how to apply it is not: do not stabilize functions.[3]

Elsewhere in the same text, Jones expressed some hope that the flexibility of new technologies might help us achieve a greater freedom in use, that processes of appropriation and interpretation would be encouraged rather than suppressed:

> Is that the meaning of the post-modern; the shift, in so many fields of life, from the planned and predictable, the multiplied ideal, the impersonal, to the empiric, the memory, the present thought? To the product not as means but as presence, as thing-in-itself?

1. Doordan 2003 **2.** Ihde 1993 **3.** Jones 1988, p 221

Software. The word, like others coming from computing and the new technologies, implies a far more than accidental change from the rigid to the gentle, the mechanical to the automatic, the imposed to the adaptive. But can we rise to it?[4]

Given the still common situation of user frustration with technology despite increased effort to ensure usability and utility, we might ask to what extent the flexible and adaptive powers of technology actually comes to expression in the design of computational things and electronic objects. We suggest that these questions may have something to do with the observation that whereas designers used to work with 'materials', we now seem to be working with 'technology' in design.

Technology design

Though phenomenological, sociological and other studies have challenged and expanded our understanding of technology,[5] practice still seems to be dominated by an instrumental perspective. Central to our understanding of technology still lies notions of use, the idea that technology is the means for achieving certain ends, often by amplifying the power of our actions. Encountering new technological devices, we ask: What is the use of this? What is it good for? We talk about 'applications'. And so, design as it relates to technology seems to involve the specification and implementation of the ways it should work, and what actions it might support. We describe technology in terms of its functionality.

Clearly, considering the workings of the technological device itself is not enough, and so the notion of functionality has also come to encompass aspects related to the thing in use, particularly its usability and, still more recently, aspects related to the user experience.[6] Still, it can be argued that it is the object in use, how it works, what actions it supports and how – its functions – that are being investigated and designed. And although explored in a much broader sense, it is precisely this focus on functions that seems problematic, since it could entail that design then becomes a matter of fixating predefined ways of interpreting and using an object. Let us consider some examples of when and why this sometimes unintentional fixation of functions is hard to avoid when designing ‘technology’.

Unknown objects

When designing a traditional object, such as a table or a pair of shoes, the object is to a great extent known beforehand, i.e., there already exist familiar categories of such objects to look to and there are traditions embedded within practices of design and use of such things that we can relate to. To design ‘new’ things of this kind partly means reinterpreting what is known, expanding on existing ideas about what can be expected, perhaps even challenging current understandings of the object category.

When introducing new kinds of objects, such as new technologies, there is not much in terms of traditions, expectations and interpretations to lean on and react against. In fact, such a framework must be developed along with the object itself.[7] This places the designer in a difficult posi-tion, since not only the object but also all aspects of its eventual use need to be envisioned. Thus, methods such as probing into possible use scenarios and user expectations become a way to get to know the object to be designed and help us build the framework needed for understanding the design problem.

4. Jones 1988, p 216 **5.** e.g. Bijker and Law 1994, Ihde 1993
6. cf. Jordan 2000, Preece et al 2002 **7.** Binder 2002

The difficulty is that while we can determine the design of a thing, we can only predict its use. And this is where we risk fixating its functions and thus also ways of using it – confusing the two different tasks, that of designing the object with that of predicting its use, we try to determine its use the way we determine its design.

In practice, this confusion between designing the thing and determining its use by means of fixating its functions has led to a strong focus on the capacities, needs and desires of people as a basis for design on one side, and the technology itself on the other. In the extreme case, design therefore risks becoming a question of how to package a given technology in a way that makes sense to a specified user group.

Of course, projecting what it will mean to use an object is something that is, to various extents, always present in design. However, when introducing not only new objects, but new object categories, these questions become central. Further, whereas it can be argued that the design of things such as the table, the chairs, or the dinnerware at a dinner party will shape the social interactions taking place, especially if significantly deviating from what we have come to expect from such objects,[8] such changes are very subtle compared to the rather dramatic effects of new communication technologies on how we relate to one another.

Seductive surfaces

When working with traditional materials, there used to be a more or less direct correspondence between the complexity of the object and its surface.[9] Mechanics usually implied that the more complex the thing, the larger its size. To some extent, this made objects self-explanatory, or at least meant that their complexity was expressed at a scale we can relate to. Looking at a mill or a steam engine, one can see how force is transferred through wheels and levers, how energy is brought into the process through the harnessing of wind, water or fire. Similarly, early examples of more recent technologies, such as the combustion engine or even the computer, share some of this visibility.

With miniaturization and new materials, this has changed. There is no longer any perceivable correspondence between the complexity of the object and its surface. Manzini writes:

> In the past, all that man produced (that is all the transformations he brought to natural substrates) belonged to his order of magnitude and was within his sensorial sphere. This made it easy to understand the components and functioning of all artificial objects… Throughout its development, technoscience brought its manipulative capacity, the level of its controlling possibilities; to dimensional scales different from those of our direct experience. Thus the artificial products it produces do not show structures or "mechanisms" sensitively connected to effects. In current practice, at the dimensional scale of our senses, functions seem to emerge mysteriously from inexpressive and dumb materials and components.
>
> This is true for those who experience this artificial environment as well as for those who are to design and manufacture it.[10]

This development cannot be underestimated with respect to how it has changed the way we need to think about both 'objects' and 'materials', and it might even be an important reason for the shift towards an interest in 'services' and 'experiences' instead (cf. also Jones' notion of 'intangible design').[11] Still, however, material objects do exist and somehow we do design them as such. But the new discrepancy between inner complexity and surface is problematic when taken in combination with the notion that the design should communicate the intended use of the object.

8. Niedderer 2004 **9.** Maeda 2000 **10.** Manzini 1992, p 2 **11.** Jones 1992

With respect to design as being in part about communication of designer intent, for example, clear statement of intended use through the design of the object, this reduction in the space available for expression and explanation forces us to make decisions about what to bring forth and what to hide away. As we deal with the question of what to explain and express, we base our decisions on the notions of use that guide the design process. Surface, then, becomes a kind of interface supporting predetermined modes of communication. But we soon approach a situation where we seem to be trying to achieve the impossible, namely, to properly express the inner workings of the object while at the same time hiding its complexity.

When design becomes 'packaging' – i.e. when the technology itself already exists and the task is to design the more or less interactive box it will reside in – it is often technological workings that need to be expressed and explained through the design. Since the surface does not suffice, the real complexity will be hidden and something else will be presented. One approach to this problem, particularly evident in the design of computational things, has been to introduce metaphors. This notion is based somehow on the rather strange idea that the complexity and structure of *another* object might be a good replacement for explaining the complexity and structure of *this* object. Another emerging approach is to render technology more or less invisible, as in the visions of *ubiquitous computing* and *ambient intelligence*.[12] Here, the workings of computational technology may be expressed as a smart and reactive layer integrated seamlessly into existing environments.

Although attempts to virtually or physically expand the spatial surface available for expression, neither metaphors nor smart environments represent a real solution to problems resulting from limitation of spatial form. Instead, they seem to be like working one's way around the problem. And again, we risk confusing the design of the object with determination of its use as we try to overcome the difficulty of expressing complexity through spatial form by presenting a limited or even an alternate picture of what is really going on that is based on how we think the device is going to be used. As soon as we leave the domain of intended use, or when something does not work they way it is expected to, the picture we provide to the user makes little sense. Which, in turn, forces the user into the ways of use that this fixation of functions has created or away from using the thing at all.

Time

Next, we need to consider one of the potential solutions to the reduction of surface, the shift towards the temporal dimension of objects. With miniaturization, there comes a need for working with time as a design variable. Maeda writes:

> The contemporary solution to the reduction in design volume has been to compensate for physical space with virtual space… Hence, although we might consider an object restricted in a spatial sense, its dynamic surfaces allow the object to transcend those restrictions through expression along the never-ending dimension of time.[13]

At first, it may seem as if working with a temporal dimension could free us from the problem of deciding what to express with the surface of things since, in theory, it would enable us to sequence everything over time. While there are systems and devices with endless menu-systems that seemingly do try to implement this idea, working with time introduces new design problems, and to realize that these are at least as complex as the spatial ones we need only look at music, film or drama.[14]

12. cf. Weiser 1991, Aarts and Marzano 2003 **13.** Maeda 2000, p 25 **14.** Jones 1992

With respect to interpreting and understanding a design in use, temporal elements present the difficulty of how to shape things that will only show when the object is being used in one way or another. Whether a result of user input, the result of more autonomous processes, or both, the appearance of the object changes over time and so we cannot simply take a quick look at the thing to see what it is to understand it, we need to experience it over time. Much work has been done on how to overcome this, for example interfaces that continuously display all or most of their functions to the user, but the basic problem remains, especially if we aim to design something that takes advantage of dynamic properties and that adapts or develops over time.

The importance of temporal form ties notions of use even closer to the design, as we turn to investigating use and users in order to learn about the expressions of the thing over time, or to design it to fit the activities of users.[15] In other words, we might try to base the temporal composition of the design on observed or envisioned behaviors. And again, we risk confusing the activity of designing the object with determining how it should be used, this time not only as functions but also in terms of more specific predefined behaviors and patterns of use.

Technology and material differences

It seems that the way we understand technology in terms of functions makes it hard for us to work in situations where we might need a more open perspective on use and where fixation of functions is problematic. And it is precisely here that the difference between working with 'technology' and working with 'materials' might be significant: while our understanding of technology seems to depend on the notion of functions, our understanding of materials does not.

When working with a design material, we find ourselves within a framework that does not depend on 'use' in the rationalistic sense, but where questions of form, expressions and aesthetics provide a basis for exploring possibilities and characteristics of the materials at hand. For instance, to understand what it means to design things using clay, wood or textiles, we would make things using the materials in questions just to better understand how they work. This is not, however, to say that this knowledge differs from our understanding of technology in that it is tacit or experiential,[16] but simply that it does not seem to rely on the specific acts of use to which the final object might, or might not, relate to in the end.

Working with the form of materials rather than the function of objects is not just an educational process – for instance, a textile designer may work with a material without knowing exactly what purposes it eventually might be used for since this is left open for the whoever decides to use it. Although the textile designer might have ideas about tablecloths, curtains or clothes, what he or she actually designs is the fabric itself. Not only textile designers but people in general have an understanding of textiles as material and a way of talking about them in terms of basic expressions such as texture, smoothness, thickness, and color without having to relate to the functionality of any final object.

This is, of course, a highly simplified account, but it nevertheless points to a fundamental difference between how we relate to, say, textiles versus computational technology as building blocks of everyday things. Now, if some of those differences depend on the how we tend to think of technology compared to how we think of materials, it seems valuable to explore what an understanding of 'technology as design material' could be like, and what new ways of thinking about the relation between design and use that a non-functional account of technology could support.

15. Mazé and Redström 2004 **16.** cf. Friedman 2003, Schön 1983

Technology as design material

According to basic definitions such as 'material is what builds the thing; form is the way material builds the thing', computational technology is a material since it is used to build certain things, 'computational things', and since computation is essential to the way they appear.[17] At the same time, technologies like this are not like traditional materials in terms of appearance, but almost 'immaterial', as they are not present to us in the way that traditional materials are. Dunne writes:

> The electronic object is an object on the threshold of materiality. Although 'dematerialisation' has become a common expression in the relation to electronic technology, it is difficult to define in relation to the tangle of logic, matter and electrons that is the electronic object. ... Dematerialisation, therefore, means different things depending what it is defined in relation to: immaterial/material, invisible/visible, energy/matter, software/hardware, virtual/real. But the physical can never be completely dismissed.[18]

Clearly, the materiality of technologies differs from that of traditional design materials. Perhaps we cannot physically shape computational things with our hands the way we shape wood, glass or concrete. But this is not only a question of the properties of matter, perceivable or not, but of what frame of reference we use, and what questions we ask as we engage in design.[19] And so we might ask, what happens if we try to think of 'technology' in terms of 'form' and 'material'?

Material expressions

Let us start by asking if the reason we do not perceive the expressions of technology as material is because there are none or because they are hidden beneath a surface of increasing technological perfection?

While we talk about, say, textiles in terms of material expressions, what could be said about the material expressions of electricity? Taking as an example a rather simple object such as a lamp, it is quite obvious that electricity, although perhaps in itself invisible, has a strong presence in the object. But while we might talk about the lampshade in terms of design expression, the presence of the electrical parts is often reduced to questions of on and off, their operation preferably described in terms of Watts. We seem to hide electronic material under increasing technological perfection and, while we may spend hours to find the right lamp to our home, it is likely that we simply buy the first, cheapest or most efficient light bulb we can find to put in it.

Another reason for thinking further about the idea that the material expressions of technology are hidden rather than non-existent is that early examples of technology, particularly before the technology was working perfectly, often have very strong expressions in themselves. In the early days of radio and television, for instance, expression of signal transmission and reception were present as noise and distortion of the sound and image. Depending on circumstances such as weather conditions or placement of the antenna, the transmission would change slightly and thus expose basic characteristics of the technologies used. Here, the technology, the material building the object, was present but since then every effort has been made to hide these expressions away, gradually achieving more technically perfect image and sound. There are also, however, examples where the expressive qualities of such technology, especially when not working properly, have been developed and emphasized, for instance in electronic music.[20]

In everyday life, the expressions of technologies as material in our things become subject to (re)interpretation. When using mobile

17. Hallnäs and Redström 2002a, 2002b, Redström 2001 **18.** Dunne 1999, p 24f
19. cf. Binder 2002, Löwgren and Stolterman 1998 **20.** Cage 1956, Cascone 2000

phones, it is still possible to experience the basic expressions of the communication technologies used to build the object. For instance, this 'material' shows at places where the communication cells do not provide optimal coverage, for instance when indoors, in tunnels or in certain areas at the countryside. Here, the connection will come and go, sometimes without us doing much at all. The expressions of this technological material clearly affect the way communicate, among other things resulting in interrupted conversations or distorted sound.

While sometimes frustrating, we have learned to use such material expressions to our advantage, as it enables a series of new ways of ending unwanted conversations. By referring to batteries running low, by making sounds ourselves to imitate the noise resulting from a fading connection, or by simply saying that we can not hear the other anymore, we can end a conversation in ways not previously imagined in the social protocols of phone use. Here, the expressions of technology as design material have been given an interpretation in terms of use that certainly was not intended by the designers of the technology itself and that is not included in any functional description of the device.

These examples are anecdotal, but they might indicate that technologies do have material expressions that come into play in design that are not captured within typical functional frameworks since they exist outside the intended use of the thing.

Form elements

Since new technologies are almost 'immaterial' in presence, notions of form as, for instance, physical shape will clearly not apply in the same way. As discussed above, primary expressions of these new materials exists in time rather than space. Taking computational technology as an example, central characteristics depend on notions of states, of processes, of algorithms, of programs being executed. Similarly, expressions of a mechanical engine comes from combustion and the resulting movement – consider the experience of driving a car when there is water in the gas or when the engine does not ignite properly.

Thinking about the form elements evident in these expressions, it is, however, also clear that it is not pure temporal form, but temporal form as manifested through some kind of spatial 'surface' (in the widest sense of the word).[21] The results of computational processes are evident to us through displays and through other devices, the electric material of the lamp through the glowing wire, and so on. In other words, temporal form elements need to be given some kind of spatial presence in order for us to be able to perceive and thus use them, just as music has to be performed for us to listen to it. This also implies that only that which expresses itself through this spatial surface will be present to us.

That temporal form needs spatial manifestation has some interesting consequences for how we can think about the form of technological objects. First of all, the relation between temporal form and how we design it to be manifested in space will, to some extent, always be arbitrary – for the most part there may be multiple design options available for expression and thus many other solutions could be found. For instance, there is nothing about computation per se that requires us to use typical LCD or CRT screens to display the results. The basic requirement is for some kind of dynamic spatial surface capable of displaying the temporal structures that such computation generates. In practice, this means that we are free to use any material that is somehow capable of expressing states. To build a computer display, we are therefore free to choose material according to what expressions in use that we are interested in, whether textiles,[22] wood,[23] water,[24] or something else.

21. Hallnäs and Redström 2002a, Redström 2001 **22.** Hallnäs et al 2002b
23. Rozin 1999 **24.** Wisneski et al 1998

This provides a foundation for thinking about how to relate technology as material to traditional design materials in terms of form: while traditional design materials primarily have spatial form elements, technologies like computation primarily have temporal form elements. Working with combinations of such materials therefore means working with combinations of spatial and temporal form and exploring how spatial form elements are used to manifest temporal structures.

If we investigate form in this way, we might re-think the design of a lamp, imagining what might happen between on and off, how the patterns printed on the lampshade might be reconsidered in relation to a much more dynamic light source, how a lamp might be used as a computer display, etc. While not a very sophisticated example of form, it illustrates how the distinction between what is considered a concern for form and material, and what is just technology present in the background, could be made to break down to give way for an understanding of the overall form of the object.

Next, one could proceed to re-think the form of a mobile phone and in what ways it depends on form elements that do not reside in the device itself but rather in the complex systems of servers, antennae, etc., that 'builds' the thing as it appears in use. Then we would understand that while its spatial form elements are bound to the material object as we experience it in our hands, its temporal form elements are not – could we tell if a given process is carried out in the device or somewhere else in the network? Although the physical thing no longer defines the object entirely, we can still talk about the form and material of the object as experienced here and now, given this interpretation of the relation between spatial and temporal form elements of objects.

Discussion

Thinking about technology in terms of material, in terms of form rather than function, seems to imply a certain vagueness with respect to use since we do not depend on a description of the way a thing should be used – cf. Jones' notion of 'pure design', i.e., "designing without purpose (or without a purpose that was fixed before the moment of use)".[25] But is it reasonable to think that it might be possible to design usable objects based on complex technologies that are inherently vague and ambiguous with respect to use?

First, we must make a distinction between objects that are intentionally vague with respect to use and objects that are ambiguous although they were designed explicitly to express some particular modes of use. In the latter case, there will be a model, although perhaps not consistent or well-defined, underlying the design that a user needs to understand and comply with in order to make the thing work. In the first case, however, the intention would be to create an object that is open for interpretation. While unintentional vagueness makes an object difficult to use and is something that can be justly criticised from a usability perspective, intentional vagueness can be, when successful, more of a provocation, an invitation to a more individual interpretation the object in use.[26]

Still, is it possible to design, say, electronic objects and computational things that are intentionally vague with respect to use or do we need a strong functional framework to make sense of such objects? While still an open question, there is a growing interest in and work exploring such designs.[27] Interesting examples can be found in the work of Dunne and Raby, for example in the 'Placebo' project where they used

25. Jones 1992 **26.** cf. Dunne 1999, Dunne and Raby 2001, Gaver et al 2003, Hallnäs and Redström 2001 **27.** Gaver et al 2003 conceptual designs as a way to investigate people's attitudes to, and experiences of, electromagnetic fields. Here, the main interest lies in probing into 'the secret life of electronic objects' – actual functionality is at best that of placebo objects that do not solve problems but rather provide some psychological comfort.[28] Other examples of such work on intentional vagueness with respect to use include work on communication and interaction devices,[29] electronic objects,[30] and more.

In such examples, it becomes evident that it is possible to design things that become meaningful to the people using them without determining precisely how they are going to be used, even though the objects themselves might be quite complex and built using complex technologies. Of course, these designs are not meant to replace current information processing systems based on specific ideas about functionality, but they point towards an alternative perspective on technology design that could prove valuable.

Concluding remarks

There seem to be at least two important advantages to developing an understanding of technology as material in design. First, it takes as a foundation long traditions of exploring new materials in craft and design, enabling us to better understand these new challenges of form, material, expressions and aesthetics in relation to more established materials and practices. Second, it could provide a framework for working with technology in combination with other design materials, something that will be of increasing importance as computers and electronics make their way into all kinds of everyday things and environments.

Perhaps most important is, however, that it could open up design with respect to how, when and why concerns about functionality and use enter into the design process. The notion of a design material could provide us with the non-functional account of technology we need in order to find ways of working in situations where we do not want to, or cannot, determine the final use of the objects we are designing. In regards to the problematics of sometimes unintentionally over-determining functions, we can now explicitly ask questions such as: What are the boundaries of the design act with respect to acts of use, of interpretation and appropriation of objects? Is the determination of the use of an object an act of design or an act of use? Thinking of design as crafting objects with form that needs to be interpreted positions us quite differently with respect to such questions in comparison to thinking about design as creating objects with functions that need to be understood.

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28. Dunne and Raby 2001 **29.** Gaver 2002, Hallnäs and Redström 2001 **30.** Dunne 1999

Methods (and Madness)

Ramia Mazé and Maria Redström

What we need to question is bricks, concrete, glass, our table manners, our utensils, our tools, the way we spend our time, our rhythms. To question that which seems to have ceased forever to astonish us. We live, true, we breathe, true; we open doors, we go down staircases, we sit at a table in order to eat, we lie down on a bed in order to sleep. How? Where? When? Why? – Georges Perec[1]

The IT+Textiles project is situated in a highly dynamic moment in both technological and design development. With a decline in the 'age of mechanization',[2] principles of mechanics and mechanical technologies that have permeated science, design and culture in the last centuries are superseded by a different set of factors. Communication and infomation technologies are increasingly miniaturized, embedded in everyday things and integrated through vast infrastructures, transforming both personal and public spheres. Simultaneously, technologies are becoming cheaper and readily available, leading to flourishing creative and (sub)cultural experimentation with off-the-shelf or even hacked technologies.

Such developments dramatically expand the scope of design. If, generally speaking, design practice can be posited in terms of a human scale and order of magnitude, for instance along a continuum ranging from components to products, systems and environments, new technologies are stretching the spectrum on either end. Today, we can talk about design at a molecular scale, design of intelligent global systems, design of virtual experiences. The effect of emerging technologies on the design space is dramatic – a vast space of possibilities is opening up and impacting all disciplines involved in imagining and creating the shape of the 'artificial world'.

Designing new technological things intended to be lived with – things which engage with the rhythms, rituals and textures of everyday life – requires new understanding. We must re-examine materials, people, practices and basic notions of design. How can we approach technology as a design material?

Methodological challenges

In this contemporary situation, designers face increasing complexity in practice. New technologies imply a dramatic shift in scale of the design act itself, beyond human scale to the basic building blocks of the physical and digital world. High-tech and traditional materials may be combined in new ways and considered in terms of interaction qualities, flow, expression and evolution. Computational things are becoming part of the fabric of everyday life, integrated with other things and systems into heterogeneous practices of use and lifestyle. With these new materials and expanding design space, designers must re-think not just form and aesthetics, use and function, but how to go about designing in such a new and complex situation. Design – and designing – thus become a critical site for research and redefinition.

1. Perec 1997, p 210 **2.** Manzini 1992

Form and materials

Considering the design of computational things, complexity increases both within the thing itself and in relation to external factors. The internal workings of computational things are increasing in complexity and decreasing in size. With means for close integration at very small scales in production, technologies such as sensors, communications and visual or other multi-modal outputs can be combined and related in new ways to familiar textiles, plastics and metals. Such recombinant materials can be characterized by both hard- and software aspects, extending the purview of design to include physical and temporal, or interactive, form elements.

Such materials introduce very different qualities, particularly in terms of time as an element in the design of things. The basic expressions of a thing, such as visual and sonic qualities, even physical structure or shape, may evolve and change over time in response to software programs, information input from sensors, and interaction in use. Additional temporal disparities between materials include notions of lifespan – consider the successions of software versions versus the stylistic decades in design history, the nature of technological aging versus wear, vintage and patina. In terms of the internal characteristics of products and their components, new combinations of technological and traditional materials with different qualities of spatial and temporal form require design to deal with a new set of variables.

With the increasing ubiquity of technologies, designers must learn to work with the complexities of such new materials and its intangible, temporal properties alongside mastery of the qualities and craft of traditional materials. A new range of skills as well as the scale of the design act increasingly requires specialization and collaboration in design work. This requires new approaches and methods of working in order to grasp and incorporate such factors into design thinking and practice.

Use and context

External to the design of things in themselves are new questions in terms of use and context. Emerging technologies are increasingly affecting and pervading things, systems and spaces in everyday personal, domestic and public life. Technological progress in the industrial revolution and the 20th century has been dominated by values relevant to industry, production and work – efficiency and functionality have been in focus. However, as technology is increasingly part of everyday life, including leisure time, social relations and personal expression, a different set of values, qualities and aspirations must be explored. Beyond human-computer interactions investigated in terms of work-oriented tasks carried out in predictable environments, computational things in everyday life must be considered within a complexity of social, cultural and emotional qualities.

In use, objects are incorporated into a complex system, they are adopted, customized, adapted, hacked and reconfigured by a spectrum of users including individuals, families and communities in relation to intricate practices and evolving activities. In de Certeau's terms, traditions of rationalized production are confronted with an 'art of consumption' evolved in relation to practices of everyday life.[3] Designed or not, qualities of form and interaction enabling personal or cultural appropriation determine the 'use' or 'functionality' of objects, the sustainability and meaningfulness of things in everyday experience over long periods of time. Use from this perspective blurs distinctions between 'design' and 'use', implying the need for re-examination of their interrelation in design practice.

3. de Certeau 1984

User research and design methods

Where typically the success of design has been evaluated by the market itself, in terms of purchase rates of the end product, the methological challenges to design practice today brings design process, practice and research into focus. On one hand, the complexity of materials themselves and the need for new skills in development processes requires new forms of collaboration and communication. For example, professional design practice often requires collaboration among various stakeholders such as marketing, manufacturing, engineering and des-ign. Principles, alternatives and constraints must often be made explicit and commonly understood as a basis for such collaborative work. This has increasingly required an externalization of what may traditionally have been tacit understandings within distinct spheres of work practice, reflected in the development and codification of a range of new design methods.[4]

In addition, 'use' and 'users' are approached in new and more comprehensive ways within design practice. Research into users, contexts and cultures is increasingly part of technology product development cycles and may just as well include sociological, anthropological and psychological as more traditional ergonomic and usability techniques.[5] Such interdisciplinarity in design work has also led to an infusion of more experimental methods into development processes. In addition to the user-centered design methods discussed below, a range of techniques from performance, film, and contemporary art have become means for project teams to generate ideas, probe into notions of 'use' and to try out possible alternatives.[6] User research and design methods from a variety of scientific and creative fields of practice are gaining value within technology design, opening up new means for exploring the complex design space (for instance, perspectives outlined in Laurel 2003).[7]

Considering the wide range of methods for user research and for design research, of which these are just a few, provides a starting point for exploring the new complexity with respect to use. While scientific and user-centered methods enable researchers to probe into and gain insight, information and inspiration from actual current situations, the challenges and scope of design, however, go far beyond the status quo and 'problem-solving'. Generally speaking, design disciplines can be said to operate explicitly in relation to a projected future. In contrast to science, design acts to anticipate and create desire, to actively change reality. The problem area with respect to emerging technologies and new materials is largely unknown – designers must build on a foundation of existing methods as well as rely on inspiration and experimentation to project possible futures.

Use and user-centered methods for design

In the field of human-computer interaction (HCI) and interaction design,[8] user-centered design is a well-established approach based on a general intention to take human values and often users themselves into design and development processes. User-centred design includes a body of methods for design or user research, incorporating techniques such as interviews, observations, ethnographic studies, questionnaires and evaluation, which may be used for gathering information about use and for including users themselves in the design process. Such processes may be framed differently in various contexts, but generally may be characterized by iterative cycles of research, analysis, design/prototyping and evaluation. By working iteratively, user feedback and experiences

4. refer to Jones 1992 for further discussion **5.** for example, Aarts and Marzano 2004
6. for example, Aldersley-Williams et al 1999, IDEO 2003 **7.** Laurel 2003
8. refer to Preece et al 2002 for a general introduction

can influence the design, which in turn makes it possible to continuously evaluate users' experience throughout a development process.

User-centered design has its advantages, such as highly developed methods for analysis and an established tradition of evaluation. Within the field of HCI, methods have developed mostly in relation to explicitly work- and task-oriented contexts. Often drawing on models from psychology and cognitive science, such approaches can tend to frame design problems in terms of means-end logic and individual, goal-oriented actions. Such methods give the ability to trace design choices back to user and task analysis, to a certain extent giving predictability by means of a systematic treatment of requirements and a set of methods established and well-documented in academia and industry.

In designing for everyday life contexts, however, certain other user-centered methods and frameworks have proved valuable for investigating use with respect to different sets of intentionalities and values. For instance, contextual design derives user needs and design criteria from studying existing patterns of use.[9] Models such as activity theory take into account interrelating and evolving factors, including material things, intangible things such as plans, rules, expertise, culture and experience, to form a use situation.[10] The fields of cooperative and participatory design are based on active formats for participation, 'design-by-doing' and the involvement of users and designers together throughout a design process (an example is the seminal Utopia project).[11] Such methods for research can engage deeply with the complexity of factors in people's lives and in design practice.

Materials and experimental methods for design

The term 'experimental' means different things in different disciplines. Related to its use in film, music or art traditions, we refer to experimental design as a practice of open exploration, an investigation into the possibilities of given materials and technologies with the purpose of exploring and expanding the boundaries of the design space, in order to deepen our understanding of what can be done.

Design experiments might range from artistic strategies for raising speculation, to trial-and-error crafting of materials (for instance, stretching traditional loom techniques to the limit), to general 'tinkering' with technology components to explore new potentials. Central to such an approach is not the drive to solve specific problems, but the generation of new design opportunities. Taking a basic set of conditions or preconceptions – for instance, a given use, method or material – an experimental approach may reconfigure, amplify or de-contextualize var-ious factors to see what new perspectives may emerge. Thus extending out of existing circumstances, experimentation allows a certain risky projection into alternative or possible futures.

With respect to the relation between user-centered and experimental methods for design, they might generally be characterized as approaching design from two different angles. In user-centered design, the starting point is typically a specific area of application, context of use, or group of people. From this perspective, certain information may be gathered and analysis made, with the general aim of defining 'what' should be designed. In experimental design, 'how' is the essential question – starting with a set of basic conditions or materials, experimentation can be a means of working with them to explore and extend the design space. The approaches are complementary, combining essential perspectives on 'use' and 'materials' in terms of existing conditions and future projection.

9. Beyer and Holtzblatt 1998 **10.** Nardi 1995 **11.** Bødker et al 1987

IT+Textiles

In IT+Textiles, our concern has been not only to develop different ways of thinking but different ways of working, to expose processes, problematics, speculations and alternatives. In thinking about the possible design space, how might we go about combining information about what is with imagination about what could be? In 'doing' design research, how might we work practically and conceptually with physical and temporal aspects of form? How might design techniques and practice be a basis for trying out, projecting and probing into the future?

Studio, lab, loom

In 'doing' research, the project was structured around certain collective activities, artefacts and resources. Material studies – weaving, printing and structural samples – accumulated in the research studio, becoming practical and conceptual building blocks. User studies, public 'happenings' and mini-ethnographies generated materials in the form of photographs and video clips, user diaries and scenarios, stories and sketches – inspirational supplements to written documentation. Seminars, workshops and teaching acted as conduits for other types of inputs and participation in the projects. Such materials and mechanisms provided an animated, and intentionally inexact, infrastructure for the circulation of people, overlapping processes and cross-fertilization of ideas.

Alongside this activity, technical materials proliferated as electronic mock-ups and prototypes. As a starting point for developing a platform for rapid prototyping, research in the Smart-Its project informed software, hardware and communication concepts. These small computational devices were developed by Lancaster University (UK), ETH

Zurich (Switzerland), the Interactive Institute (Sweden), University of Karlsruhe (Germany), Viktoria Institute (Sweden) and VTT Electronics (Finland) within the European Union's Disappearing Computer Initiative. Communication frameworks, sets of sensor and software models were adapted in IT+Textiles to enable a basic platform for plug-and-play prototyping across multiple projects.

A certain basic diversity – synergies among science, art, culture and design – proved to be critical for our research process. From the scientifically-minded, a set of questions and operations could be framed with respect to the present situation. For instance, studies of use or analysis of technological options could be conducted. From craft tradition, a learning-by-doing approach evolved a set of dynamic materials, which was used by designers as a method for communicating with and actively trying out alternatives within the research group and with stakeholders. Artistic strategies came into play as ways of framing concepts and exposing them in external contexts for critique and speculation. Drawing on this basic diversity, we combined established and experimental perspectives as a strategy to approach the methodological challenges to design – designing with new materials and designing in new ways with traditional materials.

Use and materials

As an approach in IT+Textiles, the project as a whole explored two strategies in parallel. On one hand, notions of use were examined from user-centered design perspectives and from experimental methods inspired by craft and artistic strategies. On the other hand, open exploration of textile and computational materials informed concepts for user-centered and experimental interaction design. Synergies and overlaps between these two approaches enabled work in the project to test boundaries of the design space, as well as to probe deeply into the development of certain examples.

Example: The interactive pillows

Developed through user-centered methods and experimental design, the Interactive Pillows are early prototypes exploring means of increasing the 'emotional broadband' in distance communication. Initial studies in the project included interviews with people from target user groups, such as separated generations in families. From information gathered, concepts evolved for communication through familiar everyday objects. The design developed as two pillows, each of which would glow when its pair was hugged, in this way supporting remote intimacy through shared gesture.

In parallel, studies of materials explored the soft, expressive aesthetic forms possible through the integration of electroluminescent material into the woven pattern. Physical and interactive expressions were inspired from the user interviews – a 'grandma' pillow with a subtle, traditional woven texture that illuminates dramatically, and a 'pop' pillow with a bright, strongly-patterned weave. Another user study followed as a workshop exploring perceptions and potential use of the objects among elders. This project generated a series of materials that fed into one another and into subsequent projects, ranging from information and perceptions of users, studies of material form and expressions, and an extensible technological platform.

The Interactive Pillows demonstrate the conjunction of approaches examining use and users, materials and expressions. In IT+Textiles as a whole, the intention has been to explore working methods including both user-centered and experimental methods, combining different practices of thinking and making in design. Combining these approaches has enabled a dual perspective throughout – hands-on crafting and future concepts, real-world information with aesthetic experimentation, in-depth studies and a broad overview. Artifacts such as the Interactive Pillows, thus, are placeholders marking overlaps between strategies, boundary objects for communicating among stakeholders in the present and for developing future projections.

Form and materials

In IT+Textiles, a body of dynamic textile materials has been developed using different textile weaving, printing and construction techniques in combination with sensing, processing and display elements. These provide an experimental platform for testing out qualities of form and interactivity – a palette of dynamic material expressions available to design.

In Reach and in Mute, such materials were extended through further experimentation into building blocks for interaction and expression in particular situations of use. Drawing from a palette of materials, Reach is a set of fashion accessories that are reactive to heat and noise, changing pattern to reflect the characteristics of social exchanges. Based on experiments in Sound Hiders, Mute developed through examination of particular spaces, for instance the walls in school environments. A series of kinetic structures was conceived to stretch and transform fabric surfaces in response to noise, thus changing the visual, acoustic and physical form of a space. In each of these projects, combinations of experimental materials became building blocks for developing modes of interaction for particular situations of use.

Within an artistic context, the Information Deliverer challenged basic notions of use in an installation for the Borås Art Museum. Elementary acts such as opening, writing and reading information were re-interpreted using textile materials, such that the flow, aesthetics and the shape of the environment were subject to the fabric properties, atmospheric circumstances and visitors' interaction. Through material re-interpretation, use was enlarged to a point where expression came to dominate practical functionality, rather than the other way around. This large-scale experiment dissected basic notions of use in space and time through materials, exposing issues of form and values with regards to 'use' in the design of things.

These examples give insight into ways of working with a complexity of new materials. Technological and textile techniques are closely examined, integrated or recombined, whether at the scale of the weave composition, the dynamic pattern at a product scale, or interactive behaviors at an architectural scale. While these were implemented to different degrees of technical functionality – for instance some prototypes in Reach are working electronic prototypes while others are conceptual sketches, and scale models and video techniques are used in Mute to convey possible use experiences – they demonstrate ways in which designers could get 'hands-on' with relatively in-depth explorations of the properties computational things.

Additionally, they represent a re-examination with respect to traditional notions of form. Rather like the materials samples available in hardware stores to try out different colors, textures or spatial forms, dynamic textile samples in the Materials collection give a possibility for trying out alternative 'temporal forms'. Spanning a spectrum of spatial and temporal expressions, they delve deeply into practical techniques for integrating technical and textile materials, thus acting as building-blocks for both temporal and spatial crafting in other projects and supporting synergy between diverse work practices. De- and re-constructing materials in relation to use was a strategy in these examples to study and expose different notions of spatial and temporal form elements, thus highlighting fundamental questions with regards to form and materials.

Use and context

In IT+Textiles, a variety of methods have been employed to explore notions and practices of use within different everyday life situations. Techniques based on user-centered design methods include, for example, interviews and an evaluation workshop in the Interactive Pillows project, semi-ethnographic studies in Tic-Tac-Textiles, and 'cultural probes'[12] in the Energy Curtain project. These methods brought users into the research setting and design imagination, and gave designers new lenses on everyday life, providing information and inspiration into project development.

Besides methods embedded into design processes, there were also focused initiatives specifically into user-centered methods. Underdogs & Superheroes[13] developed a game-based design methodology – a series of creative activities or games – inspired by techniques from participatory design, experience prototyping, performance methods and conceptual art. The project investigated combinations of formats, rules, roles and props as a means for engaging users' experiential and personal perspectives and for representing reality without limiting expectations to what's possible here and now. The result was a palette of techniques for generating and trying out design ideas, and which informed development of the Reach prototypes, scenarios in Tic-Tac-Textiles and the Energy Curtain concept.

In relation to re-thinking notions of 'use', open and evolving interaction was explored in the Tic-Tac-Textiles furniture objects. The design of the furniture itself fulfilled a primary function of inviting coffee-drinking, along with multiple possibilities for sitting and interacting socially around the tables locally. Through intention or accident, other layers of the (digital) interaction may be discovered and played out.

12. Gaver et al 1999 **13.** Mazé and Jacobs 2003a

However, the design suggests rather than prescribes modes of use, working with re-design of common objects and a tight integration of aesthetic and multi-modal technologies to provide a rich experience at very basic or increasingly complex levels over time.

These examples illustrate different approaches to 'use' and 'users' with regards to design methods and interaction models in IT+Textiles. User-centered and experimental design methods have been used in a variety of projects to inform and inspire design development. The iterative design process for the Interactive Pillows involved the use of various design artefacts in user workshops, not as a means for fixing or pre-determining the design, but as a platform for imagining possible future roles and visions with users. In Tic-Tac-Textiles, the objects incorporate quite specifically developed textile and technical materials, though designed with the intention to allow multiple interpretations and open-ended forms of use. Combining, thus, parallel strategies of enquiry into use and material in IT+Textiles, we framed an expedition into a relatively unknown design space – opening up possibilities through experimental and established methods, creating a meeting place for diverse work practices.

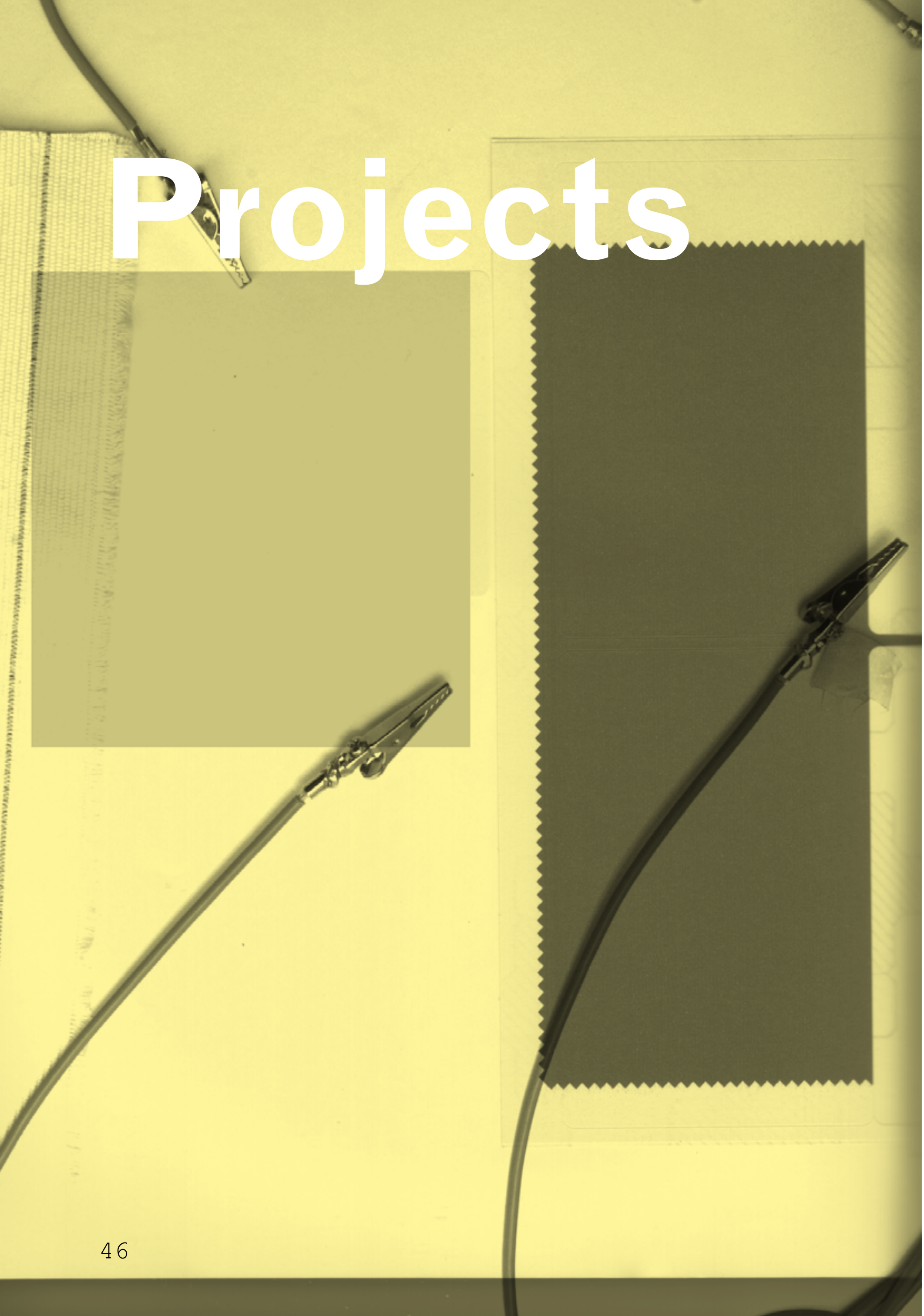
Reflections

In IT+Textiles, we probe into the possibilities of a design space opened up through the conjunction of very different kinds of materials. We try to get a better understanding of new possibilities inherent in the materials, the qualities of form, time and interactivity available to design. We explore external factors of use, interaction and situation to gain insight into design and imagine potential roles for new things in everyday life and lifestyles. In the area of design, and particularly in a climate of enormous possibilities and change for design research and practice, combining IT and textiles has provided a framework for probing into both practical and methodological questions.

Use and materials are general frames in IT+Textiles to approach a complex design space, enabling diverse perspectives and methods for working from the inside out and vice versa. On one hand, a body of textile and technological materials acted as a foundation for studying the internal workings of form and interaction, and as input into discussions and activities. On the other hand, investigations into the contextual factors external to things, such as perceptions of use and everyday lives of users, expanded imagination into possible alternative expressions evolving roles of such things in everyday life. Weaving between material and use perspectives, projects acted as meeting places between different perspectives and design methods.

Combining user-centered and experimental methods enabled information, observations and insight into the present to overlap with inspiration, speculation and tentatives into possible futures. Additionally, 'doing' experimental design research has entailed that designers and researchers find a way of working in and through ideas physically. Crafting the aesthetics of form and temporal dynamics, recombining and tinkering with materials, delving into contexts of use – research combining action and reflection enabled us to get hands-on with 'technology as design material' in practice.

Projects



The Interactive Pillows

Anders Ernevi, Johan Redström,
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One of the first concepts to be developed within the IT+Textiles project was the 'Interactive Pillows'. These pillows come in pairs, the idea being that you and your loved one have one each. If you hug yours, its twin will light up and become warm. If he or she hugs his/her pillow back, yours will do the same. To communicate, the pillows are connected via the internet, a mobile phone network, or by other (wireless) means. This is the story behind them.

As described in the Introduction, one of the two themes underlying the IT+Textiles project has been 'Emotional Broadband', the ambition to develop new devices for interpersonal communication with focus on aesthetic, social and emotional aspects. A number of projects have been exploring such questions .[1] Design examples that have inspired us include 'Faraway' by Andersen et al,[2] 'Casablanca' by Hindus et al,[3] and the work by Tollmar and Persson on remote presence.[4] Rather than trying to replace existing forms of communication, the idea behind these projects has been to extend the current range of expressions available through, for instance, phones or email.

When thinking about expressions of emotions, we wanted to build on the feeling of being able to touch or hug someone, which are types of communication that confirm closeness and signal tenderness, especially between people with very close relationships. Another important aim was to explore new interaction models. We believe that in order to achieve a feeling of intimacy in use, the experience of the interaction should be as enjoyable and direct as possible. Given these concerns, textiles seemed like an interesting material to work with, as it is a material that we often think of as soft, warm and something we like to have close to our bodies.

The idea of textile artifacts as displays opens up for thinking about various everyday objects as potential 'interaction devices'.[5] Initial concepts included objects such as curtains, blankets, pillows and clothes, explored on the basis of various new materials developed in the experimental design track. We made a series of very rapid sketches/prototypes around these ideas and found the pillow to be of special interest. It is a common behavior to hug a pillow when feeling lonely and longing for someone. An important reason for choosing the pillow was that we wanted to build an interaction model based on the inherent affordances of the object in order to enhance the feeling of a direct connection, in short, a type of interaction that the object in itself invites. The pillows were also interesting since as objects they are explicitly designed to fit into a home environment, with familiar textures, roles and a natural place on a sofa.

A second generation Interactive Pillow - a modern design, amplifying the electroluminescent fibre

A second generation Interactive Pillow - a traditional aesthetic disguising the electroluminescent material

Process

We started our process with two distinct perspectives, establishing a user-centered development track and an experimental design track, with the intention that the two processes would work in parallel but also continuously feed into each other by means of regular workshops and events. The reason for working in this way was that we were faced with questions that we found difficult to answer completely with either of the methods alone. Such questions, among others, included issues about combining textiles and IT in an aesthetic way and the appearance and role of technology in people's everyday environments and relationships. We also wanted to find ways of working with experimental design in combination with commercial user-centered design methods. Our experience was that each of the two methods – or rather viewpoints on the same subject – had its strengths in different parts of a development process.

As a basis for initiating the more experimental design work, we used our experiences from the 'Information Deliverer' project completed the year before, in which we had worked with expressions of different textiles in relation to interaction design. This included notions of 'textile displays' and the idea of textile surfaces as displays or interfaces. Being interested in re-thinking how displays might be designed, we were also investigating various ways in which a textile surface could be made dynamic, for instance, to change color or reveal a hidden pattern.

In the user-centered development track, we started out with a series of informal interviews with people that belonged to the categories of users that we were focusing on. Such user groups included divorced parents living away from their children, family members away from home during temporary institutional care, people who travel frequently and regularly spend much time away from home, and other similar situations. We focused on how such people kept in touch with their loved ones, what technology they used, and how they perceived the (means of) communication. We wanted the answers to be as personal and spontaneous as possible, and we encouraged people to talk about authentic situations, giving us examples. This meant that they often told us information in the form of stories about what actually happened yesterday and how they felt about that. From this, we got real-life scenarios that we could easily engage in and base further development on.

Target groups

(Separated) parents not living full-time with their children

The parents in our study typically lived with their child or children every second week. They expressed frustration when they talked about their communication with their child. Every second week, they get to communicate with them fully, using verbal, body language, gestures, hugs – a wide spectrum of expression. They are the one who is supposed to know 'everything' about the child and understand and react to the child's different moods.

In contrast, the next week they only got to call them on the phone or use email. They explained that they did not always feel free to call their child up at the other parent's house just to say that they longed for them or to express closeness. They felt they needed a viable (practical) reason in order to call. The issue of disturbing and intruding on the other parent's time with the child was very delicate. They expressed their frustration about not being able to hug their children goodnight, to touch their hand or to just be close to them watching TV. On the other hand, when describing the weeks that they lived with their child, they talked about their annoyance when the other parent called 'too early' in the week to plan the next weekend, or their need for not allowing their child access to certain chat venues since the other parent had been using that for 'hours' to keep in contact with their child at night. They felt that the children got stressed and divided by this contact and that it was taking far too much of their attention.

People who travel frequently

The people we spoke to expressed a feeling of emptiness when they reached their hotel rooms on their business trips. They felt that they were very far from home and that the room felt isolated and impersonal (this, of course, had very little to do with the hotel as such). They mentioned the feeling of having been away for ages, even if in reality it was only a week, when they got home to their loved ones.

They kept in touch mainly by telephone. Quite substantial amounts of time in their phone conversations were used not to exchange information but just to hear one another's voices, to confirm their relation. They spent quite a lot of time on the phone not saying anything, for example as they watched a movie 'together', scarcely commenting on it, but just enough to 'justify' their phone contact. They expressed a sense of frustration and futility when they had just finished a phone call to their loved one – that was often the moment when they felt most disconnected to them and the lack of possibilities to be close and touch them.

Within this user group, we have concentrated on people on frequent business trips and on truck drivers, the latter being in focus within a simultaneous, ongoing study. Truck drivers often spend a lot of time away from their loved ones – their truck is a sort of 'second home' and is a very special environment with its own style, which makes it very interesting to design for.

People in long-distance relationships
People in romantic relationships with a spouse or partner living far away expressed the sensation of thinking about one another in many different situations throughout the day, wondering if the other was thinking of them too. They wanted to keep in touch and to be part of each other's daily life even if they did not physically meet. Since they did not get to see each other very often, they feel a great need to confirm their closeness and to build strong bonds. They expressed a wish to be able to contact each other in everyday situations, for instance during a boring meeting or in queue in the grocery store, just to let the other know that they were thinking of them. They feared the feeling of being strangers to each other when they actually did meet. They kept in touch through all means of communication, and expressed a sense of futility when punching in the characters of a SMS text-message instead of being able to caress or smile at each other.

Design requirements

Findings from the series of interviews led us to conclude the following requirements for design:

~ The communication devices should widen people's spectra of communication, giving them more ways to express feelings than conventional communication devices. People should be able to get a strong, personal affect when using the object.
~ The act of interaction should be an enjoyable experience.
~ The expression of the object in use should be powerful and profound.
~ The devices should fit seamlessly into everyday situations, in order for people to accept them.
~ The devices should be non-disturbing.
~ The interaction should be subtle, making it possible to interact while engaging (or appear to be engaging) in other activities.
~ The feeling of connection should be direct.

These were just the main requirements, but having established them, we believed that we had a common ground to build on when formulating our design goals.

Concept

A concept of 'Interactive Pillows' was developed, in which communication between distant loved-ones involved picking up and hugging a pair of pillows. When one is hugged, the other will light up and become warm. If the other person hugs theirs back, its pair will get warm and start to glow. The pillows are wireless and communicate via the internet, or potentially via some mobile phone or other wireless network.

We investigated a number of expressions, and we found that warmth turned out to be very strongly connected with closeness. This can also be found in both Swedish and English that people may talk about their relationship as being 'warm' when they have a strong connection to someone. We used light in order to attract visual attention – not a flashing light but a rather subtle glow as an enhancement or expression of the warmth.

The temporal aspect was important in the design. Although we wanted the experience of the interaction to be direct, we did think that a certain slowness would make it more intriguing to use, as a way of experiencing subtlety and to reflect on the (emotional) connection. The design is meant to be used for longer periods of time (several minutes - possibly up to hours) as opposed to, for instance, information experienced by SMS that may only last seconds.

First prototype

The first prototype was made primarily with a focus on exploring 'what' to design. In this first iteration, we worked with a rapid prototype in order to try out our ideas and to test the technology. We used appliqués and a simple solution for the software development.

We used the first prototype to present and test the concept in different settings. We would ask people to tell us their spontaneous reaction to the concept, how they would use it, when and in what situations, what it would mean to them, etc. We would sometimes present them with a use scenario, followed by an informal interview. Our other approach was to get people to walk up to the objects and only give them the introductory clue: "These are interactive pillows". We would then observe while they used the objects, encouraging them to develop scenarios that they could relate to in dialogue with each other, or with one of us. We got very positive results from these tests. The prototypes also helped the team come to a consensus about the issues to focus on in the next phase.

The Interactive Pillows - inactive (top), interaction (middle), activated (bottom)

Second prototype

Since we found the 'Interactive Pillows' to be an interesting concept to develop further, a second iteration was made. In this iteration, the question of how to craft the pillows was more in focus. Since this was our first project in IT+Textiles, there was important work to be done in the textile development. Our challenge was to find interesting and aesthetic expressions and, in particular, we needed ways to integrate light and warmth into a textile object.

It was very important to us that the textile and the technology were not treated as different parts to be combined but that we actually found ways to integrate them closely in terms of the perception of the design and in terms of the crafting of the object. In terms of the material development, we needed to get the light into the fabric and began to work with light-emitting fibers in a woven material with the fibers as an integral part of the textile. In terms of aesthetics, this, among other things, implied that we had to work with the expressions of these fibers when both on and off and how to make these 'plastic wires' a natural part of the fabric itself.

As an illustration of different ways of achieving this integration of the light-emitting fibers, two different prototypes were developed.[6] The textile for each was hand-woven on a small loom. One pillow has a very traditional design and homemade expression. In this pillow, the light-emitting fiber, an electroluminescent wire that can light up and fade in and out, is hidden within the thick woollen craftwork. A traditional binding system called 'hålkrus' is used. When the pillow starts to glow with a serene blue light, the effect is quite surprising, like an unexpected secret. It changes the expression of the object in a rather dramatic way and yet it still gives a certain impression of austerity. We wanted this contrast in order to explore and illustrate the combination of tradition and modern technology.

The other pillow has a more contemporary expression and the light-emitting fiber is an important part of the design even when it is not activated or glowing. The electroluminescent wire is exposed as a decorative detail through a woven construction that alternates between sections of yarn and the electroluminescent wire. To enhance the 'plastic' impression, other reflecting materials were mixed into the weft.

The pillows have a certain reaction time between hugging one to lighting the other. This, in conjunction with the fading pattern of the light, gives a deliberate sense of slowness.[7] When it comes to the overall feel of the objects, they feel just like normal, albeit relatively hard, pillows. It takes some hugging pressure, but the reason is to require explicit action (rather than just putting the pillow down) to trigger the sensor.

Technical solution

The technical solution developed is based on the need for simplicity and rapid prototyping. The way the pillows work is as follows: when one pillow is being hugged, foam rubber lining the inside of the woven textile surface is compressed, causing two sheets of metal foil to make contact. This sends a signal to the microprocessor that hugging is occurring. The microprocessor in turn sends an encoded signal via radio frequency either directly or via the internet to the radio module of the other pillow. It relays the encoded signal to the microprocessor, which decodes it and turns the electroluminescent wires on. The wires fade up and down as if they are glowing. This is done using PWM (pulse width modulation), which is performed by the microprocessor by chopping the signal to the drivers into a square wave of a variable pulse width.

One part of their interaction interface is the 'hugging sensor'. This is basically a switch consisting of a piece of foam rubber sandwiched between two layers of aluminium foil. The foam rubber has a pattern of inch-size holes in it, enabling contact between the two aluminium layers whenever the foam is compressed. Communication between the pillows prototype is achieved using radio frequency (RF). The radio modules work as a virtual serial cable. That is, they need very little attention except for initial set up and serial data. A small BasicX BX24 is hidden within each pillow and operates by interpreting data from the hugging sensor, communicating with the other pillow, and turning on the electroluminescent wire. A Darlington driver circuit provides enough current for the electroluminescent circuits to be activated. These circuits in their turn provide the wire with the 100V 400Hz that it needs.

When the pillows are more than a few hundred yards apart the range of the radio is insufficient. Therefore, two additional base stations have been constructed. These, when placed within the range of the pillows, convey the serial data to a computer. The computer, in its turn, can communicate with the other pillow using the TCP/IP protocol to a similar set-up over the internet. This enables the pillows to be placed practically anywhere on earth as long as the computers are connected to the internet.

Neither the radio modules nor the microprocessor are optimal in terms of cost or effectiveness. They do, however, provide simple and fast ways of developing prototypes. With cheaper and/or more complex components, much more time would have to be spent developing electronics and programming. Regarding the hugging sensor, there were other solutions considered. For instance, elastic, stretching sensors rigged in a pre-stretched state that would relax when the pillow was being hugged. However, this option proved too complicated to be reliable. We selected the option of the 'boat alarm' described above (this sort of technique is commonly used on boats under rugs on deck to trigger a boat's burglar alarm when stepped upon).

A prototyping platform using BasicX with sensors and actuators is quite common within the sphere of ubiquitous computing.[8] This platform provides an easy-to-understand programming environment. So, while not highly applicable in a general or commercial sense, the basic components and structure can be – and is – quite widely used.

Reflections

The Interactive Pillows was one of the first concepts to be developed as an example of what 'Emotional Broadband' could be like. There are several reasons why the pillows came first. A central objective was to develop a relatively simple example in order to explain ideas, find ways of working together, and to be able to explore and show the possibilities both internally, with stakeholders and the public. Since they are an easy concept to grasp, we have often used them as a starting point for discussion and as an introduction to the research area. Other important aspects of the background included a contemporary study made by one of the commercial partners on concepts for medical care in home environments, and the fact that of us all at the time were involved in developing and teaching a new master's program in human-computer interaction/interaction design at the IT University Göteborg, thus facing questions of how to understand and build on each others work on a daily basis.

With the Pillows, our main goal was to find ways of non-verbally expressing feelings of longing, presence and closeness. To make the new objects fit into the private sphere and everyday life, we also wanted to build on existing objects. To some extent this had to do with issues related to how and why new technology could be accepted and adopted, but we were also interested in a strong relation to existing objects for another reason, namely – what happens to our current understanding of everyday things as they become computerized and communicative?

The pillows have been used to test and discuss a variety of topics in different settings ranging from gender issues in technology, technology for the elderly, methods development, and technology and fashion/interior design. In our initial tests of the objects, elderly people (greater than 75 years old) tended to perceive them as quite extreme objects and not something that they would use immediately. We sometimes get suggestions on how a 'language' could be developed for the pillows, but we do not feel that that is the way to go, since that would make the object a lot harder to grasp. Within our target groups, people in distant relationships and grandparents tend to be the most intrigued and we have had many requests from people who want to buy them.

Our experience with the second prototypes is that they give a more profound understanding of the underlying ideas in the project. The aesthetic qualities seem to make a great difference compared to the first prototypes. People often get quite surprised and intrigued by the emotional effect of the pillows' expression in use. This engages them personally with the objects, often in telling vivid and colorful stories of how they would use them. The pillows are currently used at fairs and in interviews as an example of what 'emotional broadband' might be like.

1. see Gaver 2002 for an overview
2. Andersen et al 2003
3. Hindus et al 2001
4. Tollmar and Persson 2002
5. Hallnäs et al 2002b
6. Melin 2003
7. cf. Hallnäs and Redström 2001
8. see, for example, O'Sullivan 2004

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Reach: Wearable Patterns

Margot Jacobs and Linda Worbin

The ‘Reach’ project focuses on wearable technology as a new surface for not only one-to-one communication but also for reflecting personal expression, environmental change and social constructs, thus reflecting a wide spectrum of communication taking place on a social and indeed public level. Reach not only investigates the material aspects of textile, but also the relation of textile within a certain context, namely on the body and in its movement through space and place. People invest a lot in personal objects, especially in those worn close to the body. Reach objects capitalize on this investment and on the body as an information display to promote increased local interactions, communication, social awareness and reflection.

Body as surface

What we wear and how it is worn has long since been a means for connecting visually to the outside world. Garments mark out a territory, a border between ourselves and the external world. Identity and a sense of ‘belonging’ are informed through appearance and rituals of the body. In some ways, our clothes communicate as if we were an actor on stage and the audience is everyone else. Modifying our bodies alters how we display ourselves, as it is generally the first interface we have to others. This includes how we move, all non-verbal aspects of body language and communication, what we say, and what we look like.

For example, loud remarks and gestures may only be intended for friends in the vicinity, but all those in the immediate environment, strangers or otherwise, represent the true audience. This audience is influenced by what they see and hear. This, in turn, affects their perceptions and results in their consciously or subconsciously drawing conclusions about who you are as a person.

For centuries, individuals or societies have used clothes and other body adornment such as costume as a form of non-verbal communication to hide or reveal aspects of one’s self. Putting on particular clothes gives us ‘cultural capital’, respectability, uniformity and style, and in general informs others of who we are at first glace. One’s fashion can reflect occupation, rank, gender, social or economic class, mood, self-esteem, sexual availability, locality, religion or group affiliation using a language of signs, symbols and iconography that non-verbally communicate meanings and express individual identity.

In some sense, fashion can also be seen as a barometer of social change. A sea of peoples’ particular clothes tells a story of that society. All the time, whether or not we are aware of it, we are building common spaces and stories merely by how we represent ourselves. For instance, the role of the 'dandy' or fashion-forward person unites both observation and display, communicating messages and meanings about a society as well as about him or herself.[1]

From mobile devices to embodied mobility

In our daily lives, what we communicate publicly has broadened with the advent of new ubiquitous and mobile technology. Mobile communication has long since surpassed the physical and geographic constraints of the mobile phone. Increasingly, mobile embodiments are emerging that extend beyond a device held in one's hand into our environment and onto our body, supporting new modes of personal and social communication encompassing gesture, movement and proximity.

Today, mobile communication devices are at the forefront of the digital age. Over the past few decades, the mobile phone has transformed into a new entity supporting a heavier bandwidth. There have been surges in extensions to the mobile phone including the use of video and new gaming platforms as well as new alternate mobile communication devices that communicate more emotional content than words (for instance, 'LoveGety',[2] or increasing social connections (for instance, 'Dodgeball'[3] by revealing relationships between strangers.

This evolution has opened a space for new design possibilities. For instance, in 'Hertzian Tales',[4] electronic products, aesthetic experience and critical design are combined to reflect and give examples of how technology can be further developed. Here, ideas both about electronic products, the space between people and awareness about electromagnetic fields are discussed. By reflecting upon the use of the electronic product, one can integrate and question the use of it and begin to see technology as much more than something that is covered by a plastic or metallic shell.

As a result, the casing or surface of mobile and communication technologies has moved into our homes, our streets and onto our bodies. With mobile internet access and the ubiquity of location-sensing technologies, space (outdoors) is now a site for digital media. Screens have moved from computers and mobile devices and onto bus stops and bulletin boards. Certain projects seek to situate computing in an attempt to increase social awareness and support expression (for example, 'Geonotes'[5] and 'Tejp'[6]).

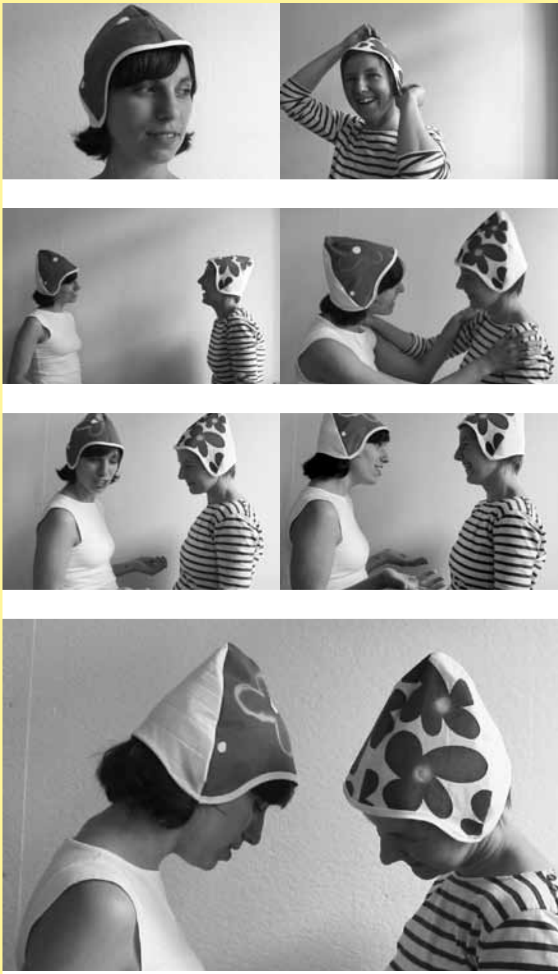
Taking advantage of lessons learned with mobile technologies and situated media, new surfaces can be created in relation to the body, at the border between who we are and what we share, augmenting the interface between ourselves and the rest of the world. Although wearable technology is not new – glasses, for example, have been around for centuries – we now have new tools for exploring how information technology can influence the mode in which we adorn ourselves, strengthening messages about not only our own identity but also about the state of society. In addition, placing technological artifacts on the body allows for new forms of embodied interaction combining gesture and motor reflexes with a new sense of control.

Wearable technology

Wearable technology is an evolution of portable and mobile computing that includes wearable computing or the distribution of the computer on the body, smart textiles (which tends to focus more on material science such as new materials and fabric-finishing techniques), and the field of 'wearables'. The latter combines aspects of wearable computing, smart textiles and mobile computing with interaction design or critical art practices in the search for new opportunities for wearable technologies.

Several projects investigating this area draw connections between the self and society through either communication or display of information. Joey Berzowska and her work with non-emissive displays and what she terms 'soft computation' focuses on wearables as memory-rich garments, as exemplified in the 'Electric Plaid' and 'Shimmering Flower' projects that reveal layers of an individual's history.[7] Katherine Moriwaki's 'Urban Chameleon'[8] looks at the ability of reactive garments to influence and change perceptions of one's surroundings. As perhaps a more direct example of the connection between the self and community, the work of Lucy Orta[9] creates a symbolic space of interaction between a person and his or her neighbor via visible collectivism in clothing.

What is interesting about all of these examples is how each of these wearable technologies is not only dependent upon the body, but also upon the space through which the body moves in creating its movement and presence. A particular aspect of wearable technology is how it differs depending upon the space in which the interactive aspects occur.



Reach out hats share patterns when close together

Social place and local interaction

Using the body as an interface supports actions already occurring in public spaces

The Torch bag lights up in the dark

Reach around scarves provide warmth and reveal hidden patterns

while providing room for new ones to emerge. Individuals may take a more active role, adorning their perceptions of and reactions towards others and society as opposed to remaining simply a passive observer in public space.[10] This can increase access to information about the social environment, which can in turn increase what we know not only about other peoples lives – how they behave and perhaps more importantly how they feel – but about our own. This helps us establish a relationship with the world around us, enriching local interaction and the quality of social spaces.

Public and social spaces are made up of living elements. There are not just static walls, tunnels and roads, but a dynamic whirl of people walking and planes flying. And in addition to physical elements, static or otherwise, there are the invisible elements, for example, conversations, oxygen levels and radio waves. All of these make up the space that we, as individuals, share with others on a daily basis each time we venture outside the constructs of our own home. It is these spaces in which we move, in which social context is applied, that are understood as places or locales.

Perception of a place can be seen as the combination of physical location and social context. In the modern, highly urbanized era, large numbers of people come into contact with each other everyday and each time they enter a place they change the social setting. They bring with them their self and their identity contained within the boundaries of their own bodies.

Taking note of how people already interact in public, or inside of places, through the use of their bodies or even simply the presence thereof, one can concur that people are drawn to seeing others in action, to activities, to other people in general.

And it might be said that the use of public space reflects general changes in society. Today, the spread of digital culture has affected our society, altering the way we express ourselves, how we contact one another, increasing the importance of a mutual display and a new way of being together in society.[11] This provides a basis for supporting increased local interaction or general awareness and communication with others in social settings. Perhaps by engaging new surfaces, or mutual displays, it might be possible to provide less complicated channels or opportunities for maintaining established contacts with others and forging new ones.

Seeing and hearing other people is the foundation for our perceptions and reactions to others in the public sphere, laying the basis for contact and local interaction. Connecting with others can also be achieved on other levels. An alternative approach to designing for local interaction is to locally amplify these senses, namely to design for and on the body.

Reach

Reach investigates the potential for communication and expression incorporated dynamically and interactively into the things we wear everyday. Through a series of iterative prototypes, we have been exploring both textile materials and the interaction qualities of clothing and accessories. In some sense, Reach takes a step backward in using textiles and patterns as a starting to point for understanding, re-examining the underlying mechanisms of these relationships so that they might be built upon. Our intention is to develop computational properties and interactive behaviours that are incorporated directly into wearable items, while simultaneously exploring how dynamic patterns can be woven into the material. In initial prototypes, we are exploring properties of person-to-person communication, proximity and environmental sensitivity as expressive properties. Ultimately, we aim to develop a new dynamic language of wearable expression integrating aesthetics, pattern and computation into everyday articles with increased personal and cultural meaning.

Wearable sketches

In our investigation of new forms for wearable communication and expression, our aim has been the creation of ‘wearable sketches’, or prototypes, that test both material and interactive qualities. Through an iterative process, we incorporate our findings into new ‘smart’ clothing or textiles.

Wearable sketches include everyday items such as hats, bags, scarves and skirts that react or interact with the environment or people within the environment. In addition, they explore both additive and subtractive patterns, expressing processes through growing or revealing patterns in response to changes in one’s personal, social or environmental space. Material samples and prototypes include the use of cottons, woven linens, conductive materials, UV-sensitive textiles, thermochromic materials and electroluminescent wire. The result of this project is a line of interactive wearable pieces demonstrating a new vocabulary of dynamic expression. Since each piece in the collection is a sketch, some pieces are full working prototypes, while others are partial technical solutions and mock-ups. This was done because our interest was focussed mainly on conveying and 'trying out' an idea. As a result, the degree to which each sketch is integrated with technology varies.

Dynamic textile patterns

Today, there is a range of different 'smart' textiles that can interact with surrounding conditions. Materials can change color depending on temperature or light and can even adjust temperature. Creating a dynamic pattern using 'smart' textiles can be more or less the same thing as designing a pattern using traditional textile materials. But to extend the possibilities that 'smart' textiles offer in a more developed way is a bit more difficult. There are also some practical 'problems' that are hard to overcome. For example, dynamic patterns may be invisible until the power is switched on – in relation to traditional working practice it can feel that one is working blindfolded.

There are new textiles with properties that change depending on surrounding conditions. These materials can be divided into more or less 'smart' categories depending upon what level the material can adapt/react to the surrounding conditions. As an overview of 'smart' textiles, we can describe materials within some basic groups: phase-changing materials (PCM), shape memory materials, chromic materials and conductive materials. There are also different types of coatings and light-emitting materials like electroluminescent and fiber-optics. But it is not only about the material, textile construction (whether woven, knitted or non-woven) or what the fabric will be used for, and in what context. It is the assimilation of all of these together that plays a role in the construction of 'smart' textiles.

In the project 'Fabrication', information and computer technology take active roles in the creation of dynamic patterns.[12] Dynamic patterns reflect individual expression and display this information in an aesthetic manner integrated in objects such as an apron and a bag for a mobile phone. Through the use of dynamic patterns, a decorative textile pattern can involve more than merely a static decoration. It can integrate an informative aspect into a decorative object/pattern and thus be used for communicating.[13]

With Reach, our intention is to illustrate how dynamic patterns in 'smart' textiles might be further developed and used, with a focus not only on the aesthetics of pattern, but how such patterns can convey new meanings and extend our palette for communication in social spaces.

Local interaction: Connecting individuals and increasing awareness

One of the initial goals of the Reach project was to increase local interaction – namely communication – in public space through the use of playful mechanisms as well as enhancement of the senses and increased awareness on a local level. This began as an exploration into how to share sound experiences with others in the public realm and has resulted in several different ideas based on human-to-human interaction and, in particular, proximity.

Reach out hats

Different incarnations of 'Reach out hats' share textile patterns or sound (music) when two or more people wearing the garments are in close proximity with one another. The closer one gets to the other, the more the visual or sonic pattern 'bleeds' or is shared and experienced with another person. In other words, patterns change in relation to the distance between people.

Both pairs of hats explore distances between people in public space. Distance between people generally reflects the intensity and intimacy of the relationship. Edward T. Hall's 'hidden dimension' defines a number of social distances, ranging from intimate distances, where intense feelings are expressed, to personal distances and conversation distance between close friends, to social distances such as exchanges in stores or conversations with acquaintances, and finally to public distance, for instance the distance between a speaker and his or her audience.[14]

Our intention with these hats is to blur these boundaries, to redraw the distances between people, to promote contact and to investigate human perceptions of space, pattern and sound in relation to others in the environment. People are, generally speaking, attracted to one another, gathering towards and often moving in syncopation with others in their environment.[15] With both pairs of hats, we promote playful interaction through changing patterns, stimulating new interactions among people. In addition, both pairs of hats provide for both active and passive participation – for example, the sound hats accommodate both music generation and passive listening.

In one of our examples, we made two different patterns on separate hats using thermochromic ink. The pattern on each hat was designed to visualize meetings between people. One pattern is made using dots and the other is made in the shape of a flower. When the pattern is shared, or two people wearing the hats come into contact with one another, the hat with the dot pattern grows flowers, whereas the hat with the flower pattern receives a dot. This is accomplished by means of an under-layer of conductive thread that is heated when two people are within range of one another. At this point in the process, the conductive thread is in place, however, we currently simulate the distance-sensing. This is just a simple way of showing an aesthetic pattern that might be shared. We envision the distance-sensing to work by combining ultrasound and radio frequency to exchange information about how close people are to one another.

Another example simulates changing harmonic tones when people are drawing closer to or further away from one another, and might accommodate multiple people wearing these hats to hypothetically 'play along'. These hats simply incorporated headsets channelling midi signals, again simulating the distance-sensing. The aesthetic pattern hats could also be extended to include more players if the pattern were modified with several layers that could emerge or disappear depending on how close each was to the others.

Our intention is that results of using such hats would not just be common actions, cooperation, spontaneous conversations, lyrical movements and play, but the creation of a mutual display where the meaning of actions might be co-determined and provide for new means of communicating. More work needs to be done in both cases, for finding more interesting aesthetic expressions in the case of the first example and exploring different uses of sound in the second example. Also, both examples are not yet technologically complete – these sketches simply convey ideas about how to use dynamic textile pattern or sound to elicit new connections between people.

However, results from these first sketches have already led to other investigations. We can concur on some level that spatial location informs social behaviour. Currently, we are examining hats or headgear that can augment sound and/or create silent spaces, as well as clothing that can change pattern based on proximity to other objects and on the type of space the wearer is in (for instance, public space or private space).

Torch bag

Another goal we had with the wearable sketches was to experiment with an increased awareness and heightening of senses on a local level. In response to this, we created a handbag, the 'Torch bag', that creates light in the dark. Our intention with this bag was to work on two levels, creating light for the wearer to be able to see what was around them and to create light that reveals the contents of the bag. Thus, the bag works either simply by lighting up its interior when it is opened and turning off when closed or by turning its exterior on in dark surroundings and turning off again in well-lit areas, in reaction to a light sensor or photo-resistor.

The Torch bag is also a simple sketch, illustrating how light might be used on the body in various ways to increase awareness and add light to personal space. Currently, we are investigating means to power this bag using solar cells so that it can run independent of batteries, gathering energy in well-lit areas for dispersal in darker areas.

Urban reflections

In order to better reveal the structure of relationships in public space and build upon increasing awareness at a more local level, we began to focus on creating objects with aesthetic displays. Society has quickened its pace in the last decades and with these objects we wanted promote moments of reflection and concentration as opposed to mere efficiency in use. In addition, we believe that the use of more aesthetic, ambient displays might reduce information overload and reflections of the environment might change how people relate to their surroundings and to one another.

Two of the Reach wearable sketches were created in response to these issues, a bag and a series of scarves. With one of the 'Reach in bags', called 'Environmental patterns', we concentrated on what computation could bring both to already existing interaction patterns associated with bags as well as to layering new information within the bag to reveal dynamic patterns based on the surroundings. The 'Reach around scarves' reveal or create patterns and even hidden messages based on environmental conditions (sunlight, temperature and wind). In all cases, we were interested in seeing how personal identity and connection with the environment might stimulate reflection and awareness and spur new conversations.

Environmental patterns

Inspired by the plug-and-play aspect of the 'Sonic City' project[16] this bag is intended for use with several sensors that react to and reflect aspects of the environment. Sensors measure sound level, light and temperature. A BX-24 chip processes the data input from the external sensors and translates the values into a dynamic textile pattern using a combination of electroluminescent film and synthetic fabric. In addition, we amplify the amperage and voltage so that the bag can remain wireless, powered from two nine-volt batteries.

Revealing and creating patterns

The ‘Reach around scarves’ provide warmth in addition to changing patterns on the fabric based on temperature. With these scarves, we were interested in the use qualities associated with warmth as well as how patterns created and revealed by heating elements could be realized and worn in a public manner. When it gets cold outside, the scarves heat up and change the pattern on the surface of the scarf. A temperature sensor triggers the heating of conductive thread sandwiched between two layers of the scarf fabric.

One scarf takes an additive approach, creating a pattern where there was none before. In this case, conductive thread heats thermochromic ink, changing the color of the fabric and creating a pattern. In the other scarf, messages are revealed to both the wearer and others as the scarf heats up. Here both thermochromic and pigmented ink work together so that when the conductive thread is heated, part of the pattern simply disappears, revealing a permanent underlying pattern. In addition to temperature-changing scarves, we are researching possibilities for creating a scarf for all seasons that might generate different patterns based on what time of year it is.

The story continues: Social communication

The next phase of Reach will include new sketches based on outcomes from existing sketches, addressing practical and social issues as well as combining lessons learned about both the making of patterns and the interaction qualities.

Social issues surrounding wearable technology (as with any mobile technology

In the Reach in bags, dynamic patterns reflect the sound environment or situated media located in public spaces) include concerns about security and/or privacy and what this means socially. For instance, imagine a society where everyone was connected via their clothing. Although this world may prove to be more playful and communicative, perhaps issues would arise concerning privacy or the desire not to be connected. As a basis for discovering what kinds of future scenarios might be in store, this project uses design sketches to probe into communicative and communal factors, realizing and exposing the implications to raise the issues for debate.

In addition to social implications, there are practical issues that must be addressed. For instance, instead of developing a technology and then giving the item a superficial, separate surface, we are interested in possibilities where the construction might become the item itself, allowing for greater integration of the technology into the actual fabric. From a textile perspective, we would like to combine electronic hardware with the fabric so that pattern creation would not be a separate process from making the fabric. This might be done by weaving the heat elements into the construction of the fabric.

Other practical issues include the need for further research into energy usage and power supply. It is possible to incorporate sensors and methods for using alternative energy sources and/or using less energy in some of the pieces through different technical solutions. In addition, we want to further our exploration of how dynamic patterns can be incorporated into textiles, making more aesthetic examples and deepening the level of technological integration.

Our hope is to continue expanding our own ideas about what a dynamic textile is and exploring different modes of interaction for communicating in and reflecting upon social space. Ideas include the design of textiles that change based on the location of an individual, serving as a critique for social constructs. Our goal would to reflect the nature of a space as outlined by the 'letter of law'. Fabric pattern might change based on whether a person is in a public or private space. In addition, we want to continue to increase the flow of personal information and intrapersonal communication through the creation of electronic patches containing stories and or personal imagery that individuals stitch inside. With such an idea, it would be possible for individuals to create their own stories and then trade with others wearing these patches in order to share their stories and add a new experience.

Future implications: A wearable language

It is clear that patterns play a concrete and objective role in determining the extent to which we come to life in any given place.[17]

Ultimately, the richest experiences we have in public life occur when we can interact with one another. We are inspired by conversations and actions that we come across on a daily basis. New digital means have provided us with opportunities for supporting even more new forms of expression and communication.

Both computer technology and textile patterns should, and thus can be, used in alternative ways to further new forms of social communication. Reach wearable sketches have been a tool and starting point for experimenting with design, technology and smart materials. We have investigated systems where information technology is integrated and expressed in personal garments and have identified new ways of interacting with the technology available today.

We conclude that patterns are not merely instrumental but might also have a life in themselves. The wearable sketches were not made in order to prescribe what people might express or to report on what has happened. Instead, it is our hope that the behaviours and experiences of people who use such devices would define an entirely new language of expression, an open framework in which people could exchange ideas and relate to their environment in a new and personal ways. New forms of wearable communication can reshape our understanding of public spaces and expand our customs of interconnecting. In turn, if we consider the ways that vocal language reveals the culture and the state of the society, we might imagine the nuances that a wearable language could add to this conversation.

1. Taylor 1989
2. Iwatini 1998
3. Crowley et al 2004
4. Dunne 1999
5. Espinoza et al 2001
6. Jacobs et al 2003
7. Berzowska 2005
8. Moriwaki 2003
9. Restany et al 1998
10. Gehl 2001
11. Taylor 1989
12. Landin and Worbin 2004
13. Redström et al 2000
14. Hall 1966
15. Gehl 2001
16. Mazé and Jacobs 2003b
17. Alexander 1979, p.115

Project: Anders Ernevi, Margot Jacobs and Linda Worbin

Tic-Tac-Textiles: A Waiting Game

Daniel Eriksson, Anders Ernevi, Margot Jacobs, Ulrika Löfgren, Ramia Mazé, Johan Redström, Johan Thoresson and Linda Worbin

Computational things are often considered time-saving tools to help people perform certain tasks in faster, better and more efficient ways – when 'time' is mentioned as a parameter in HCI and interaction design, effectiveness is often the dominant value. But even as technology in general and computer technology in particular strives to save time and make us more effective, it also creates waiting time.

Cars and buses help us to get from one place to another, but time is spent waiting in traffic jams, at traffic lights or for the bus to come. Elevators take us from one floor to the next, and we stand waiting during the ride. Computers help us in many different ways but – even though they get faster and faster all the time – we still have to wait for them to start up, load and execute programs, connect to the internet, and to download files, emails and web pages. Though we agree that time should be considered a central parameter in interaction design, we are not convinced that effectiveness is the most interesting or even most important aspect of time to relate to. Restricting notions of time in the design of computer-based artefacts to efficiency can unnecessarily exclude values central to everyday life. With respect to experiential, narrative and sensory factors, interaction design may offer a different perspective on considerations of the temporal aesthetics of computational things.

Waiting

In our previous projects, such as 'Photo Phone Entertainment'[1] and the 'Toilet Entertainment System',[2] we have designed computer-based artefacts intended to engage and entertain people while they wait or have time to kill. A related application, called 'Printertainment', was developed by Hong et al:[3] in this system that entertains users as they wait for their documents to be printed, a set of interactive cover sheets is provided for users to fill in, scan and then use as input to entertainment applications. Yet another approach, described by Hallnäs and Redström,[4] is a mobile phone that is designed based on a number of phoning-acts, where waiting is an available option.

Since we believe that acts or actions are central to the design of interaction, we base this project on an act – an approach that relates to that described by Hallnäs and Redström.[5] But whereas they designed an artefact and a selection of defined acts typical of a given artefact, in this project we identify and analyse an actual act and use its characteristics to design a new artefact. We investigated the ‘act of waiting’ as a starting point for creating an experimental design based on the characteristics of such an act. Our design process included observations of acts of waiting, identification and analysis of characteristic expressions, and then the design of new objects based on the information collected and ideas generated.

Observations

Since we wanted to base our design on characteristics of the act of waiting, we made a series of semi-ethnographic observations of people waiting. Information was collected as videos of people in waiting situations – while not restricted to computer-related waiting time, the focus was on situations in which technology is present as a structuring element in everyday behavior. Places where observations were made included shopping malls, tram stops, bus stations and in front of computers. A second observational strategy was the use of probes, based on the ‘cultural probe’ design method.[6] This involved the distribution of small notebooks among a group of people with a request for them to make notes of how, when, where and why people were waiting.

Identification and analysis

To identify the characteristics of the act we were focussing on, we started ‘playing’ with the collected material. The video material was played with, edited in various ways, and played back at different speeds. Typical behaviors observed were scribbling, finger-tapping, and other small bodily movements while standing in one spot. Another characteristic behavior that caught

The ‘tic’ and ‘tac’ furniture pieces

our attention was small foot movements while standing waiting at, for instance, a bus stop, where such movement was frequently combined with slight changes in posture over time. In many respects, these movements resembled very slow dance performances, an effect that was enhanced when playing with the frame-rate of the video recordings.

Interpreting the expressions of waiting in this fashion, we developed the idea of Disco Boy based on 'dance moves' observed at bus stations. In this speculative scenario, sensors hidden beneath the tiles on the sidewalk at the bus station might recognize movements of the people above and connect to the traffic control network in the city. By performing the 'right' moves, 'Disco Boy' can control the traffic lights and thus the bus schedule. This idea is interesting both since it offers the user something to do while waiting for the bus and the possibility to influence and shorten the waiting time.

Another behavior that caught our attention was the small circular movements made with the mouse when waiting for a computer to perform its tasks, almost as if the user was trying to urge the computer along. This observation inspired the design of a 'hand-driven computer' similar to the 'Crank' by Brucker-Cohen,[7] where a handle must be cranked to download web pages from the internet. However instead of controlling the bandwidth, the speed of the processor is controlled by the hand-driven computer, thereby empowering a user during his or her waiting time.

Finally, we determined some characteristics of waiting to explore further:

~ Physical movement: All the acts identified included some kind of differential physical movement (or non-movement).
~ Spatial patterns: Visual patterns, such as 'telephone scribble'
~ Temporal patterns: Patterns that appear over time, for instance repeated physical movement

In addition to these, two other characteristics were interesting on another level of abstraction:

~ Communication: Notes in the collected probe notebooks and observations at bus stations showed that people often use the waiting time to communicate with other, via mobile phones or face-to-face.
~ Play: Another finding from the notebooks and the observations was that people like to spend their waiting time by playing games.

Experimental tablecloths

Parallel to the investigations of waiting, we experimented with dynamic textiles surfaces and objects used for decoration.

Based on the notion of 'Party Textiles',[8] we developed a series of dynamic textile samples where, for instance, electroluminescent film integrated into the weave was controlled by sound sensors, such that patterned light effects would relate to local sonic conditions. We also worked with fabric samples that reacted to temperature or light to see how decorative objects such as tablecloths might reflect the ambience of a social setting.

Another series of experiments with time-based dynamics of everyday textile objects turned our interest towards tablecloths and their relation to the social settings in which they are used. In a design sketch made during a series of temporal form studies, we worked with the role that a tablecloth might play in an intimate dinner setting at a restaurant. Here, the tablecloth is physically pulled into a gap in the middle of the table so as to also gradually draw two people at the table closer together. When the dinner is over and the cloth straightened out again in preparation for another couple, a residual color pattern reflects how much of the cloth was drawn away, thus telling the story of how close the couple got before leaving.

Additional textile experiments with cloths that challenged their current use included series of designs based on the notion of 'textile disobedience'. One such design is an asymmetrically weighted tablecloth that slides off the table if it is not held on to. Another more or less dysfunctional design is the 'Structure Cloth', a tablecloth with a very rugged surface that prohibits any stable placement of cups and glasses.

Experiments such as these far from practical examples of possible products helped us re-think some of our preconceptions of how tablecloths might be designed and used. Based on a collection of inspiration and provocative materials, both from observations an act of use and material experiments, the concept for 'Tic-Tac-Textiles' gradually evolved.

Tic-Tac-Textiles

'Tic' and 'tac' are two pieces of furniture designed for tea and coffee breaks. Taking a comfortable seat on 'tic' and setting your hot cup on the attached table activates patterns hidden in the table's textile surface. These patterns – your 'x' or 'o' marks – are communicated to the textile surface in 'tac'. By intention or accident, you can discover and invite another into an aesthetic and subtle game of 'tic-tac-toe' that lasts just as long as your coffee stays hot.

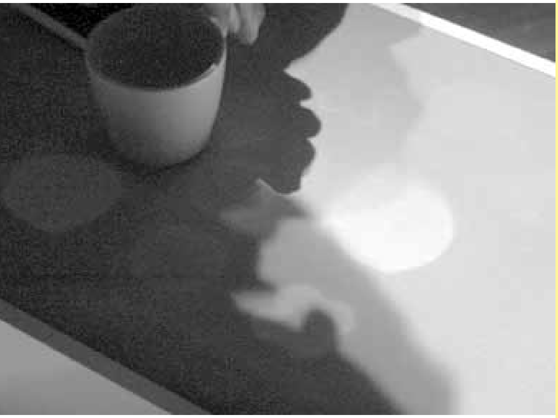
Woven thermochromic fabric – a heat-sensitive woven textile that changes color above a certain temperature – clads the attached tables of the 'tic' and 'tac' furniture objects. Underneath the table surface are heating elements laid out in a nine-square tic-tac-toe grid – when a hot object is placed on top of a spot in the grid, the element heats up causing an 'x' or 'o' mark to appear in the fabric of both the tables.

To be more exact, if you place a cup of hot coffee on top of one of the heating elements, three things occur: the color of the textile surface changes beneath the cup; a sensor beneath the textile registers the change in temperature, and sends the information to the other table (which can be placed almost anywhere else in the world since the communication is carried via internet), and; the corresponding heat element in the other table is warmed so an 'x' or 'o' is generated for the other player. In response, they can place their own hot cup on another spot on the grid, sending their mark to your tablecloth – thus together you begin a game of tic-tac-toe.

When the hot cup or other heated artefact is removed from the surface, there will be a visible trace of the cup in the square that will slowly fade away until the cloth returns to its natural state. The length of time this takes is related to how hot the object was. Ultimately, players seated on 'tic' and 'tac' mark their own and the others' table by moving their cups and waiting for patterns to emerge and be exchanged.

Furniture design

The prototype was realized as two pieces of furniture combining together seats and



Tic-Tac-Textiles at the
Textil evolution exhibition

side tables. The design intention with the furniture was to create a story around the situation of a fika – 'fika' is the Swedish custom of taking a coffee break. Inspiration for the furniture design is based on practices of coffee or tea parties, from memories of tables donned with pretty tablecloths and cookies as well as the tradition of Arabic tea tables. The placement of a side table next to each seat makes it possible to put your coffee down while you're waiting or taking a break. In fact, the furniture is designed so that the table-top – and thus the game-board – is the natural and inevitable place to set your cup, with some extra margin of possibility for scribbling, leaning or setting a plate.

We purposely designed the two furniture pieces 'tic' and 'tac' as inexact mirrors of one another. 'Tic' is fashioned with one seat and a tabletop while 'tac' is fashioned with two seats and a shared tabletop. This was done in order to suggest and encourage multiple possibilities for social interaction. For example, 'tac' is designed so that participants sit fairly close to one another, thus closely connecting with one another while still oriented toward the overall space. 'Tic' and 'tac' are modular, thus also affording the possibility of connecting the furniture together if used in the same location. With these pieces, we can test out and illustrate two different communication models – playing over a distance and social exchanges shared or sparked locally.

Textile design

Inspiration for the first textile design came from 'Do-It-Yourself', a paint-by-numbers picture by Andy Warhol, in which an obvious idea engaged a viewer deeper into wanting to participate – essentially a simple invitation for engagement and action. Some earlier experiments had involved a pleated fabric with a hidden text message that was legible in various ways depending on how people folded the pleats – searching and surprise were built into interaction with the textile material. Other inspiration came from an early fabric screen-printed with thermochromic ink, which made patterns when hot artefacts were placed on it. In the textile design for Tic-Tac-Textiles, our investigation involved how decoration might invite coffee or tea drinkers to explore the tablecloth by playing a game during a break.

In the design of the textiles used in the final prototype, the entire surface of a woven textile is printed with thermochromic ink. The original idea was to have a nine-square grid printed in order to show exactly where to place the hot cups to play. Instead, the concept evolved for the final prototype such that both the decorative patterns and game-board interaction are hidden until user interaction activates 'x' and 'o' marks to appear. While this design may make it hard to grasp the hidden game immediately, it adds a lot of other qualities such as aspects of slow play, surprise upon receipt of other's marks, and self-discovery of the 'rules'. It creates more room for players to use the cloth as they wish, for example making their own patterns, scribbling with a friend seated beside, or perhaps just leaving traces for the next to arrive and see.

The woven pattern used in the textile design is inspired from antique patterns associated with tea traditions in order to match the furniture and create an overall feel. The seat cushion fabric is also printed in thermochromic ink. The cushions do not house any technology and the pattern is only affected by the body heat of the person who sits on them and the amount of time they stay to play. In this manner, it is possible to denote a certain level of presence. Additionally, working with heat in various ways – electronically-generated, liquid beverage, and body heat – creates a rich, multi-sensorial experience around an act of remote communication and digital game-play.

Game design

We had various ideas as to how much control of the game should be taken care of by the software game engine and what 'degree of freedom' users should have.

A simple game engine would merely send temperature values between the two tables and cause heat to generate in the elements when temperature values reached a certain threshold. With this option, it is clearly up to users not to cheat and to decide who wins, giving the players the same freedom as with the traditional paper version of the game, with the difference that here the marks disappear after some time.

A more advanced game engine could do a lot more. Besides sending values and heating elements, it might also keep track of which spots on the grid were used and keep them hot until the game was over or until it was time to move the mark, depending on how the rules were set up. This engine would also be able to remember which of the tablecloths had the most wins, the number of moves needed and so on. It would also be possible to play a game of solitaire tic-tac-toe against the table.

In the end, we decided to implement the simple game engine because we believed that it made the artefact more interesting and more logical due to the, in some sense, imprecise and inflexible interface.

Hardware design

The hardware consists of: a plastic sheet with laser-cut heater wiring, nine temperature sensors, a controller unit and a laptop computer carrying the software hidden inside the two furniture pieces. The table is clad in thermochromic fabric under which the plastic sheet and temperature sensors reside. The computers connect to each other via a local wireless network, either directly or over the internet. The controller module is mounted under the board around which the thermochromic fabric is wrapped. The board also conceals the computer and power supplies that rest on a shelf inside.

When a hot cup is placed at one of the nine available spots, the temperature sensor value begins to rise. If it rises above a threshold value, the software detects that a cup has been placed. Originally, the intention was to let the heat element in the 'home board' display a mark in order to maintain the pattern for a while. However, this turned out to be unnecessary since the cup itself leaves quite a substantial impression. It also turned out to be problematic since the inner circle of the heater wiring got so hot that it caused the sensor to self-sustain the 'on state' and consequently the other board to display a cross. The actual workings of this differ a bit from the short description that follows here.

The heat elements consist of a sheet of plastic film with heater wiring for nine separate circles and crosses printed in thin metal. The patterns of the metal are designed to have a constant, minimal thickness throughout the circle or cross so that they have a high resistance. This results in those parts becoming hot when voltage is applied. Because of their difference in length, the circle and cross have different thicknesses in order to provide equal resistance, thus ensuring that they become equally hot. For the same reason, connections between the patterns and the soldering points are substantially wider in order not to heat up enough to transfer a visible pattern on the thermochromic fabric. Each subsection of the pattern comprises one circle and one cross with a common ground terminal. Regular wires are soldered to the subsection's terminals in a network that connects to the controller unit.

Underneath the heater sheet are nine separate temperature sensors. These are fixed using hot glue, one under each heater subsection. The sensors use the Dallas One-Wire protocol and therefore only need a common supply, data and ground wire connecting them all to a single node. This is made possible due to their individual ID number. All One-Wire electronics come with a free downloadable software package that enables reading ID numbers and verifying functionalities. The temperature sensor bus is directly connected to the computer. The program reads their value and compares it to a preset threshold in order to indicate that a hot cup has been placed in the spot in question.

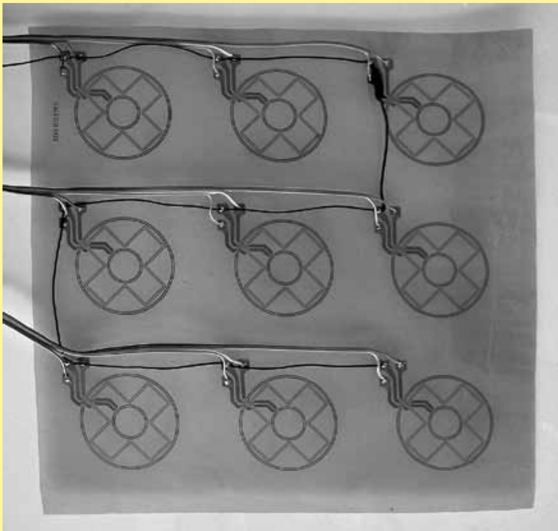
The controller unit carries three One-Wire switches with eight switched outputs. Since there are a total of eighteen separate heater circuits (nine circles and nine crosses) only six outputs on each switch are used. These One-Wire switches work in the same manner as the temperature sensors and are connected to the same node. The difference is that after they have been identified according to their placement, the software controls the switching whereas the temperature sensors are just called on for a reading. In order to cope with the current needed to heat the sensors (to produce heat one needs power = voltage times current) the switches are connected to three seven-channel Darlington drivers. Darlington is a specific transistor coupling designed to provide loads of current. As above, only six channels are used in each Darlington IC. All these parts together with data pull-up resistors are surface mount soldered to a single board. This board with its computer and power supply connections makes up the entire control module.

Software design

The computer located inside in of the furniture pieces communicates with the controller modules in the prototypes via a dongle on the serial port. The dongle translates the RS232 signal on the serial port to a TTL signal that the One-Wire devices use. All One-Wire devices are connected to ground and a signal wire. The protocol for the One-Wire devices demands a certain time of a logical '1' on the signal wire, so that it can be used to power the devices as well. All devices have a unique ID stored in them that have to be used when reading and writing to them. The software for Tic-Tac-Textiles is written in Java with an API for the One-Wire devices.

Initiation

The ID from all connected devices can be located but the physical position is unknown. During the initiation phase, all devices are searched for and compared to a configuration file where the IDs are mapped to a physical position on the module. Another reason for an initiation phase is to make a virtual board of the temperature sensors on one prototype that can be sent to the other prototype.



Patterns created by hot coffee cups and heat elements underneath the cloth

Connecting modules

The modules have to be connected using the TCP-protocol. The Java API has classes that support this as well as the ability to send objects via the connection. One of the modules has to be set up as a server and the other as a client for this to work. The client tries to connect to the IP-address and port of the server that is stated in the configuration file. After a connection has been established, the virtual boards are frequently exchanged so that the one module has information about the status of the other module.

Displaying information

The information displayed on the tablecloth is frequently updated. This is accomplished by a function that checks the information from the temperature sensors on both modules and activates a corresponding switch to heat the circles and crosses. The switches are also One-Wire devices and controlled with the help of the Java API. One board is mapped to the 'o' or circles and the other board is mapped to the 'x' or crosses.

Experiences and reflections

As we exhibited and demonstrated the Tic-Tac-Textiles furniture, observing and talking to many people trying them out, we realized that the multiple layers of interaction were perhaps even more evident in use than we had imagined during the design process. First encounters with the objects generally centered on the immediate changes in the visual surface of the textile resulting from either a warm cup or hand. While there was not necessarily any advanced scribbling, there was nonetheless a certain fascination with the possibility to 'write' on the surface using heat. The next level of engagement was exploring the communication going on between the 'tic' and 'tac' furniture pieces and the possibility to play a game of tic-tac-toe. However, playing the game on these devices proved to be quite different from the normal experience.

For instance, most people think of tic-tac-toe as a fairly quick game that you try to do almost as fast as you can. Having to wait at least a minute for the first marks to appear clearly challenged this understanding. And since the rate at which the marks appear depends on how hot the cup is, the temporal aspect of the game change, becoming slower as the beverage cools down.

The fact that markings appear and disappear slowly also introduces a kind of ambiguity with respect to what is present as the game board. For instance, at what point are you allowed to claim a position that was previously taken as its mark starts to fade? Even though the design of the game and the objects themselves are quite simple, they still seemed to expose rather complex and important problems, requiring that players renegotiate the rules of a familiar game through a new set of social and material variables.

Another interesting response relating to the physicality of the design was that some people discovered that if you have a really hot cup and place it in-between two positions of the game board, it is possible to activate two sensors at once and cause two crosses to appear on the other table. The discovery of such possibilities for cheating with respect to the physical design of the devices raises important issues about the choice of materials when designing computational or communication devices.

It is also true that this design might cause frustration for some players since they do not receive any exact information about what is going on at the other table – the fact that questions like "Is there still a person on the other side?" and "Has there been any person there at all?" cannot always be answered further adds to the ambiguity of the game. However, generally speaking, interferences between the layers of interaction, possibly due to the open and deliberately ambiguous expressions of the design, posed very interesting directions for further explorations into the communication aspects of these pieces. Clearly, there are not only problems but also interesting new opportunities for more sublime communication.

One way to further investigate the communication aspects might be to develop a 'free-play-tablecloth' with higher in- and output resolution, in which temperature sensitivity and heat generation is not limited to just a few spots, but where the entire cloth can be activated. This would increase the flexibility of the interface while remaining relatively simple.

Finally, a rather obvious question is the relevance of choosing the act of waiting as a starting point, and what might have been different if we had chosen another act to start with. For sure, this design does not in any way resolve questions about waiting time in computer-based artefacts, but it presents an alternative way of thinking about such questions. Although the final design strongly relates to acts of waiting through notions of slow play and the 'fika' break, the aspects defined are not necessarily specific to the acts of waiting defined early in the process. But perhaps this is one of the characteristics of interaction design as it is used to (re-) interpret existing behaviors and use patterns – somewhere below the surface of what we think we are doing there are often unexpected things to be found, some which might give rise to new ways of using, doing or thinking.

1. Thoresson 2003
2. Stenberg and Thoresson 2003
3. Hong et al 1999
4. Hallnäs and Redström 2002 a
5. Hallnäs and Redström 2002 a, b
6. Gaver et al 1999
7. Brucker-Cohen 2001
8. Melin et al 2003

Wait study: Johan Thoresson

Experimental tablecloths: Henrik Jernström, Peter Ljungstrand, Johan Redström, Maria Redström, Linda Worbin

Tic-Tac-Textiles: Daniel Eriksson, Anders Ernevi, Margot Jacobs, Ulrika Löfgren, Ramia Mazé, Johan Redström, Johan Thoresson and Linda Worbin

Information Deliverer: Abstract Information Appliances

Johan Redström

This project is an investigation into the aesthetics of computational things, that is to say, how such things build their appearance. Our investigation is based on a series of experiments in which we study how the specific properties of computational material could result in certain kinds of structures of expression. We have worked with experimental interaction design to create a collection of examples that, in different ways, illustrate aspects of the expressiveness of textiles and computational technology.

The temporal expressions that characterise computational things can be seen in the basic acts of information technology use, for instance in notions of 'reading' or 'writing' information which are actions that unfold over time. To investigate such expressions while completely disregarding practical use is somewhat problematic since the basic expressions of acts all have to do with a temporal gestalt that is only explicitly revealed through use and interaction with a thing.

This problem of how to separate function and expression is a part of the ever-present dilemma of how the expressions and functions of designed things depend on each other, an interdependency that we might call the function-expression circle. Fortunately – or unfortunately depending on your perspective – computational technology entails that this is a central concern since the characteristics of temporally-based things make it perhaps even more difficult to distinguish between expression and function. Still, the distinction is there to be made and working with computational technology can be a means of enquiring into such fundamental notions in design.

As an example, consider the difference between a pen and a computer as used for writing a text. In terms of general func-tionality, they are both tools to accomplish 'writing', but the expressions of the act of writing are in each case radically different. Seen the other way around, we can think about what we 'see' as we think of what it means to write something. If we are about to design a tool for writing, the perspective we get if our picture is based on the expressions of handwriting versus word-processing using a computer reveals several important differences. Not only does the functionality of a thing explain its expressions, func-tionality must be understood on basis of the expressions of acts of use.

As we set up design experiments on the aesthetics of IT and textiles, this circle of functions and expressions is a central concern in our investigation.

Appliances and expressionals

As an approach to resolving the function-expression circle and working with the basic 'pictures' we employ to understand the thing we are about to design, we have worked with a complementary pair of concepts: the notion of information *appliances* and information *expressionals*.

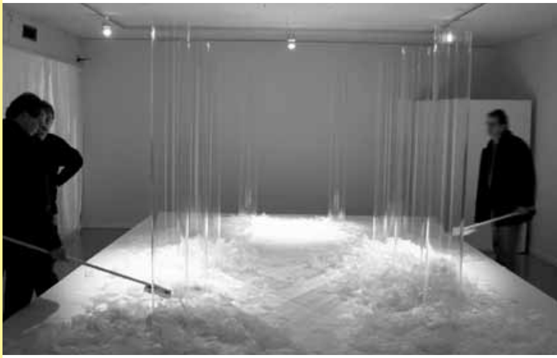
An *information appliance* is a computational thing designed to perform some set of functions. It could, for example, be a device for writing, for printing, or for taking pictures.

An *information expressional* is a computational thing designed to be the carrier of certain expressions related to some elementary information-handling act without any reference to a specific application.

Generally speaking, in creating an information appliance, the starting point in a design process is typically concern for the functionality of the thing. In designing information expressionals the objective is different – we are more concerned with the expressions of using the thing and less concerned with the functioning or application of the thing. For instance, we might work with expressions of writing without any concern about there being something to be written. To further emph-asize this alternative perspective, we have worked with the amplification of such expressions to the point where they come to dominate completely over practical func-tionality. To work with such expressions is similar to when our focus shifts from the text we are writing to how the pen feels in our hand, how its design affects the things that are written, or how it feels against the paper.

In this project, our starting point was the

Scattered pieces of delivered information



Visiters to the exhibit interacting with the Information Deliverer use of various textile materials and objects to re-approach basic information-handling acts. How might textile materials reinterpret the act of writing or reading information? How could the specific expressive properties of textiles be used to manifest the temporal gestalt of such acts?

Process

Based on the notion of abstract information appliances, our work process was centered on the development of a series of conceptual sketches. These were then used as a basis for practical experiments with materials. Based on the results from this process, one concept was selected for full-scale impl-ementation – a full-scale experiment – as an exhibition at the Borås Art Museum in Sweden in 2001.

Conceptual sketches

These are conceptual sketches made to illustrate various ways in which a textile material or object could be used to reinterpret what a given information-handling act might be like. The focus is almost exclusively on expressions, and so these objects have lost almost all practical functionality.

An information opener

~ The information appliance: Any appliance used to unfold or unpack given information, for example, a software application with a graphical user interface requiring a double-click on a certain type of icon as input in order to open up a certain document or picture.

~ Expression of use: Acts of displaying hidden things. We click on an icon at our desktop or write a command to open a document or extract a compressed file. We press buttons on our PDA or mobile phone to read a message or answer a telephone call.

~ Textile artefact: Large rotating textile screens that, when in certain positions, open up to reveal some distant information written on a piece of fabric hanging on a wall behind the screens.

~ Reinterpretation: A complex pattern of large, rotating textile screens to visualize the mysteries of opening information. The information available to be opened is always behind the opening mechanism.

~ The abstract information appliance: Imagine four 2x2 meter textile screens mounted on wooden and metal frames hanging on wires. The screens will coll-ectively display various patterns depend-ing on their relative positions, patterns that indicate the state of opening. Each screen consists of a complex textile structure that displays distinctly different patterns depending on which angle it is seen from. Computer-controlled stepper motors turn the textile screens around their axes. On a wall behind the rotating screens, we put some information, for example a projection of a TV news program.

An information compiler

~ The information appliance: Any computational device used to compile information, that is to say, an information visualisation application where different databases are combined in a search for certain information.

~ Expression of use: Acts of combining information and relating them to each other in order to form something new.

~ Textile expression: Layers of broken fabric hanging from the ceiling that occlude each other in various ways.

- ~ Reinterpretation: **Like silhouette projections, patterns of holes in the pieces of fabric create images as we look through them to the wall behind. As the layers of fabric move sideways, different images seem to appear. To compile information and create a certain image, we try to move the layers to the correct positions.**
- ~ The abstract information appliance: **Sheets of fabric hanging from tracks in the ceiling. Each sheet has a certain pattern of holes in it, representing some set of information. Computer-controlled electrical motors move the sheets sideways in the tracks. Sometimes the configuration of positions makes it possible to see an abstract image through the layers causing reflection on how the different information sources contribute to the compiled images.**

An information marker

- ~ The information appliance: **Any appliance that helps us to mark out pieces of information, for instance, a word-processor that enables us to highlight sections of a text.**
- ~ Expression of use: **Acts of drawing and displaying boundary lines.**
- ~ Textile expression: **Pulling various threads in elastic fabric to make specific sections of the fabric transparent.**
- ~ Reinterpretation: **Marking information is interpreted through an act of stretching textile material to form transparent 'holes' in the material.**
- ~ The abstract information appliance: **Elastic textile material mounted on a large frame in front of information projected on a free-hanging textile. Using computer-controlled stepper motors, a process of marking information by pulling threads in the elastic textile material is controlled.**

An information uncoverer

- ~ The information appliance: **Any appliance that helps to reveal information by means of tracing how something is built – a software debugger is a typical example.**
- ~ Expression of use: **Acts of following a path and keeping track of its history.**
- ~ Textile expression: **Unravelling a piece of knitwear.**
- ~ Reinterpretation: **The structure-revealing process involved in unravelling a complex knit structure visualizes the mysteries of uncovering information. Information appears as the knitwear – its cover – disappears.**
- ~ The abstract information appliance: **A complex knitted structure is mounted on a frame. A computer-controlled stepper motor pulls certain threads to unravel the knitted object.**

An information deliverer

- ~ The information appliance: **Any appliance that somehow delivers information, for instance, an email application or a telephone system.**
- ~ Expression of use: **Acts of handing things out – the mail program delivers information as I see mails arrive; the phone delivers information as I talk to my friends.**
- ~ Textile expression: **Diverse pieces of fabric on which information is printed using UV-luminescent color.**
- ~ Reinterpretation: **A complex pattern of floating, flying fabric pieces of various textures to visualize and conceptualize the mysteries of delivering information. Information is simply blowing in the wind.**
- ~ The abstract information appliance: **Large trays are hanging from the ceiling at different heights. Pieces of fabric are lying**

on the trays. Electrical fans are mounted on each tray and as they turn on and off causing patterns of falling pieces of fabric. As they land on the floor, the information can be read using UV light.

Final design

It was decided that the 'Information Deliverer' would be built as an installation for an exhibition. After experimenting with different kinds of fabric blowing in airflows, we replaced the trays with another solution based on large plastic tubes. Information was still to be delivered as pieces of fabric falling to the floor, moving as a result of airflows generated by computer-controlled fans – but they would blow out of tubes standing on the floor instead of from trays suspended from the ceiling.

Installation overview

A 3.5x6 meter podium, 40 cm above the floor. 10 plastic tubes, two meters high and 20 cm in diameter, rise from holes on the podium. Airflow through each tube is generated by two electronic fans underneath, regulated by a microcontroller and adjusted using a dimmer switch.

Each day, each tube 'delivers' about 50 pieces of fabric blown out through the tube. Each tube is associated a major news event during the 20th century, such as the first man on the moon, the assassination of President Kennedy, the Chernobyl nuclear accident, or the wedding of Prince Charles and Lady Diana. About 50 fragments of texts and images were collected from news articles covering each of these events.

A unique collection of fabric pieces was designed for each tube and each day. Fragments of text were printed in UV-luminescent color on different kinds of fabric, the qualities of which were intended to reflect some property of the news event in question. Each collection of fabric was made in a specific material and each piece had its own characteristic of shape or folds that would thus cause it to float and fly up and out through the tubes in a unique pattern.

A computer program records and plays back a radio news channel in 10 independent 'threads', each of which controls the fans beneath one of the 10 tubes. Thus, current news delivered in near-real time controls the delivery of the historical news that blows out of each tube and falls down onto the podium.

Everything in the room is white, including the podium and all pieces of fabric. Thus, the text fragments screen-printed onto the fabric are visible only when illuminated with UV light. Therefore, a special 'instrument' consisting of a UV lamp mounted on the end of a stick must be used to read the information.

This installation at the Borås Art Museum was built to run for 23 days, which means that at the end of the exhibition there were approximately 11,500 unique pieces of fabric piled up on the podium. During this period, 'news' collected on the podium in the form of small pieces of textile fabric, gradually transforming the empty surface into a complex landscape of yesterday's news still lying there to be read and reflected upon.

Reflections

As a 'design experiment', what can be seen in and learned from it? An experiment is often set up to address and hopefully answer some given question(s). The way we think about these questions, of course, influences the way we set up the experiment. As such, design experiments can tell us just as much about what we think about what we design as they help us learn more about the designed things themselves.

In 'Silence', John Cage expressed his view on 'experimental music' as follows:

> Formerly, whenever anyone said the music I presented was experimental, I objected. It seemed to me that composers knew what they were doing, and that the experiments that had been made had taken place prior to the finished works, just as sketches are made before paintings and rehearsals precede performances. But, giving the matter further thought, I realized that there is ordinarily an essential difference between making a piece of music and hearing one. A composer knows his work as a woodsman knows a path he has traced and retraced, while a listener is confronted by the same work as one is in the woods by a plant he has never seen before.
>
> Now, on the other hand, times have changed; music has changed; and I no longer object to the word experimental. … What has happened is that I have become a listener and the music has become something to hear[1]…
>
> And what is the purpose of writing music? One is, of course, not dealing with purposes but dealing with sounds. Or the answer must take the form of a paradox: a purposeful purposelessness or a purposeless play.[2]

Instead of taking the perhaps more typical approach of considering people's reactions to the exhibition as the starting point for learning more, we wanted to concentrate on questions inherent to the design itself, such as how the thing built its presence through the materials used, and how expressive qualities related to these particular materials influenced the way information was delivered.

If viewed from an application-oriented perspective concerned with the functionality of things, this experiment may seem a bit strange – but there is a different kind of knowledge to be gained by asking questions such as these compared to what you get when working with people's ideas about and experiences of something. If we take music as a comparison, one could say that the primary reason for composing and performing music is not necessarily to be able to ask people what they think about it, but to make it possible to *listen* to it.

One way of looking at the Information Deliverer is as a critical counter-example to current solutions designed to deliver information. Here, the basic acts of use have been reinterpreted with a focus on the expressions of the acts themselves without much reference to their intended practical functions. As such, it does not tell us much about what it means to design efficient ways of doing something, but it does provide us with an alternative way of thinking about how it might be done. Instead of designing things to be as efficient and fast as possible, the inherent resistance designed into such an example may provoke reflections upon what it means to use such a thing (similar to how a 'broken' appliance might cause reflection upon the activity of use since it no longer works they way it is expected to).

Such alternative designs may expose the fact that even though it may not be explicit in our daily use, there are certain basic ideas, metaphors and structures embedded in the design of all our appliances, some of which are never or very rarely challenged. By replacing such basic assumptions and building up other ones instead, we create alternative designs that can help us re-discover various basic, hidden assumptions. In moving towards

Revealing text and reading information using the UV light

such a perspective, we might think of the information deliverer as a canonical example.

What would the world of appliances be like if the archetypical form of information delivery was based on pieces of fabric blowing out of pipes? Though certainly not a realistic scenario, we can reflect upon the questions we would have been asking in interaction design if this was indeed the case. One possibility could be that information design would be close to fashion in many ways – designing pieces of information might be primarily concerned with specific characteristics of fabric as it behaves in air currents, what shapes and textures to use for what information, how to individuate each fragment in a world of billions of almost identical pieces.

Further, we might think of textiles not as they appear on a surface such as the body, but as they appear flying in the air. We might think about computational processes in relation to the control of air flow, which implies working with non-linear, chaotic behaviors rather than well-defined, determinate ones. Since most characteristic things in the Information Deliverer happen in between static, controllable states (for instance, in between a resting state in the pipe and resting on the floor), we must focus on what happens as something is being delivered. Compared to current design practice, this perspective opens up a whole new design space in between the two states we now get to work with.

And as we do think about such processes, in between the states that we know we can control, we can discover a range of 'new' expressive qualities present. For instance, in the Information Deliverer, disparate types of fabric resulted in different movement patterns. Some seemed to generate a lot of static electricity and got stuck to the walls of the tubes; others got caught on one another and behaved like one large object; still others would fly independently, whirling around like leaves. This meant that some collections of fabric would react at the slightest air current, whereas others would only react when the fans were on full power for half a minute. Although we cannot completely control these behaviors, we can, through practical experiments, learn about how different kinds of fabric might be used to create different kinds of movement patterns. Which, in turn, makes it possible to refine and fine-tune movements and temporal structures in a quite different manner from how one might traditionally work with an information appliance.

The design of the information deliverer also implies certain relations between the temporal and spatial form of such an appliance. Although you might have to spend some time with the thing to see what happens – or even wait for something to be delivered since the fabric pieces might spend a day or so simply whirling up and down inside the tube before finally making it up and over the top – there is also an existing trace of what has happened present, since the pieces gradually builds a landscape of old news piling up on the floor. At any given moment, it is not possible to see whether the thing is on or off – that is, unless there is some explicit activity in any of the pipes. Just as there is a range of interesting things happening between, before and after the pieces of information have been delivered, the way in which the spatial form evolves over time opens up a design space in between the more explicit electronic and computational states of 'on' and 'off'. This, in turn, allows us as designers to work with aspects of continuity and presence that are hard to achieve in the design of typical information appliances.

Though clearly distinct from the kind of knowledge one would gain from making studies of people, we think that reflecting upon experiments in this way is essential to understanding the design space from within. Both the things that we design – and the materials we use to do so – do talk to us. But we must listen carefully.

1. Cage 1961, p 7 **2.** Cage 1961, p 12

This text is based on:

Hallnäs, L, Melin, L and Redström, J (2002b). Textile Displays: Using Textiles to Investigate Computational Technology as Design Material, in: *Proceedings of the Second Nordic Conference on Human-Computer Interaction (NordiCHI 2002)*, pp 157–166, ACM Press, New York, USA.

Hallnäs, L and Redström, J (2002b). Abstract Information Appliances; Methodological Exercises in Conceptual Design of Computational Things, in: *Proceedings of the Symposium on Designing Interactive Systems (DIS2002)*, pp 105–116, ACM Press, New York, USA.

Project: Lars Hallnäs, Johan Redström and Linda Worbin

Exhibition: Staffan Björk, Lars Hallnäs, Rebecca Hansson, Peter Ljungstrand, Johan Redström and Linda Worbin

Sound Hiders: Textile Sound Design

Lars Hallnäs and Margareta Zetterblom

…there is a story about a possible near future when it will be possible to hide sounds like other *things* we usually hide, to get rid of, to keep secret etc. – as long as we know where they are hidden we can find them, but it is our choice…

We used this story as a conceptual background for a series of design experiments concerning the expressions of textiles as sound-absorbing and sound-reflecting material.[1] The basic motivation for the experiments was twofold:

1 to use conceptual design as a driving force in investigations of the expressiveness of given material, and
2 to use material experiments as a basis for critical design.

To investigate any given material as design material requires, among other things, an investigation of the range of expressiveness of the material. Such investigations may be guided by specific problems, expressed in terms of functionality – the task of muffling noise in a given context, for example. But in order to solve this type of problem, there is a need for more basic investigations, where we try to map out the design space more generally.[2] This type of investigation must necessarily be based on scientific knowledge about material, such as the physics or chemistry of the given materials, but the investigations themselves are more phenomenological in nature, i.e. understanding and describing the expressiveness of material with respect to some given context of use.[3]

The basic question is then: how can we use this material in design praxis? This is a more direct approach than reliance on art practice as the main source of knowledge about the expressiveness of material. Experimental design can in this context be seen as a counterpart to basic research in natural science. We need to set up experiments and 'test' ideas about expressions and expressiveness. Such 'tests' can be expressed in terms of a conceptual design, which may give a context for the experiments – which corresponds to the testing of a hypothesis or a theory. Typically, a conceptual design sketches a context of use where the expressiveness of the material is critical. Thus, a general background story may give a framework for a program of experimental design with focus on the investigations of expressiveness of certain given materials. In this case, the purpose was to investigate expressive properties of textile material as sound-hiding material.

It's a world of its own… it's both a matter of fashion and functional design, in a sense. We have to invent 'sound' situations, test materials, listen, listen… then name, describe and list specific properties.

Design for sound hiders is also a program for critical design where we try to use design aesthetics to discuss and analyse ideas about the future use of technology.[4] In using textiles as basic design material, we filter the idea of a possible technological future through the inherent expressiveness of this given design material.

Here, we sketch a program for experimental design[5] with focus on investigating the expressiveness of textiles as sound-absorbing and sound-reflecting material, a program where we use conceptual design to map out a fictitious design space and where investigations of materials give a foundation for critical design. Rather than simply a theoretical discussion of such a possible program, we chose the form of a series of museum installations to describe and discuss basic ideas. This means that we have done some experiments, some listening, some reflections – but to develop the necessary descriptive tools needed for the formulation of precise questions and systematic results there are a lot of further experiments to be done.

Design for sound hiders

The stories

Sometimes you feel haunted by sounds, you are more or less desperate to hide from them: you close the windows, you pull a thick woollen cap over your head, you put earplugs in your ears, you flee out into the woods, you install triple-glazed windows... Now, suppose we should try to hide the sound instead, collect it like water in a bucket and put it where we want it...

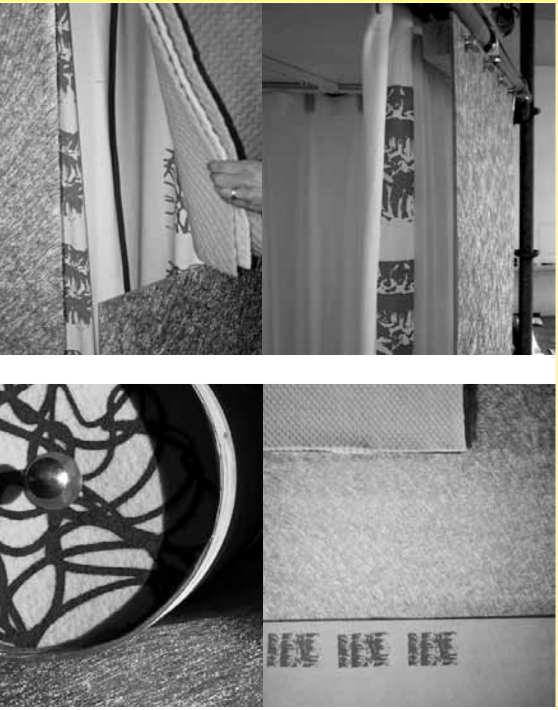
Now, as we know, it is very difficult to collect sounds and hide them, but we imagine a possible near future when sensor technology and modern computational technology make it possible to catch and hide sound in an efficient and simple manner. A near future when we may become sound hiders. In our installations, we use this story to discuss and illustrate the aesthetics of sound hiding using textiles as a basic design material, i.e. designing for sound hiders with textile material.

We consider four scenarios, four examples of sound hiders:

Around
Radka is getting more and more tired of the noise constantly surrounding her in her urban apartment. The traffic noise is there almost all the time, people shouting in the street... that's enough to make the signals from the phone or the door bell almost unbearably irritating... the radio, the TV...

So, we have devised a big box for her where she can hide all the sounds surrounding her. She may place the box in the middle of her living room and visit the sounds when she feels up to it – now she rules the sounds. She only has to press a button and all noise around here will disappear into the box. The box has textile sides absorbing and reflecting sounds in intricate patterns, the sounds bounce around inside the box and are muffled as they are absorbed by the thick layers of textile material.

~ Installation: A triangular scaffold dressed with various textile materials in several layers; solid reflecting material, soft, thick, heavy absorbing material, rubber carpets. Inside the triangle, loud street noise comes from two studio monitors. Each side of the scaffold triangle was also covered in part by plexiglass frames laminated with a non-woven polyester material.
~ Textile material, side one: Materials made of natural wool-fibers. One part of the wall was made of several layers hanging over



Around, along, round, over

The Sound Hiders exhibition

each other made of knitted and tangled wool. The knitted wool-material was dyed yellow with special wool-pigment. The second textile part of the wall was made of thick stamped wool felt. The felt was dyed yellow and had a printed pattern made with pigment color. Both of these textiles are sound absorbing.

~ Textile material, side two: **Textiles made of rubber conveyor belts. The belts were made of rubber principally but had several textile layers integrated. These belts are sound absorbing.**
~ Textile material, side three: **One of the textiles on this side was made of a knitted polyester fabric in several layers. This knitted fabric is sound-absorbent. The other textile on this side was made of various laminated materials originally made for shoe soles. These laminated soles have a hard and stiff surface that implies sound reflection.**
~ Sound material: **Street noise recorded about 15 meters above the ground. A mixture of very loud, low frequency noise from accelerating motor-cycles etc. with high pitched clatter and a more or less constant background of nearly white noise.**

Along

Me and my alarm clock... how could we learn to get along in a civilized manner? I really don't know. Waiting for an answer to this question, I hide its sound in a tube forgetting its intended functionality. It's a sort of redesign where hiding the wake-up signal is in focus.

~ Installation: **A two meter long section of an old ventilation shaft; at one end I put my alarm clock, at the other I insert textile lids of various textures to muffle the sound of the alarm clock.**

- ~ Textile material: The textiles in this installation were made of wool and synthetic felt. The textiles were circle-shaped and used as lids. Each lid had a screen-print, printed with puff-binder.
- ~ Sound material: An amplified signal from a typical digital alarm clock.

Round

Erik is very tired of all this nagging... can't they just stop nagging about going to bed early, washing this or that, picking up clothes, plates etc. from the floor and so on...

Finally he gives up, presses a button and collects the nagging sound and put it under lock and key. The sound passes through several filters that cleanses it of its emotional charge and transforms it into some sort of sound poetry. After a while, he gets tired of this poetry, wraps a long woollen scarf around it and gets on with more important things in a nagging-free environment.

- ~ Installation: A two meter high cylinder made of sheep-fencing. Inside the cylinder are two loudspeakers. The cylinder is covered with long woollen scarves that muffle sound coming out of the loudspeakers.
- ~ Textile material: Long, thin felt-strips were wound many times around a cylindrical fence. The felt material was knitted and dyed. Some felt-strips were printed with pigment color.
- ~ Sound material: An eight voice 'nagging'-canon.

Over

Cajsa, a stockbroker, is by now very tired of all the depressing news about the stock market that comes out of her TV. She collects it and puts it under her favourite chair, which she covers with thick woollen cloth. She is sitting there now, waiting for better times to come.

- ~ Installation: A chair covered with woollen-cloth. Under the seat of the chair are two loudspeakers directed upwards.
- ~ Textile material: Knitted and tangled wool. Several layers of wool-cloth make the sound from the chair softer.
- ~ Sound material: A mixture of several cut-up layers of radio financial news.

The aesthetics of textile sound design – near field design

Knowing the principal acoustics of a given textile material is of course essential in textile sound design, but we also need a phenomenological description of its expressiveness as a 'sound design' material. If we say that that the woollen-cloth covering Cajsa's chair muffles sound, that does not tell us much more than what is somehow obvious. Purely acoustic facts about the muffling properties of low and high frequencies do not help much either. What is the character of the material with respect to sound design in a given context? To answer this type of question, we may use a given conceptual context that guides the experiments. In designing for Cajsa, we might be looking for material that is 'dark', 'sombre', etc. The material we need for Radka's box should perhaps be 'solid', 'calm' and 'open'. Other types of material for sound hiders might be 'secret', 'lying', etc. A conceptual context can in this way provide a foundation for the phenomenological descriptions that are basic in design practice.

Our experiments also constantly reminded us about two ‘leitmotifs’ that somehow seem intrinsic to textile sound design:

1 To look and to hear – contrasts between characteristics of visual and audible expressions is a rich source of different, strong design expressions; light and dark cloth, absorbing and glittering textiles, etc. The true strength of these expressions always refers to a specific context that plays a basic role in defining the expressive characteristics.
2 It is a subtle matter – although we know as a matter of principle how to achieve very strong effects of sound absorption and sound reflection using textiles in various ways, effects in many situations are of a much more subtle nature. Slight but interesting effects; a fine structure of sound characteristics. To a large extent, it is a matter of near-field design.

1. Hallnäs and Zetterblom 2003
2. cf. Braddock and O’Mahoney 1998, 2002 **3.** cf. Shaeffer 1966
4. cf. Dunne 1999, Dunne and Raby 2001 **5.** cf. Hallnäs et al 2002a

Project: Lars Hallnäs and Margareta Zetterblom

Mute: Interactive Sound Absorbers

Anders Ernevi, Johan Redström and Margareta Zetterblom

Based on earlier work on the acoustic properties of textiles, such as the Sound Hiders described elsewhere in this book, a new project combining textile and interaction design was formed. In 'Mute', the idea was to work with interactive sound-absorbent textile surfaces in public, office, school or daycare settings.

Having worked extensively in other projects with textiles that change color, we set out to explore textiles that would change spatial form as a response to certain conditions. Such a change could be, for instance, transformation between a flat, two-dimensional surface and a complex three-dimensional structure.

The design concept that became our guiding idea was that of a 'silent bulletinboard' – a large surface made for communication, but in this case by absorbing rather than adding sounds to the soundscape. At a basic level, such a bulletinboard would simply reduce the general sound-level of the room it is located in. But as it does so by changing its own appearance, it would also visualize that the sound level is rising or falling. In relation to the daycare or school setting, this reduction of sound in combination with visualization of amplitude were central aspects since we wanted to explore how information about sound levels rising above what is healthy could be presented.

We also explored more poetic settings. One interpretation of these boards is that they might become 'silent instruments' for composing soundscapes, that the design of their behavior in relation to surrounding sound levels and characteristics might be used to affect and reshape current soundscapes by absorbing, rather than adding, sound. As a design concept for such boards, we worked with the notion of large public billboards placed near highways that would be used to compose subtle and interesting soundscapes out of the rather monotonous and boring noise generated by the passing traffic.

Early experiments

To create textile objects that would have different acoustic properties depending on their state, significant changes in the textile 'surface' are needed. This, in combination with the idea that the changing surfaces of these boards might also work as a kind of visual display, led us to investigate the possible expressions of different kinds of movements, such as the following:

~ Tentacles, the movements of sea anemones: control over each tentacle to bend the bottom surface up and down

- ~ Elastic surfaces with spots/structures stretching inwards and outwards
- ~ Shapes that push through a net structure underneath an elastic material: differently shaped nets; movements in and out like breathing
- ~ Surfaces stretched or slacked: integrated fibers stretching or slacking shaping the surface
- ~ Wrinkles: a surface expanding and contracting creating deep wrinkles
- ~ Transparency: layers of different textiles to create different expressions as they are stretched and slacked revealing layers behind, for example a flat surface becoming more transparent to reveal a complex structure behind, moiré effects
- ~ Planes: different planes change angle, parts of the surface being pushed or pulled
- ~ Holes and gaps: holes in the material exposed as it is stretched; layers of materials with bigger holes in the front, smaller in the back, to create a gradually 'deeper' and more complex surface

To develop methodologies for and to gain practical knowledge about what it means to design textiles on the basis of movements, a series of practical experiments was made to test new materials and their properties. The main problem is that much textile development at this level is slow and based on creating rather small samples, whereas working with sound in this project would require the use of rather large surfaces if the effects are to be perceivable. Thus, the models we created are more like design sketches as basis for further development than full-scale acoustic experiments. In order to film scenarios that could give a sense of what movements and fabric might look like, we created a series of small models to test fabrics of varying textures and structures.

A model of textile blocks sliding in and out between each other was created. It uses tiny pneumatic cylinders and a compressor built out of Fischer Technic,® a technical toy system. The blocks of textile were constructed out of cardboard boxes covered in fuzzy fabric. For the stretching fabrics, a special frame was constructed using servomotors, rolls and a microcontroller. The fabrics change their acoustic properties as they are stretched, reducing their ability to dampen sound as well as changing their visual appearance. The rolls are fitted along the edges of the frame and have a piece of fabric attached to them for easy replacement with various fabrics. They are turned by servomotors that are modified to enable them to rotate all the way around instead of to a precise angle. A microcontroller is connected to a special board for the servos to send commands at the push of a button.

Future work

So far, our work on the interactive properties of these textiles has been mainly conceptual, mostly because of the difficulty in producing the large textile samples needed to realise the designs developed. This project will progress, however, as Margareta Zetterblom continues to work on textiles with new sonic properties as part of her PhD in collaboration with Acqwool.

Project: Daniel Eriksson, Anders Ernevi, Johan Redström and Margareta Zetterblom

The Energy Curtain: Energy Awareness

Anders Ernevi, Margot Jacobs, Ramia Mazé, Carolin Müller, Johan Redström and Linda Worbin

A central ambition in IT+Textiles has been to challenge the distinction between technologies and design materials, the traditional association of the first with functional characteristics and the latter with form, aesthetics and expressions. The notion of 'technology as design material' frames an alternative mindset – re-thinking the aesthetics of technological qualities and roles of design expressions in everyday use. While to some extent it may suggest ways of working with technology analogous to familiar ways of working with other design materials, there are of course fundamental differences in technique and skill required for the implementation of complex computational things. Nevertheless, exploring such a notion, and putting it into practice at early stages of both aesthetic and technical development, enables us to take advantage of synergies between materials and thus a deeper integration in design with respect to use.

The Energy Curtain builds on this perspective on 'technology as design material'. Like other examples in this book, the project is concerned with a close integration of materials, working deeply to develop techniques for realizing a single, dynamic textile surface combining both active materials and static pattern – a synthesis of technological function and aesthetic expression.

In addition to computational materials, the Energy Curtain focuses specifically on energy as an essential material building the design. In all the IT+Textiles projects, and in regards to computational things in general, power presents design challenges. In the Energy Curtain, we bring energy into focus, not merely in terms of a technical solution but in terms of the expression of the energy in a design object. Thus, it is not so much the technical questions we are addressing, but the question of how we might design different expressions for energy in everyday life – with the potential that such expressions might change our relationship to and behaviors in relation to energy over time.

The Energy Curtain is a window shade woven from a combination of textile, solar-collection and light-emitting materials.

During the day, the shade can be drawn to the extent that people choose to collect sunlight and, during the evening, the collected energy is expressed as a glowing pattern on the inside of the shade. In this example, people make direct and tangible choices over how much energy to save and spend, and their choices are experienced as an aesthetic presence in their home.

Interaction qualities

Concepts in relation to the Energy Curtain were informed by initial design studies using, for instance the 'cultural probes' method,[1] in which we dispatched disposable cameras and workbooks with a set of people in order to gain insight into their intimate and emotional perceptions of energy and technology. From the collected materials, we were inspired by contrasting images of the jumble of electrical things around wall sockets in people's homes juxtaposed with poetic notions of ecological cycles in sketches by the same respondents. In the Energy Curtain, we decided to re-design an existing domestic object where electricity is not hidden out of the way but is an explicit and aesthetic part of the design, and where the cycle of energy use is put tangibly and visibly into the hands of users.

We decided to begin with a relatively simple system. The Energy Curtain functions by capturing energy converted from sun-light during the day, sensing when the light disappears in the evening, and then activating to emit light. Generated light is in direct proportion to collected light, and users make an explicit choice of how much light to collect based on how much they draw the blind during daylight hours. If the curtain is pulled all the way down during the day, then the maximum amount of energy is stored for use at night. Similarly, if the curtain is completely lowered in the evening, then it will emit the maximum amount of stored light.

This provides the user with a direct and tangible choice over enjoying the sunlight or saving the sunlight for enjoyment later on. In this way, the object acts to stimulate reflection on the trade-offs with regards to a local, sustainable system, and a basis for exploring how people might evolve a relationship with such a self-sustaining object and their energy behaviors over time.

Textile design and engineering

The Energy Curtain fabric will be developed through iterative prototyping – more advanced versions will be made in close coll-aboration with industrial partners special-izing in textile design and manufacturing and advanced lighting systems.

The first prototype is constructed in two layers – an inner layer woven with optical fibers and an outer layer integrating solar cells. The inner and outer fabric layers are sewn together at the edges and horizontal seams secure the entire span of the curtain. Three polyester filament yarns, in the middle and on the sides, are drawn through the curtain and connected to bars across the top and bottom of the curtain, which additionally provide some weight to facilitate lowering the curtain. This fan-folded blind construction allows the curtain to be lowered or raised, its fabric unfolding or folding back onto itself about every 5 cm in zig-zag fashion.

Inner fabric layer

The inner fabric layer, intended to face the inside of a room, is a plain weave fabric of Nm (Nummermetric) 50/2 cotton yarn with a density of 33 warp yarns per cm and 12 weft yarns per cm. Special 'floats' – or sections of threads raised above and spanning across some part of the weave – are constructed of 3 yarns lying side-by-side and spanning about 4 mm in length along the warp direction of the weave. Those floats are separated horizontally by about 8 cm and vertically by about 1 cm. Floats along a horizontal line may be shifted in relation to the floats running in parallel lines above or below, thus giving the possibility to make a patterned texture and to bring the optical fibers closer together.

The optical fibers are made of plexiglass. They are about 2 mm in diameter and are inserted into the weave after each line of floats so that the optical fibers are fastened into the textile horizontally. The ends of the optical fibers are connected to white LED lights fastened in a row up each side of the curtain. Up to 5 optical fibers may be connected to each LED, and the LEDs, the cables, and the electronic parts, are hidden between the inner and the outer fabric of the curtain. The lighting effect of the inner fabric is a result of the light from the LEDs conducted through the optical fibers integrated into the weave, causing their tips to glow brightly. The intensity or spread of the emitted light can be spread and controlled along the length of the optical fiber by scoring or sanding its surface.

To amplify the light emitted from the optical fibers, a reflective yarn or fluorescent yarn is woven underneath each fiber. The reflective yarn gives the effect of increased light reflection and thus a stronger glow. The fluorescent yarn gives luminescence, a sort of 'afterglow', to the overall appearance. The best effect may be gained by combining both types of yarns beneath the optical fiber. In order to obtain the brightest light effect, these yarns are woven with long floats in the weft direction.

Outer fabric layer

The outer fabric, facing toward the window glass and the outside environment, consists of a cotton weave with similar properties to the inner fabric – 33 warp yarns and 12 weft yarns per cm. The construction of the outer fabric relies on quite long floats of about 4 cm along the warp direction. Since the fabric just underneath those floats is very loose, the lines of floats must be shifted in relation to those above and below in the weave to ensure the strength of the overall fabric.

These floats are constructed of fifteen of the warp yarns lying side-by-side, thus building a sort of 'loop' together with the fabric underneath. Each loop is separated from the next by 10.5 cm, enabling strips of flat solar cell material to be inserted and secured by loops on either end. The float loops also conceal the connection between all the solar cells – they are each soldered to a wire that conveys the electricity collected from the sunlight away for storage. Distance between the solar cells can be varied in both the vertical and horizontal direction.

So far in the prototype construction, an extra wire is needed to connect the solar cells with one another, but soon we will replace its function with a special yarn of stainless steel that can be integrated directly into the weave. The warp yarns building the float loops will be substituted with the conductive yarn, and the solar cells will be soldered directly to this yarn. Thus, it will be the conductive yarn that connects the solar cells with one another and the electricity will be lead away by the textile material itself.

Technology description

The electronic construction of the curtain is quite simple, borrowing many principles from solar garden lights. The solar cells are flexible, thin film panels that collect a constant charge of 3V and 0.04A in normal sunlight conditions. They are arrayed in two rows across and 13 rows down the outer layer of the curtain, thus resulting in a voltage of 6V and a possible current of 0.52A, though this may be improved upon in bright sunlight. This power is used to charge four 1.2V batteries through a diode, which prevents the solar cells themselves from being powered by the batteries in bad weather or darkness.

The lighting effect of the inner layer of the curtain consists of a number of LEDs, a light sensor and a MOSFET transistor. When the sun goes down, it is sensed by a LDR (light dependent resistor) that causes a signal to the MOSFET to turn on the LEDs. The power for this is supplied by the batteries – thus the circuit is self-sustaining. The LEDs provide light to the optical fibers that distribute light throughout the curtain. In the next version of the prototype, the curtain will have more solar cells charging more batteries, thus enabling a greater number of LEDs to be lit for a longer time during the night.

Future development

At this stage, we are continuing to develop the integration of materials in the first prototype. Improvements include building stainless steel yarn into the weave and refining the design of reflective and fluorescent amplification and the sanding treatment of the fiber optics to obtain an aesthetically pleasing and engineered integration to the overall appearance to the fabric. Additionally, a greater number of solar panels arrayed on the outer layer will increase the scale and experience of the prototype suitable for use and testing at a real-world scale.

Our next step will be to test the curtain in various use and environmental contexts including work and home settings, use among different types and ages of users, and in different weather conditions. Since these factors are interwoven into any given use situation, testing will be designed to engage emotional and personal feedback over longer periods of time, in order to get a sense of the role of the object in relation to perceptions of energy and in relation to everyday routines and behaviors. From this feedback, we hope to extend the knowledge into new iterations of the Energy Curtain and into other products for both private and public use.

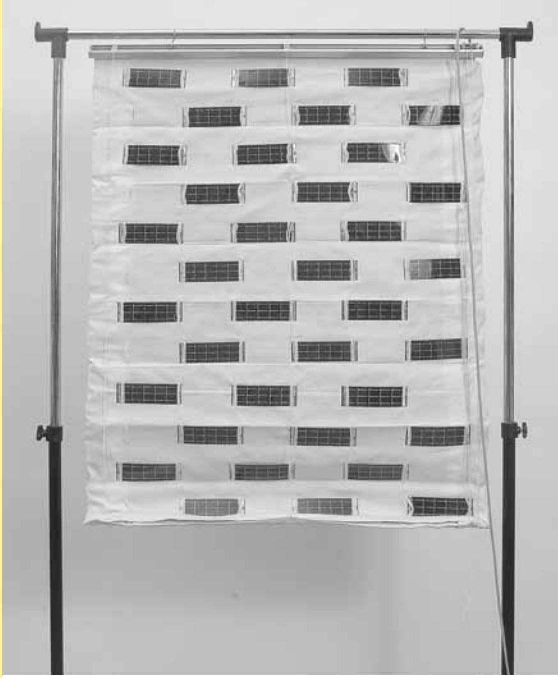
Ideas for future versions include the design of energy curtains with enhanced properties, such as the integration of other new materials, such as phase change fabrics and liquid-based properties.

Phase-change version of the Energy Curtain

A possible future version of the Energy Curtain may explore energy from an insulation as well as visualization perspective. One solution may be to integrate fiber-optics and solar panels into an insulating weave, such as the company Ludvig Svensson's 'energy weave' materials that are designed and manufactured into fabrics for applications ranging from greenhouses to high-design interiors.

Additional solutions for augmenting insulation properties can be the integration of phase-change material made of small wax pellets at an extremely small, micrometer scale. The wax takes in energy by melting when the temperature is high and gives up energy by becoming solid if the temperature falls. A future version of the Energy Curtain could be coated with polyurethane foam containing this material.

Integrated into an insulating weave there could be a layer or woven pattern in thermochromic material which would visualize – depending on the temperature and thus the condition of the phase-changing materials – various color patterns to reflect the energy state of the curtain. In this possible design scenario, it is possible to use thermochromic properties to represent when energy is being saved versus consumed by the curtain in form of visible temperature differences. Additionally, such materials can increase overall sustainability by insulating drafty windows.



Solar panels integrated in the outer fabric layer of the Energy Curtain

Water-tube version of the Energy Curtain

Another insulating idea for a future version of the Energy Curtain is to make a roller-blind out of tubes that are bound closely together using a welded seam or a loose-knit construction. When the roller blind is pulled down, these tubes would be filled with water from a reservoir in the construction above. Water has a high heat coefficient and therefore insulates better than textile. The tubes may be transparent, so that sunlight can penetrate the interior of the room even

Constructing the inner fabric layer of the Energy Curtain as it heats up the water up during the day. The heated water in the curtain would cool down slowly during the night. If the curtain is pulled up, the water could be pressed out of the tubes into a reservoir above the curtain. Adding some color or glitter to the water would add pattern the curtain.

Reflections – energy as design material

In the Energy Curtain, we explore a slightly different interweaving of material properties than in other IT+Textiles projects. In add-ition to textile and computational materials, power becomes integral to the function and the aesthetic expression of the artefact – thus energy is in focus as a design material. Designing for visualization and choice over energy use led us to an interaction model based on a self-sustaining energy cycle, where natural rhythms and human decisions together build the expression of the object.
In future development of this notion, we want to incorporate such ideas of local determinism and environmental interdependency into other products for the home or community.

Such product ideas might include systems of lighting that are locally and collectively determined within a neighborhood or household. Another example might be visualization within automobiles, or other vehicular systems, that could reuse energy stored in the day to power lights or interior information displays. Such a concept might also apply for personal use close to the body. For instance, it could be used in the Interactive Pillows or the Reach bag to power expressions of communication, such as the remote glow of the Pillows or charging one's mobile phone in the Reach bag. By extension, such textile-energy integration could eventually be incorporated into clothing so that the body itself could be used to store and transport energy.

The Energy Curtain is one of a series of concepts to be developed in the Interactive Institute's Static! project funded by the Swedish Energy Agency (Energimyndigheten). Building on experiences gained in IT+Textiles, this project aims at investigating how experimental interaction design and notions of 'energy as design material' may be used as a way of increasing energy awareness in everyday life.

1. Gaver et al 1999, Gaver and Dunne 1999

Project: Anders Ernevi, Margot Jacobs, Ramia Mazé, Carolin Müller, Johan Redström and Linda Worbin

Project and Material Illustrations

Pigmented and unpigmented thermochromic screen print on cotton – carbon fibers are used as a heat element to change the printed pattern

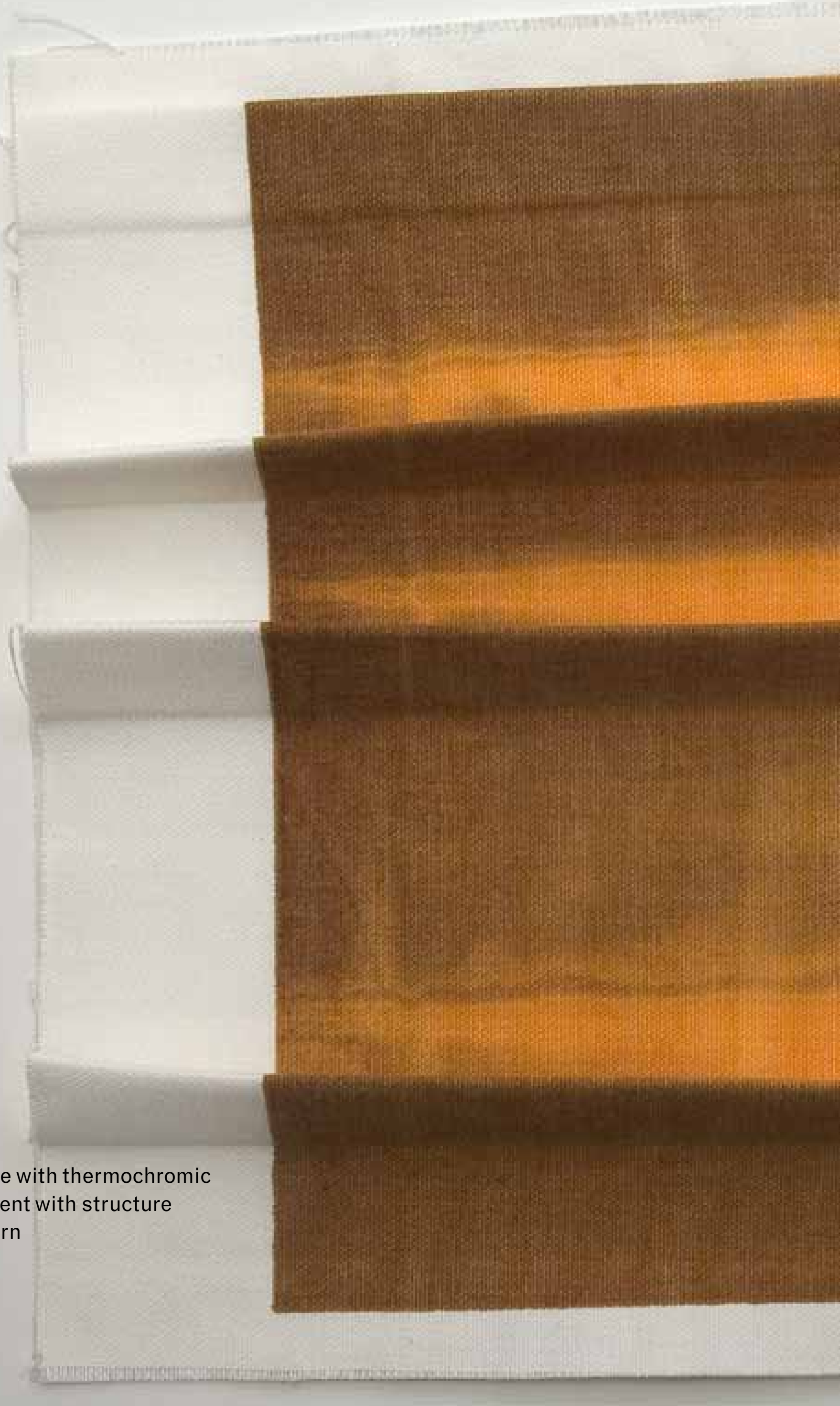
Dynamic textile pattern after activation

Dynamic textile pattern by Linda Worbin using thermochromic pigment and carbon fibers

Early textile samples for the Energy Curtain – integrated reflective and afterglow materials

Early textile experiments for
Tic-Tac-Textiles

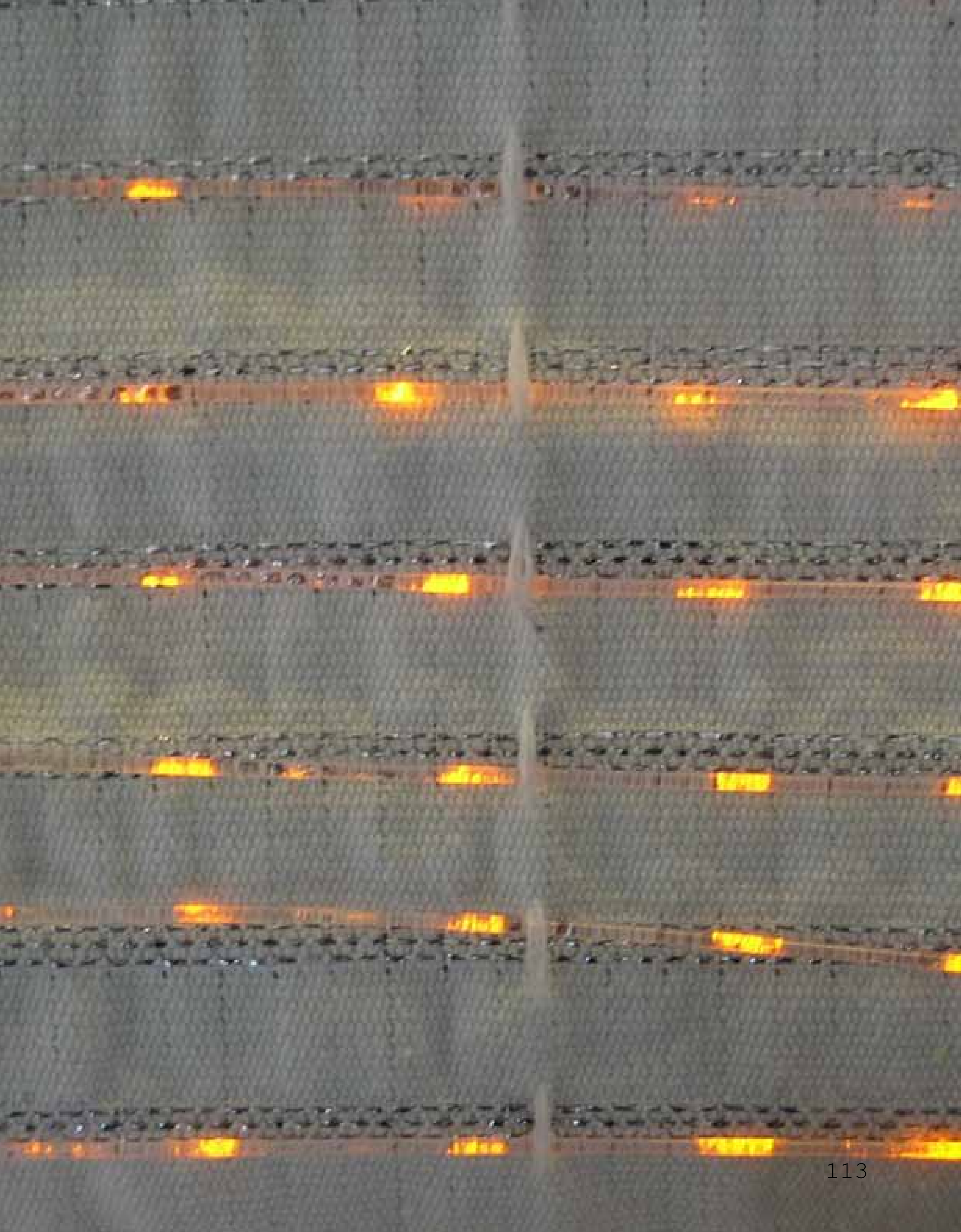

Playing together through the Tic-Tac-Textiles

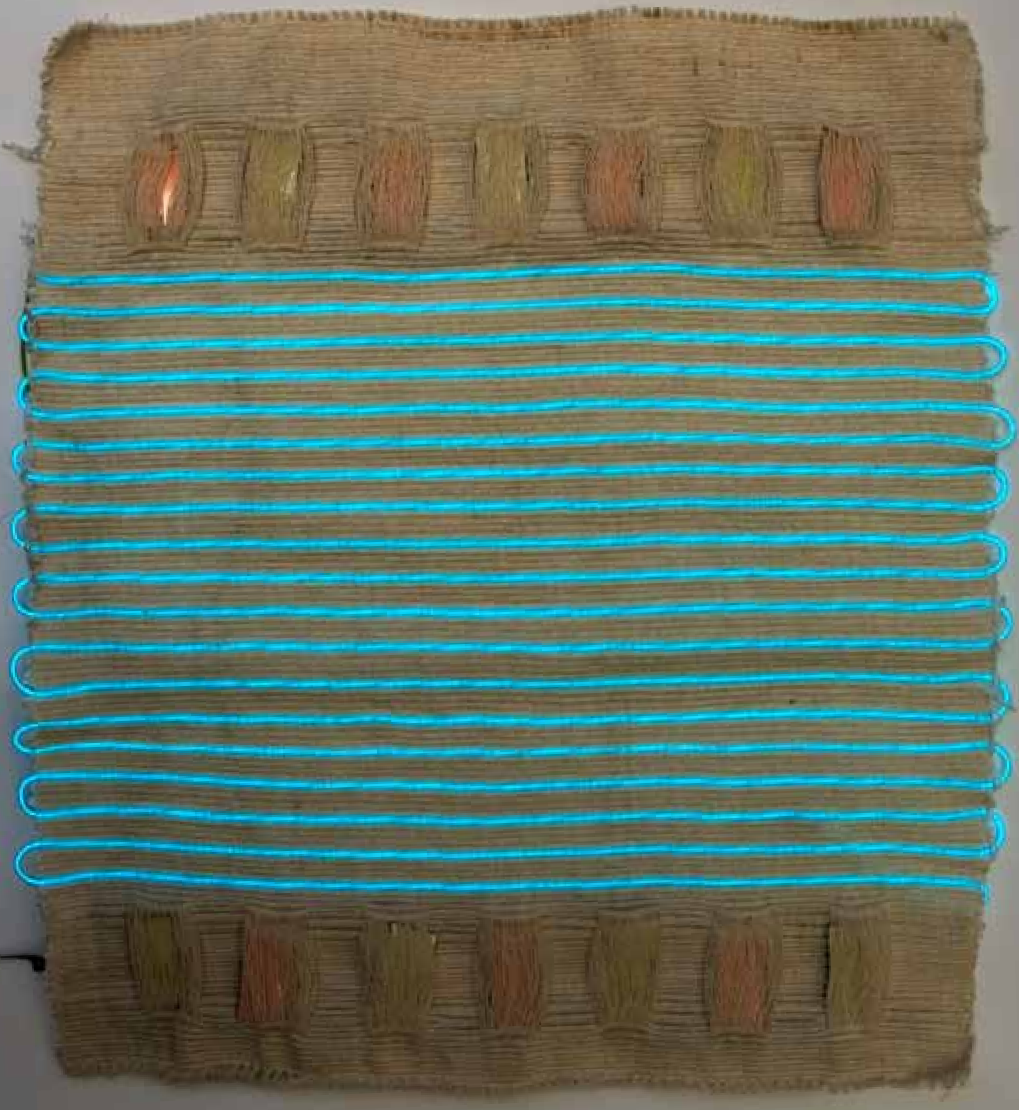


Constructed textile with thermochromic pigment – experiment with structure and dynamic pattern

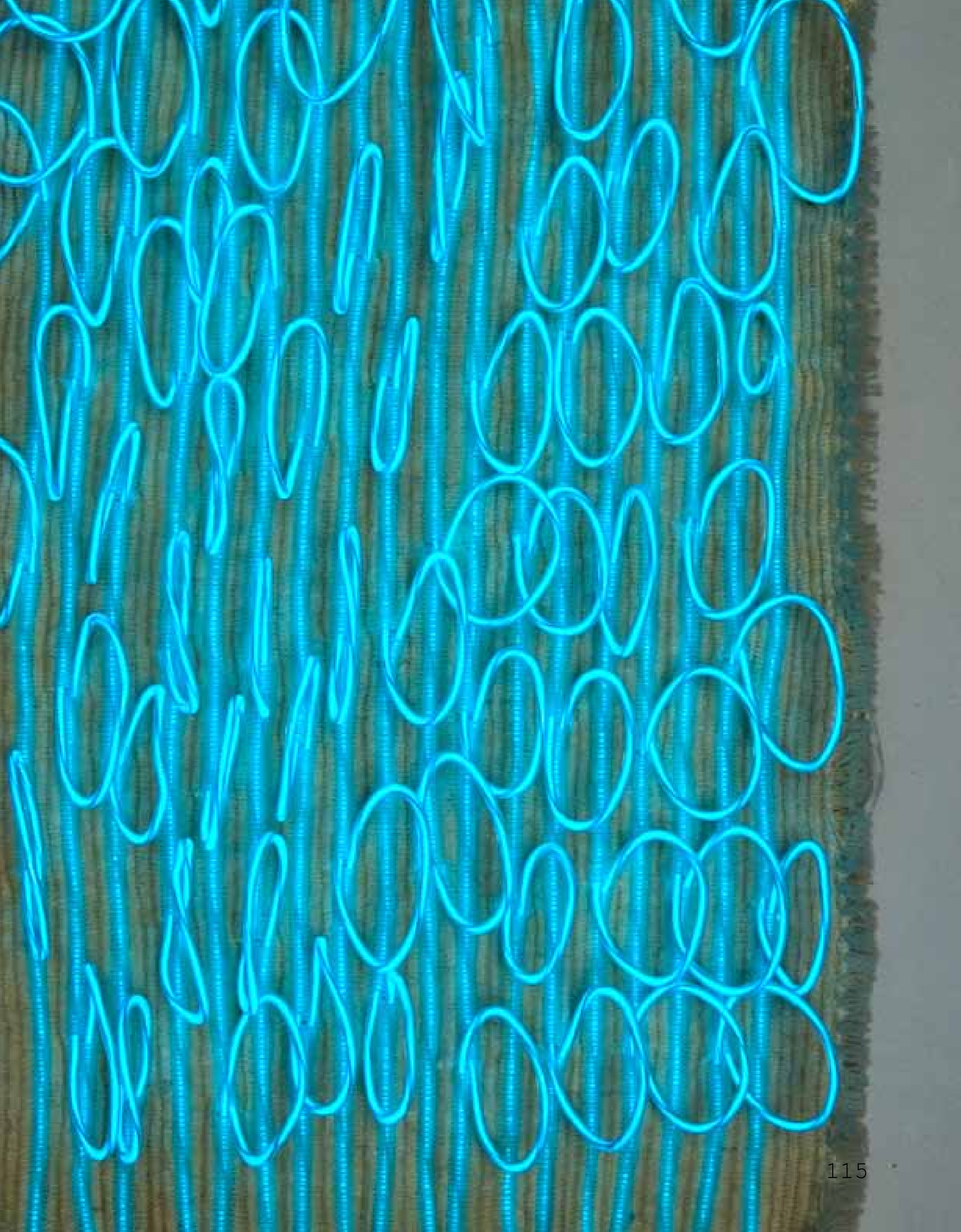
Growth-pattern print – UV-sensitive fabric reacting to sunlight (design by Linda Worbin)

A first prototype of the Energy Curtain – experimentation with patterns using sanded fiber optic material

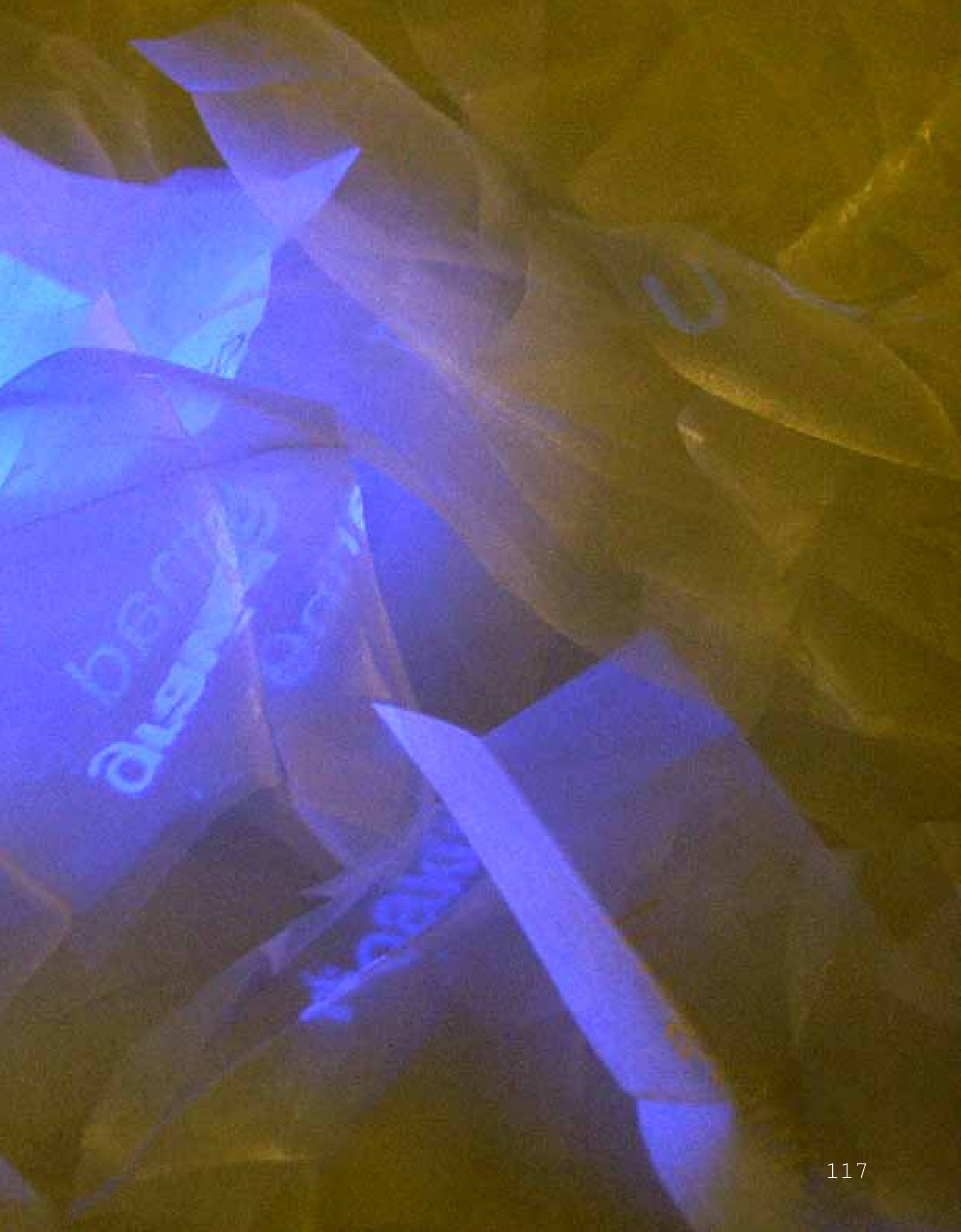


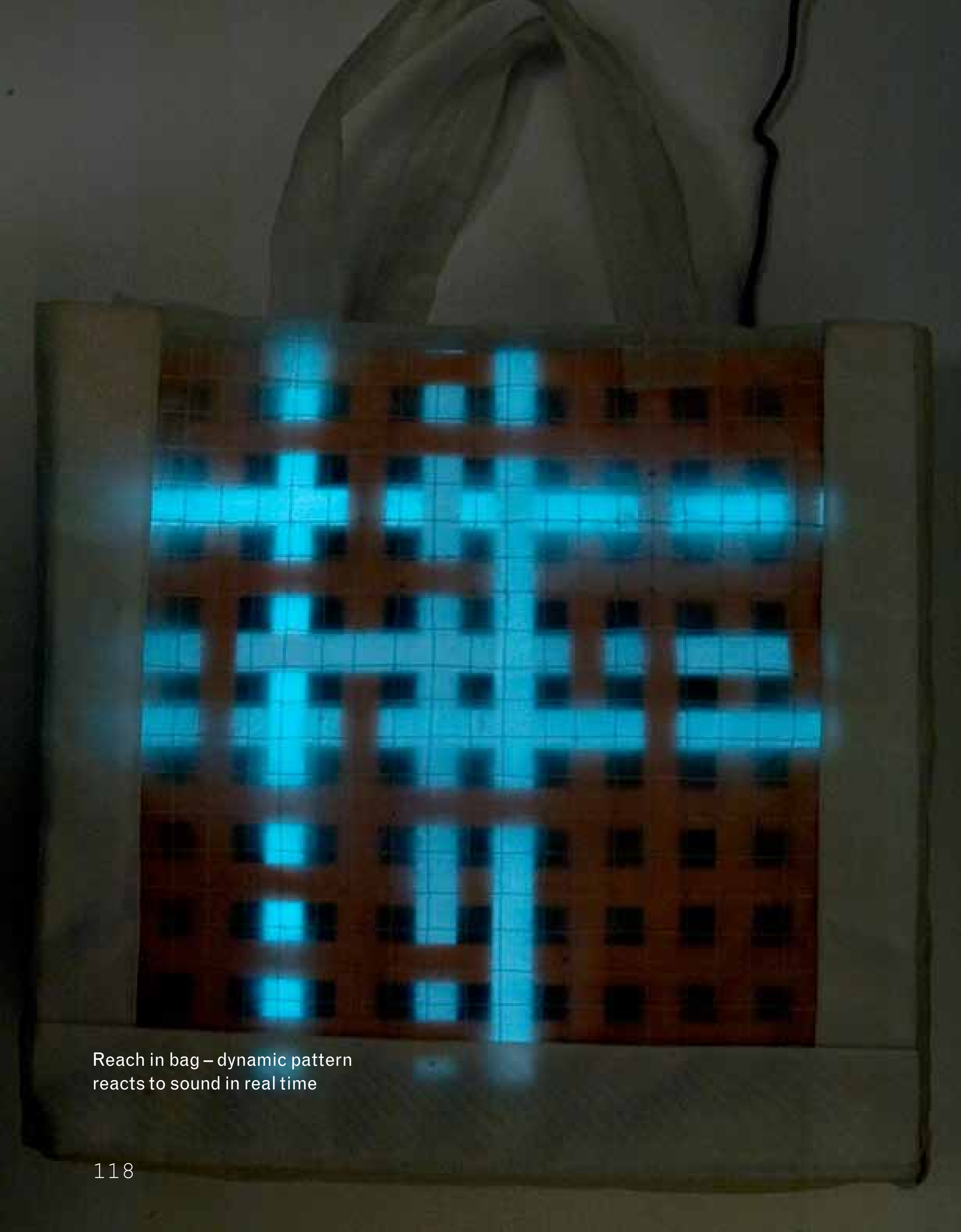


PartyTextiles experiments – cloths exploring relations between eight different patterns that react to input from 3 sensors (light, sound and temperature)



The Information Deliverer – text printed with optical whitener revealed with the UV-lamp



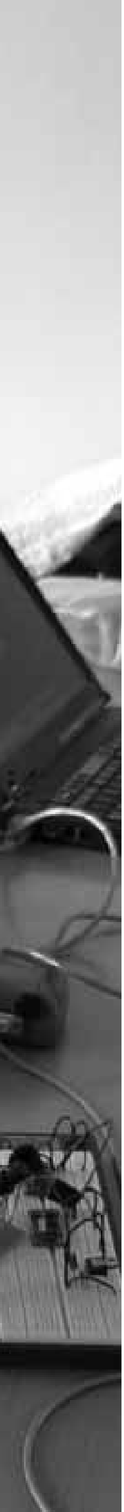


Reach in bag – dynamic pattern
reacts to sound in real time

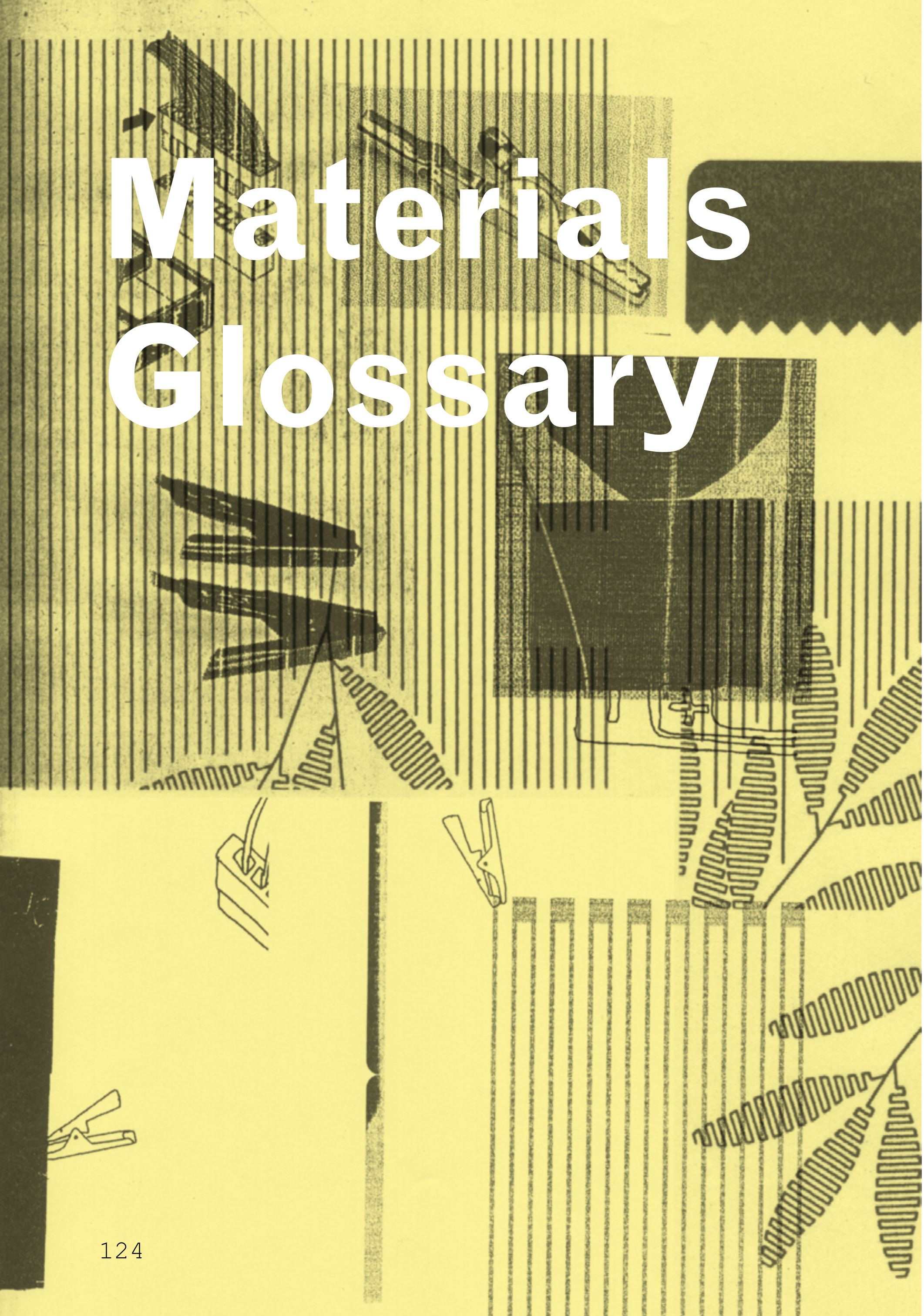
The Interactive Pillows

Weaving department at the Swedish School of Textiles – Linda Worbin's Lamp-Curtain coming from the loom

‘Fabrication’ project by Hanna Landin and Linda Worbin



Materials Glossary



In integrating electronic and computational behaviours into textile materials, there are a few general things to consider. Our goal in IT+Textiles is to enhance traditional textile materials, creating more expressive fabrics that may not at first glance differ much from normal ones. Therefore, our ultimate aim is to achieve a seamless integration and blend of electronic materials and textile materials. In order to accomplish this, certain characteristics – such as the flexibility or 'bend-ability' of selected electronic material, the dimensions of the components, the size and type of power source – are critical to maintaining the original textile qualities when interacting or just looking at the fabric. To give an example: in order to make a fabric change color as a response to interaction, we have dyed the Tic-Tac-Textiles fabric with thermochromic ink, integrated it with Calesco foil (to make 'o's and 'x's), and finally used computation as the material to make the Calesco foil heat up. In essence, our approach to designing computational things is not about unique materials – but their combination as a means for opening new possibilities for interaction.

In this section, we discuss our use of and experiences with some of the materials used in IT+Textiles – while by no means a complete survey of the materials, suppliers, or possibilities available, this may be used as a reference to the projects described in this book.

Sensors – input

Sensors are devices that generate an input, typically to a microcontroller, and are used to detect changes.

Microphones

~ Used in project: Reach
~ Technical facts: Require a low DC voltage to work
~ Particular interest to interaction design: Detecting sound levels in the environment, information can be used for visualizations in different ways.
~ How we used it: Very tiny, simple microphones have been used to detect sound levels in several of the projects.

One-Wire temperature sensor DS1822

~ Used in project: Tic-Tac-Textiles, Party Textiles
~ Retailer/Supplier: Dallas Semiconductor (USA), http:// www.maxim-ic.com
~ Traditional use: Temperature sensing in battery chargers and other industrial applications
~ Technical facts: Temperature sensors housed in a tiny electronic package. They operate using the Dallas One-Wire protocol, which makes them easy to connect and apply.
~ How we used it: They are used in Tic-Tac-Textiles to detect cups of hot liquid.

LDR - Light dependent resistor

~ Used in project: Party Textiles
~ Traditional use: Light sensors, Photo cells, solar-powered garden lights.
~ Technical facts: A simple photosensitive resistor is used in a voltage divider, causing a voltage that depends on the amount of light incident on the resistor.

CdS (Cadmium Sulfide)

~ Particular interest to interaction design: LDRs can operate as cheap and easy-to-use light sensors with relatively few components.
~ How we used it: It is used as a light sensor in several projects.

Actuators – output

Actuators are devices that change appearance or other physical properties in response to a signal received, usually from microcontrollers.

Calesco foil

~ Used in project: Tic-Tac-Textiles
~ Retailer/Supplier: Calesco Foil AB (Sweden)
~ Technical facts: These are custom-made printed metal patterns, the thickness of which is designed to heat up relative to a certain electrical voltage.
~ Particular interest to interaction design: In combination with fabric, for instance dyed with thermochromic ink, there are several ways to use the Calesco foil. Since it was custom made for us (printed with 'x's and 'o's), it could certainly be printed in different metal patterns as well, causing another type of output suitable for other projects.
~ How we used it: We used it to create a waiting game in Tic-Tac-Textiles, using heat as input and output in combination with thermochromic textile material.

Carbon-fiber yarn

~ Used in project: Reach scarves, Tablecloth and apron
~ Retailer/Supplier: IFP SICOMP (Institute for Fibre and Polymer, Sweden)
~ Traditional use: Used in car seats to heat them up
~ Technical facts: Excerpt from website http://www.ifpsicomp.se: "Current consumption rises with the number of parallel carbon threads. In the same way voltage rises with the length of the threads. It is therefore important to check if it's feasible to produce enough heat without an impossible power supply. The easiest way to do this is to test one short wire and see how much current and voltage is needed in order to heat the thermochromic ink sufficiently. Then if, for example, seven threads of five times the length is used the current will be seven times higher at five times the measured voltage. This could quickly turn impossible without huge power supplies and even quicker using batteries."
~ One solution is to use thinner carbon fibers since this would reduce not only the voltage but also the electrical current needed to heat the threads. This could be used in reverse to determine how thin the threads need to be using a given power supply and a specific number of threads at a certain length. This is the approach ideally used.
~ Another problem to be solved is getting the current to the actual carbon fibers. Since the heat is supposed to be developed in the carbon fibers, it is important that the wires connecting to them are sufficiently thick and that a good connection is made to the carbon. Thick, multi-thread copper wire has proven useful and, up to this point, the best connection method has been screw-clamping the copper wire to the carbon threads. If neglected, this may result in unwanted patterns on the way to the threads and, in the worst case, sparks flying at the point of

a bad connection to the carbon fibers.
~ Particular interest to interaction design: Since the carbon fiber acts as a heat element as well as being a part of the woven pattern, it can change the textile through dynamic pattern. It does, however, require quite a lot of power to become hot enough, making it unsuitable for some applications.
~ How we used it: By making a textile weave out of carbon fiber and cotton, we were able to print on the surface with a thermochromic screen-print so that the pattern would change when the heat elements were activated.
~ Note: Itches when in contact with skin.

Electroluminescent film
~ Used in project: Reach, Systems
~ Retailer/Supplier: Stefecco AB (Sweden), Kvartselektronik AB (Sweden)
~ Manufacturer: Seiko Precision, Inc. (Japan)
~ Traditional use: Mainly backlighting in LCD displays
~ Technical facts: Any electroluminescent (EL) material is essentially a capacitor, with two electrodes and a dielectricum. Like all capacitors, it needs an AC current. EL film typically requires a 100V 400Hz driver circuit, called an inverter, to work. The color and maximum luminosity of each film sheet is fixed and depends on the chemical constituents of the material. However, the brightness of the film can be varied and controlled either by modulating the voltage or the frequency.
~ Particular interest to interaction design: EL film comes in form of a flexible thin film resembling plastic. It is a two-dimensional surface that can be cut in almost any shape, bent easily, and holes may even be cut out of it.
~ How we used it: The film was used in the Reach bag in combination with different sensors to make dynamic lighting patterns in response to information from the environment.
~ Other points of interests: As mentioned before, the film requires a 100V 400Hz driver circuit to work. This renders it a bit tedious since the drivers are expensive and the voltage can be, if not dangerous, at least painful and therefore needs to be insulated. The film has the additional drawback that the contacts are not conducive to soldering. They need to be glued using conductive glue that is quite expensive. The inverter circuits we used are manufactured by Epicenter Co. (China), http://www.epicenter.com.tw.

Electroluminescent wire
~ Used in project: Interactive Pillows
~ Manufacturer: ELAM (Israel), http://www.elam.co.il
~ Traditional use: Marketed under the name Lytec; applications for interior in truck, aeroplanes, safety applications, computer customisation, hobby and more
~ Technical facts: The wire requires electrical voltage of approximately 100V 400Hz for the driver circuit to work. It comes in various thicknesses, from 1.2 mm to 5 mm in diameter.
~ Particular interest to interaction design: The EL wire is very flexible and quite robust. The high-voltage parts are shielded by a plastic enclosure, so the risk of electric shock is very small.
~ How we used it: By weaving or otherwise integrating electroluminescent wire into a fabric, light can be integrated without a light source.

Heating wire

- ~ Used in project: Tic-Tac-Textiles
- ~ Retailer/Supplier: Kanthal AB (Sweden), http://www.kanthal.com
- ~ Traditional use: Kitchen toasters
- ~ Technical facts: We used 0.10 mm Kanthal wire. The wire is made of a ferritic alloy (FeCrAl) with high resistance.
- ~ Particular interest to interaction design: The thread is flexible enough to sew with but the best way to do so is by hand – never crossing the wires across one another. When an electric current passes through the wire, it heats up, and if sewn into a fabric dyed with thermochromic ink, the color (and thus textile pattern) changes.
- ~ How we used it: We used it in an early version of Tic-Tac-Textiles to make the fabric change color.
- ~ Other points of interests: 0.10 mm Kanthal wire can be used with a sewing machine (0.15 mm would probably be better for that) although the risk of short circuiting (if combined with current) is high since the threads may easily be crossed.

One-Wire switches

- ~ Used in project: Tic-Tac-Textiles
- ~ Retailer/Supplier: Dallas Semiconductor (USA), http:// www.maxim-ic.com
- ~ Technical facts: This circuit has a number of outputs that can be set either high or low. It uses the One-Wire protocol developed by Dallas Semiconductor and is controlled by one data wire, hence the name One-Wire. The circuits can easily be controlled by either a microcontroller or a computer. A Java API is available from the developers.
- ~ How we used it: The same easy-to-use protocol as used in the temperature sensors is employed here. This enables software in a computer to turn on and off several different things using just one wire. They are used in the Tic-Tac-Textiles to activate the Darlington drivers, which in turn activate the heat elements.

Optical whitener

- ~ Used in project: Information Deliverer
- ~ Retailer/Supplier: Zenit AB Konsthantverksmaterial (Sweden)
- ~ Traditional use: Applied to white fabric to make it look even whiter
- ~ Manufacture: Screen-print with optical whitener on fabric not treated with whitener
- ~ Interaction design aspects: By printing a pattern on fabric with optical whitener, the pattern will be revealed if viewed under ultraviolet light.
- ~ How we used it: The Information Deliverer installation uses fabric pieces with text fragments printed with optical whitener. In plain light, it is not visible, but with the UV lamp 'hidden' information is revealed.

Photochromic ink

- ~ Used in project: Information Deliverer
- ~ Manufacture: Hand silkscreen print with thermochromic ink on cotton
- ~ Interaction design aspects: The ink gives dynamic properties to pattern/information

Thermochromic ink

- ~ Used in project: Tic-Tac-Textiles
- ~ Retailer/Supplier: Zenit AB Konsthantverksmaterial (Sweden)
- ~ Traditional use: Gimmick product applications, the color changing properties have been used in plastic for golf balls, tea kettles, t-shirts and toys.
- ~ Interaction design aspects: This material changes color when heated up. It is enough to touch it with a hand or other hot object for the existing color change.
- ~ Textile design aspects: May be ironed

delicately and washed in 40 degrees Celsius – color changing properties last through about 20 washings.

~ How we used it: This material opens up for a new way of affecting or creating a surface pattern.
~ Other points of interests: Thermochromic screen-print ink comes in five colors: orange, magenta, blue, green and grey.

Photochromic yarn

~ Used in project: Growth-pattern textile print
~ Retailer/Supplier: SolarActive™ International, Inc. (USA)
~ Traditional use: Gimmick product applications, the color changing properties have been used in plastic for golf balls, tea kettles, t-shirts and toys.
~ Manufacture: A jacquard weave is made by Ludvig Svensson AB (Sweden) out of polyester and photochromic yarn. The photochromic yarn is a polypropylene with color changing properties.
~ Interaction design aspects: This material changes color when exposed to ultraviolet light. The yarn is made in a range of colors that turns from white to a color and from one color to another. By using a fabric made of photochromic material, it is possible to design patterns or information, which is revealed under UV light.
~ How we used it: We had a textile manufactured that may be used as curtain fabric such that different patterns fade in or out depending on the light conditions during the night or day time. In the example of the Growth-pattern print, the textile design involves two overlapping patterns that may be visible depending on surrounding condition, opening up for integrating more than one pattern into the same fabric.

Microcontrollers, Processing and Communication devices

Microcontrollers are the core of much work in electronics. They operate to process data from sensors and display information with actuators. Processing devices are used to alter a signal in various ways, for example, in relation to the route, frequency components or the voltage levels. Communication devices are used to send data between different controlling units such as microcontrollers and computers.

BasicX BX-24 microcontroller

~ Used in project: Tic-Tac-Textiles, Party Textiles, Interactive Pillows, Mute, Reach bag
~ Retailer/Supplier: NetMedia, Inc. (USA)
~ Technical facts: This is a small microcontroller with 16 assignable input/outputs. It is easy to program using Basic. Another advantage is that it has its own voltage regulator, enabling it to operate on a wide range of voltages. The programming is carried out using the COM port of the computer.
~ Particular interest to interaction design: It is at the heart of most of the IT+Textiles projects because of its advantages for rapid prototyping. It proved easy to use and thus excellent for students and others who are not used to hardware.
~ Other points of interests: Of course there are other microcontrollers that could be used in projects like ours, but we chose it for fast prototyping purposes.

Darlington driver circuits, ULN2003A
~ Used in project: Tic-Tac-Textiles
~ Technical facts: When a computer output cannot deliver enough current, these components are used to source current.
~ Particular interest to interaction design: This is an excellent device for connecting to various actuators.
~ How we used it: They are used in Tic-Tac-Textiles to turn on the heating elements that create the textile patterns.

One-Wire dongle, serial RS232 connector
~ Used in project: Tic-Tac-Textiles
~ Technical facts: This is the computer interface for the One-Wire components. It connects to the serial port and converts the data signal to a 5V level, used in TTL electronics.
~ How we used it: The dongle is used in Tic-Tac-Textiles as an interface between the One-Wire components and the software in the computers. It's used in conjunction with the thermometers and the switches.

Operational amplifiers
~ Used in project: Reach
~ Traditional use: Anything, from amplifiers to oscillators
~ Technical facts: Operational amplifiers are most often used to process analogue signals, while microcontrollers are used to process digital signals. This can also be accomplished with a microcontroller but it requires a lot of operations.
~ Particular interest to interaction design: Operational amplifiers are used to process analogue signals, like filtering and amplifying audio signals. They are very useful building blocks used in almost all electronics equipment.
~ How we used it: In IT+Textiles, they are used mainly in the microphone circuits used for sound level detection. Here, they amplify the tiny signals from the microphone into useable information.

RS232 interface
~ Used in project: Interactive Pillows
~ Technical facts: This is basically a voltage translator, converting COM port levels to 5V logic (TTL) and vice versa.
~ How we used it: This is a circuit that we use to interface the Interactive Pillows with the COM port of the computer via the addLink module.

Solid-state relays
~ Used in project: Reach bag
~ Traditional use: Remote switching signals such as high voltage or audio
~ Technical facts: These relays take a tiny DC current to turn on almost any type of signal, regardless of polarity or voltage.
~ How we used it: Since the electroluminescent drivers are oversized and so expensive, whenever many different wires need to be controlled, solid-state relays are a good solution. They use a tiny control signal to let another independent signal pass through them, thus enabling the 100V signal to the EL wire/film to be turned on and off. The Reach bag utilizes these since it has a complex pattern made of EL film.

AddLink radio module
~ Used in project: Interactive Pillows
~ Retailer/Supplier: RF Solutions (UK), http://www.rfsolutions.co.uk
~ Manufacturer: AdCon (Austria, Hungary)
~ Technical facts: The addLink module is a digital radio communications device, broadcasting on the license free band 433MHz. The protocol supports both peer-

to-peer and broadcast communication. It can easily be controlled by a microcontroller and the registers are set using a RS-232 AT command set.

~ Particular interest to interaction design: This radio is basically a wireless serial cable, which is useful for wireless ubiquitous computing applications.

~ How we used it: In the Interactive Pillows, it supports seamless wireless communication.

~ Other points of interests: It is very easy to use, requiring nothing but power supply and ground.

Materials Glossary compiled by:
Anders Ernevi, Peter Ljungstrand,
Linda Worbin and Maria Åresund

End Notes

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Credits

Additional Collaborators

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