DESIGNING WITH SMART TEXTILES: A NEW RESEARCH PROGRAM

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ABSTRACT

No longer is it sufficient to add ‘smart’ to textiles to secure interesting research results. We have surpassed the initial stages of explorations and testing and now need to raise the bar. We have thus specified a research program in which we investigate what it means to design with smart textiles. *What* can we design with smart textiles? And *how* do we design with smart textiles? We now explore how these complex, often abstract, materials can enter traditional design practices and what role smart textile can play in the design of our environment. In this paper, we discuss the challenges we see at present, we outline our new research program and we qualify it through three examples of our ongoing projects: The smart textile sample collection, Dynamic textile patterns, and Bonad [tapestry]. The paper is as much an invitation to join forces, as it is a description of a maturing process within design research. We are over the first love, now what?

INTRODUCTION

For over a decade, we have in various constellations with other researchers experimented with smart textiles (Redström *et al.* 2005; Worbin 2010a). We have become familiar with the basic aspects of this composite material—its vast potential and its practical limitations. We have seen and demonstrated a wide range of possible expressions (Post *et al.* 2000; Berzowska and Coelho 2005; Redström *et al.* 2005; Braddock-Clarke and O'Mahony 2006; Seymore 2008; Worbin 2010a). However, research into smart textiles has gradually surpassed the stage where anything 'smart' in a textile context is new and thus has a research value. Thus, we need to reformulate our research program (cf. Hallnäs and Redström 2006).

The new program is concerned with what it means to design with smart textiles. How the smart textiles can enter existing design practices and production processes and what these new material possibilities will do to them in turn? We will investigate what role smart textiles can play in the design of our physical environment and contexts of use. Before we go on to elaborate on the research program by means of three ongoing projects, we give a brief status of the smart textile research that has led us in this direction.

SMART TEXTILES

We can generally define smart textiles as a material that interacts with its environment in more or less complex ways, including textiles that react and adapt to their environment. The research we summarize here is that which has directly led to the formulation of our new research program.

We have become familiar with what smart textiles can and cannot do with present day technologies. We master the skills of making them, and we have demonstrated a range of expressions (Redström *et al.* 2005; Landin *et al.* 2008; Bondesson *et al.* 2009; Worbin 2010a). Obviously, new developments happen continuously: new dyes, new fibers, new electronics, etc., but the basic principles are likely to stay the same for now.

We have learned how the design of dynamic patterns bare strong relations temporal arts, like music, movie etc. (Worbin 2010a). And, we have learned to think of the textile as a layered set of expressions consisting of the construction technique (i.e., weaving or knitting) combined with the materials (i.e. the yarns), the after-treatment (i.e., printed patterns) and the textile’s dependence on its surrounding conditions (whether, and how it reacts to or even adapts to events in the environment). Seeing these layers it becomes apparent that a designer of smart textiles must handle new variables regarding the temporal and environmental context (Worbin 2010a). We are still, however, to find out how to handle these new variables in practice.

From another perspective, we have learned that smart textiles are difficult to grasp both physically and mentally—physically because they primarily exist as abstract notions of possibilities and mentally because they hold expressions that come to be in context over time (Bergström *et al.* 2010). We have suggested overcoming these difficulties by creating low-fi large-scale prototypes as a method to play with the expression before getting entangled in technicalities. However, we need a larger repertoire of methods to suit the range purposes for designing with smart textiles. Furthermore, only few commercial products embed smart textiles and the dissemination seems to happen primarily as do-it-yourself handicraft (cf., Buechley 2006; Buechley and Hill 2010). Hence, there is a need to investigate present textile design practices as well as to develop new practices for smart textiles.

We have also changed our understanding of computers in this process (Hallnäs and Redström 2008). Where the role of the textile in the beginning was to serve as computer displays it is now back as textile material in its own right. Computers and other electronics, instead, serve as a raw material that can be combined with textiles to form composite materials with new properties (Redström 2005; Vallgårda and Redström 2007).

We have built prototypes of products out of smart textiles, and we have studied their use in context (cf. Ernevi *et al.* 2005; Redström *et al.* 2005; Hallnäs and Redström 2006). Still, however, we have little understanding of the full design potential of smart textiles. Little understanding of what we can do with these expression-changing and context dependent textiles.

These are the challenges that make up the foundation of our new research program.

RESEARCH PROGRAM: DESIGNING WITH SMART TEXTILES

The two main questions coming out of the work so far are:

How do we design with smart textiles?

What can we do with smart textiles?

These questions form the frame of our new research program. *What* we can do with smart textiles are obviously linked to *how* we do it and vice versa. However, the smart textiles, defined by their material properties and behaviors, will in and by themselves usually have a stronger influence on both *what* we can do and *how* we do it. And it is exactly this influence of smart textiles we will explore within this program.

To carry out this program we primarily draw from the research traditions of textile design and interaction design.

TEXTILE DESIGN

There are two important elements from the textile design tradition that will play a role in our further studies of smart textiles. One is related to the division of labor and the other to the design variable at play in the practical process of design.

Traditionally, the development and design of textile products and applications are layered enterprises with multiple roles and responsibilities. The road from the fiber to the finished application often starts with textile engineers developing fibers, yarns, and construction, textile designer(s) designing the structure and pattern of the fabric and finally other designers such as industrial or fashion designers using that fabric in their endeavor to create products or clothes. Smart textiles, however, have proved difficult to fit into this division of labor, primarily because it is impossible to develop by the meter for designers freely to place and integrate in their designs. Indeed, it seems necessary to break up the divisions between the disciplines and find new ways to integrate the design of the textile into the design of the garments or the interior. This brings up questions of how to actually deal with smart textiles in design practice. How can smart textiles enter traditional design contexts when they are seldom accessible for purchase? How can the potential of smart textile be communicated in the context of a design practice?

The design variables traditionally at play in a textile design process such as yarn quality, structure, color, shape, and rhythm are all challenged by different types of smart textile possibilities as they are expanded with state changes and thus significantly extended in their complexity. Indeed, we need to investigate what this complexity entails in a design practice and how can we find ways to deal with it.

INTERACTION DESIGN

Smart textiles offer the possibility of having the material to respond to actions—a trait we otherwise primarily know from finished products. Interaction design is a design practice and research field that deals with the context specific actions of use as well as the temporality embedded in any computational design (cf. Hallnäs and Redström 2006; Mazé 2007). As such, interaction design should be able to provide some understanding of what it means to design responsive environments. Furthermore, a recent trend within interaction design is to perceive the computer as a material for design which means that are starting to emerge practices around giving forms to computers in comparable ways to giving form to smart textiles (Vallgårda and Redström 2007; Robles and Wiberg 2010; Vallgårda and Sokoler 2010). Indeed, it seems like the two disciplines could have something to offer each other when it comes to developing new design practice around complex materials. With a background in interaction design we will investigate what it means to design with materials that changes in context over time. How the changing expressions can be used consciously as a design

parameter. And particularly, what design spaces smart textiles can open as well as the constrains they invoke.

Generally, within this research program every investigation takes its outset in the material—whether it is the material's role in the design process, or the materials influence on the design of products and environments. Thus, the investigations comprise material experiments and prototyping, prototypes of textile things, studies of design practices, and interventions into contexts of use. Essentially, with this program we shift the focus from the material in and by itself and begin to study it in a larger context of design.

PROJECTS WITHIN THE PROGRAM

In this section, we will outline three of our ongoing projects and show how each explores different aspects of our new research program.

SMART TEXTILE SAMPLE COLLECTION

Smart textile sample collection is project in which we develop a collection of smart textile raw materials with various qualities and properties. The collection will serve both as a dissemination platform for the potential of smart textiles but also as an opportunity for us to have a repertoire to draw on in future projects (Worbin 2010b). In a sense this project can be seen as a bridge between the previous program and the new. It will give a picture of what we can do with smart textiles at present, but it will also serve as a new starting point for future projects—a step above square one.

The collection will comprise "raw" samples of smart textiles that can be used directly as sketch or prototype material. This means, for instance, that the samples printed with thermo chromatic ink are designed as generic patterns to suit a wide variety of expressions. Currently, we have made approximately 100 meters of fabric design from five different principles. Four of which are woven cotton printed with different thermo chromatic inks, and one is another quality of woven cotton with strategically embedded conductive threads (see Figure 1 and 4). Additionally, we have a collection of conductive knitted textiles though only as test samples that we can reproduce when needed (see Figure 3).

The project also includes a series of workshops for various kinds and levels of designers. They are here given the opportunity to sketch and work directly in the material as means to gain some experience. The workshops also serve as a feedback platform for us to learn how the samples work as conveyers of the larger potential of smart textiles.

This project will run along side the other projects and gradually expand in size and complexity.

Figure 1 Sample of woven cotton with conductive threads on one side. The threads can serve as heating elements and thus change the color of a thermo chromatic pattern printed on the other side.

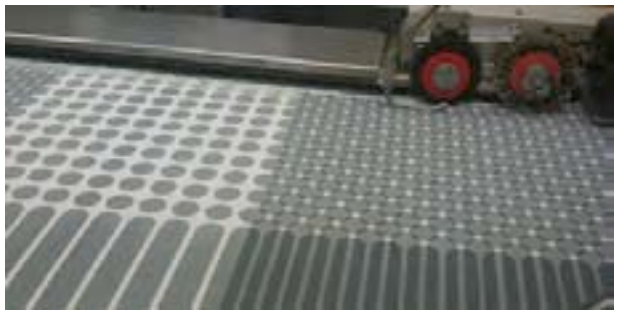

Figure 2 Sample of cotton printed with gray thermo chrome ink that turns white when heated above 27C. Half of this sample is moreover coated with acryl to give a stronger surface for prototyping.

Figure 3 Three samples of textiles knitted with different strength of conductivity. Left: knitted cupper with viscose. Center: knitted blue mohair with brass. Right: knitted turquoise cotton with stainless steel.

DESIGNING DYNAMIC TEXTILE PATTERNS

Dynamic textile patterns, is an ongoing project where we investigate the complexity of designing with smart textiles.

In one experiment we have worked with a Swedish furniture company who wanted some concept furniture to demonstrate possibilities for smart textiles in furniture design. We designed the fabric for two footstools by using the woven conductive fabric (see Figure 1) from the smart textile sample collection and printed it with thermo chromatic ink. The general concept was that sitting on one of the stools would result in a pattern change either in the same stool or in the other.

In this experiment, we have through our own design practice been able to analyze the complexity of designing with state changing materials. In some cases, we can suggest strategies, or tools to deal with the

complexity in the design process. For example, in the case of designing the temporal pattern of the dynamic pattern we used with success a combination of a "note sheet" and a graphical interface to gain an overview of the sequence of the changes (see Figure 4). In other cases, however, we are still at a loss for how to cope with the complexity in a useful way. For example, putting together the color palette for one of the patterns, which in it self was a collection of patterns, proved to be incomprehensible (see Figure 5). At first we thought it was a matter of merely composing the two possible color states so they all would fit a coherent expression. We soon realized, however, that the actual transition between two states also contained a range of colors resulting in combinatorial possibilities that at present is difficult if not impossible to sketch. Obviously, this experiment will lead to new experiments where we will try different strategies and hopefully be able to develop new tools.

Figure 4 Left: The graphical interface of the software on computer screen. Right: picture of the "note sheets" to visualize the progress of the heating.

Figure 5 An example of the range of colors expressed in the transition between two color states.

BONAD [TAPESTRY]

Bonad [Swedish for tapestry] is a project investigating what it does to the depth, complexity, and quality of the designed textile expressions when one part of the material composition is held stable throughout the design process. Bonad is a platform comprising 1-48 servomotors mounted on a surface controlled by a computer, which in the test setup is controlled either through a graphical interface or through a row of potentiometers. We investigate whether such a platform is a viable way to reduce the complexity of the technological aspects and thus leave room for more advanced textile design.

From a textile design perspective the platform is used for developing new textile structures and patterns that can achieve interesting expressions with this kind of slow or rapid explicit rotations. How, for instance, a textile surface becomes more or less permeable, how it changes from a smooth surface to one with three dimensional features, or how pattern combinations can play together through the rotations. We expect to end up with an understanding of the potential expressions of textiles in composition with this kind of movement.

From an interaction design perspective we investigate how textiles in movement can influence and be influenced by the atmosphere of a room (Landin *et al.* 2011). Currently, for instance, we are experimenting with different combinations of context dependent behavior for a setup in a chapel and in an elderly home. As means to get an understanding of what new roles smart textiles can play in our environment.

Figure 6 Above shows an example of texture changes for a 3D knitted elastic surface and below shows of movements within a stiff 3D knitted construction. Both designed by Delia Dumitrescu.

AN INVITATION

This paper describes a process of the maturing of a research field from the initial explorations designed to give a basic understanding of what is at play, to formulating more specific questions and designing more focused explorations. The research program proposed here is still, however, a sign of an early stage in a research field. It is a program formulated to find ways for the new materials possibilities to reach a greater audience in parallel with studying in what this could mean for the design of textile products and environments.

The reason for publishing the formulation of this research program is not only to demarcate the maturing of the research within smart textiles, but also to formulate an invitation for others to participate. Participate both in discussing the direction we are taking

but also to contribute with own experiments and investigations—perhaps even in collaboration with us.

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