CHROMATIC
CHLOROPHYLL

- CONCEPTUAL HOSPITAL
TEXTILES WITH CHROMATIC
SMART MATERIALS

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**ABSTRACT**

*This project aims to* look at how Smart Textiles can change today’s view and use of the interiors of the healthcare environment, through conceptual examples of the usability of the Photochromics and Thermochromics working as an information bridge for more isolated patients. The thesis has a practical experimental approach and points out some of the chromatic materials possibilities in relation to present research of the two chromatic materials.

The thesis discusses the relation between healing environment and the importance of aesthetics, with a purpose to meet Emotional and Social needs of feeling “alive”, “well” and “included”. Research indicate that nature has a calming affect on patients, therefore flowers and leaves have been inspiration for the expression of the textiles. The colour change creates a subtle communicative bridge between patient and movement in the hospital - ‘the Rhythm of the House’ and the outdoor - ‘the Rhythm of the Sun’. The conceptual proposal presents a design solution where the colour changeability stands for a communicative level, as well as a decorative and a dynamic level. The textile samples communicate the visual and hepatic expression, as well as the integration of the electronics. The scenario for the thesis is set to the 2015-20, due to reasonability for Smart Textiles to be developed to be used as interior textile products for the healthcare environment.
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17. MATERIALS - chromatic colour changer
FUTURISTIC PROSPECT - for the chromatics in question
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EXPRESSION - to think outside the box
NATURE - a positive image for healing

COLOUR - inspiration for freshness and new life

AESTHETICS - the carrier of the Emotional needs

THE FINAL MOMENT
This chapter includes the conclusion, as well as tables with the main points gathered during the project. The tables are divided into Thermochromic – Lueco Dye as well as Photochromic Dye. The two groups are then divided into the tree aspects; "Working today", "Limitations today” and “Possibilities for the Future”.

THE CONCLUSION - of the thesis
THERMOCHROMIC - the now and the tomorrow

PHOTOCHROMIC - the now and the tomorrow

REFERENCES - for further investigations

APPENDIX - additional knowledge
A SLIGHTLY DIFFERENT APPROACH

THE DESIGN BRIEF - the framework for the project

The soil - the plants symbiosis with its prerequisites makes wonders dazzling with intense colours.
THIS PROJECT AIMS TO look at how Smart Textiles can change today’s view and use of the interiors of the healthcare environment, through conceptual examples of the usability of the Photochromics and Thermochromics working as an information bridge for more isolated patients. The ongoing debate on the significance of the effect the environment has on the patient’s wellbeing and recovery is of importance for the healthcare environment.

The overall discussion talks about the term “healing environment”. How we as patients are being affected by our surrounding and how that will have spin-off effects on our recovery when staying in hospitals. In my view, this debate is essential for the progress in getting a more sound hospital environment. The demands on textiles in hospitals are that they must be flame retardant, allergy safe, washable and UV-tolerant; all of them are often important properties for the final product. These are qualities that have to be met, but we also have to treat the aesthetic expression as an equally important requirement. By having a clear humanistic approach, meaning that the patients’ wellbeing is the starting point of the design development, the demands of the human needs will easier be met. By working with the aesthetics of the environment the hospital indirectly shows their patients that their total wellbeing is of importance. In a bigger perspective, over time for hospitals in general, I hope that by eliminating as many as possible of the issues/problems that might interfere with the patient negatively the atmosphere becomes more secure and positive.

The focus of the physical environment takes its starting point in areas such as light, colour and shape as well as sound. Textiles stands for the well-known and the second skin, being a fundamental part of human lives since the days we started to cover our bodies and build our houses. I am arguing that textiles will be a suitable object for creating a warm, relaxing and secure environment. With today’s research and development in Smart Textiles parameters such as colour changeability, light and sound can be incorporated into the textile, creating a more functional textile with an added value in contrast to the more traditional textiles”.  

* The usage of the material to create a feeling of wellbeing. It is important to look at the use of the aesthetics within Smart Textiles. A lot of the Smart Textile research still focuses on the more technical angle of product concepts. The surface of the textile could be a way to give an emotional feedback to the patient, giving the colour change within the textile surface a symbolic communicative meaning. In an attempt to wanting to take in the subtle and more poetic side of the colour changeability rather than letting it stand for some direct hands-on communication with buttons.

** LIMITATIONS **  

* The Photochromics and Thermochromics have strength in being materials that reacts on outside stimuli and thereby change its appearance. There are a number of chromatic materials on the market today such as, Photochromic (reacts on light), Thermo chromic (reacts on heat), Electrochromic (reacts on electricity), Piezochromic (reacts on pressure), Solvatechomic (reacts on liquid) and Carsolchromic (reacts on electronic beam). (Berzina, 2004, p.143)
new field the materials are not at present meeting the requirements of today’s healthcare industry. The aim of the project is to see how Smart Textile materials might be used in wards in the future. The conceptual textile solutions being presented in this project is therefore developed in relation to a thought scenario of a patient room for the target group, in year 2015-20.

* The present requirement specification for hospital textiles would probably look quite different in the year 2015-20, due to the present rather fast changing research in areas such as coating and the development of new fibres with added properties (cleanable, anti-bacterial, salvage resistant etc) are changing the requirement of the textile products. Because of this and also to be able to try to stretch the boundaries of the aesthetic and the use of today’s interior hospital textiles the present requirement specification was disregarded.

* To not limit the aesthetic expression for the textile prototypes the constructing techniques will not be fully set before starting the project. The techniques in question are knitting, printing, embroidery, bonding and after treatments, in what way and which combinations of the techniques will be used is to be decided during the design process.

THE IDEA OF WORKING with hospitals as a specific environment started with the Bachelor degree project spring 2005, designing motifs for sound-absorbing tiles and hanging textiles for treatment rooms. During the years at the Swedish School of Textiles investigations have been done to see how today’s interior textiles in hospitals can be developed and changed to improve the environment for the patient. Work with textiles and colour changeability has been done with use of new materials such as conductive yarns, Photochromic (UV-sensitive) yarns and dyes, Thermochromic (heat sensitive) printing inks, LEDs.

The purpose has been to develop textiles that can meet both aesthetic as well as functional demands, to underline the role of the interior textiles within the healthcare environment. To investigate the potentials for using an interior textile as a communication platform within the patient room more advanced technical experiments with implementing sensors and electronics within the textiles has been started.

AESTHETICS – This work has a focus on how the aesthetic expression can be used as an interface for a subtle communication with isolated patients. The healthcare environment is an example of an application area. The concept in general can be applicable in other areas with similar parameters, for example, where persons for other reasons are being isolated or imprisoned.

TECHNIQUES – This work includes the use of sensors and electronics integrated into textiles to see which role the aest-

IMAGE 2: A sample for the concept for “the Rhythm of the Sun”, with embroidered Photochromic yarn extruded in Scotland in collaboration with Veriham.
The conceptual ideas are used as visual arguments for how the chromatic materials can be used in the intended environment. To clarify the two ideas both “The Rhythm of the House” and “The Rhythm of the Sun” will be visualized.

“The Rhythm of the House” - The idea of this concept is to give the patient a feeling of not being alone by mapping the movement of people within the hospital by changing the colour in different parts of the pattern in the wall hanging. The colour change in a certain area informs the patient that there is movement in that part of the building. A number of sensors, triggered by people passing by, are placed around the hospital. Each sensor is connected to a specific part of the circuit within the textile, making that specific area in the pattern change colour. In the example presented in the visualization one sensor is placed in the corridor outside the patient’s room, one in the entrance to the chosen ward and a third in a corridor in another ward within the hospital. The change in the pattern gives an opportunity for the patient to reflect over the relation between the areas in the pattern and where the movement is taking part within the hospital.

“The Rhythm of the Sun” - The idea of this concept is to give the patient a connection to the outside and time, by the colour change of the pattern in the window screen in relation to the intensity of the Sun. Over longer time the colour change might indicate to the patient that time is passing, by the continuity of when in the day the Sun is strong enough for changing the pattern. The pattern also allows the patient to reflect over whether there are changes in the rhythm of the change in relation to how long or short the day is.

The result in the interviews indicated that there was a lack in the fulfillment of the Social and the Emotional needs in relation to living and housing. To be able to structure the information the team divided human needs into the following groups: Social (human contact and belonging, such as feeling included); Emotional (non-physiological feelings, such as the will to feel alive); Fundamental (basic needs such as eating). (Re Design Ex 2007, p. 16-17)

The discussion in this thesis has a design perspective, with a focus on finding out whether the aesthetic expression can work as a subtle communicative tool. Therefore a large part of the design process was planned for sketching, investigating colours, colour compositions and experimenting with colour changing Smart materials, and developing the aesthetic expression. The final eight samples (both Photochromic and Thermochromic) function as a discussion platform aesthetically for what is possible to achieve with the materials today (in relation to the techniques printing and embroidering) and which possibilities could be stressed in the future through collaborations between designers and chemists. The final eight samples are neither a collection of nor final product prototypes, but are intended to be a conclusion of the research done in this project. The samples are a complement to the visualization of the concept, communicating visual and haptic expression, as well as the integrating electronics.

How personal can a designer become in relation to the expression of the textile, especially when the product is intended for a target group as wide as the range of patients in a ward? The fact is that the breadth of the target group contributes to the arguments for a professional designer having the valid knowledge for making good decisions regarding the expression in relation to meeting the brief of a textile that can speak to the patient’s Emotional and Social needs. Emotional and Social needs are hard to measure in numbers and statistics.

In the Project Re Design Exp in 2007 I and six other designers and architects conducted interviews, both quantitative and qualitative, to try to understand what is important in relation to living and housing. To be able to structure the information the team divided human needs into the following groups: Social (human contact and belonging), Emotional (non-physiological feelings, such as the will to feel alive); Fundamental (basic needs such as eating). (Re Design Ex 2007, p. 16-17)

The result in the interviews indicated that there was a lack in the fulfillment of the Social and the Emotional needs in relation to living, which also appeared to be needs that our participants thought were the most important to be fulfilled. The result pointed towards a higher focus on softer values in contrast to the more practical once that normally are being met within built envir...
The group stated that the basic needs such as eating, sleeping and staying warm are so fundamental that we take the fulfilment of them for granted.

This might be different in conditions when being ill, however the result from the research showed a tendency towards what the respondents found important in relation of how a living/a space will meet the human needs, and the importance of the Social and the Emotional needs being met. Also our needs do not alter because our prerequisites changes, but rather our demands on the environment in satisfying the needs. (Re Design Ex 2007, p. 14-19)

Meaning that in a state of illness, being in a hospital environment the fulfilment of the Social and Emotional needs is probably still of importance, and in relation to the situation it might sometimes even be more so. It is of course of significance to remember that people often perceive objects/situations etc that is congruent with their emotional state. (M. Barnes, 2002, p. 136-137)

This meaning the designer has to keep in mind that the viewer is often someone in physical as well as physiological stress when designing the expression of artefacts for the healthcare environment. In the following project the needs in focus are the Social need “to feel included” and the Emotional needs of “feeling alive” and “feeling well”.

7 The participant for the interviews were not hospitalized and the questions had a focus on what one would want in relation to once living in general.

IMAGE 3: The Puff print adds experience to the textile surface.
1. The patient room
Camera Angle (CA): A person coming into the treatment room, is looking around (to describe the room).
- looks at the bed and the window
- looks at the bathroom door and the sink area

2. The patient room
CA: From the bed, as if the patient is laying in the bed, looking around the room.
See how the view differs when laying in the bed instead of standing. It is important to design the room from the patients view angle, in this case the bed. The patient shall still be able to see out the window. Laying in the bed one easily sees the ceiling.

3. The corridor
CA: The sensor that is located in the corridor outside the patient room. Only two people are moving in the corridor, which is too few to trigger the colour change in the textile in the patients room. This informs the patient in the treatment room that the ward is rather quiet.

4. The patient room (Morning)
CA: The moving camera ends with the window screen in focus, no reaction in the pattern, not enough UV-light.

5. The patient room (Mid day)
CA: The window screen in focus. The Photochromatic dye has changed by the UV-light from the Sun and the Thermochromic ink has changed from the heat from the Sun. The colour change in the pattern becomes more and more intense as the hours passes towards Mid day. The time quickly changes from Morning to Mid day (one sees how the light alters).

6. The patient room
CA: The wall panel in focus showing the reaction in the pattern that is connected to the sensor in the corridor outside the patient's room. The colour change is activated from the heat loss from the currant that runs through the activated circuit.

7. The entrance
CA: The sensor that is located by the entrance into the ward with the patient in question. The amount of movement is triggering the circuit in the pattern in the textile wall hanging that is connected to this sensor.

8. The patient room
CA: The wall panel in focus showing the reaction in the pattern that is connected to the sensor by the entrance into the ward. The colour change is activated from the heat loss from the currant that runs through the activated circuit.

9. The patient room (After noon)
CA: The window screen in focus. The colour change in the pattern slowly goes back to the unchanged state as the hour's passes towards After noon. The time quickly changes from Mid day to After noon (one sees how the light alters).
A NEW TOMORROW

RESEARCH - the background for the project
CONCEPT - the carrier of the Social needs
THERE ARE DIFFERENT wards\textsuperscript{8} that house patients that are more isolated, which ward partly depends on which complaint the patient have. The target group can be divided into three more general groups\textsuperscript{9};

* Patients with serious complaints such as cancer and patients undergoing heavy surgery, that therefore has to be hospitalised for a longer period of time. It is not unusual that the surgery patients stay hospitalised for one to several weeks and untreatable cancer patients\textsuperscript{10} are being hospitalized on and off up to a year.

* Patients with an unusually impaired immune system that are isolated due to their extended risk of their bodies not being able to handle new bacteria's.

* Patients with infections, such as for example epidemics, that might put other patients at risk.

Due to the time the patients of the first group can be hospitalised a decision was made to primarily focus on these patients. Because of the psychological and physiological stress in relation to their illness it is not unusual that these patients becomes depressed, and after a longer time in the hospital even lose the will to have their daily meals together with other patients in the dining hall. It is also not unusual that the patients in question lack frequent visitors, making the hospital staff their main social contact. Normal social needs such as the human touch and talking to someone about nothing particular then becomes unfulfilled. Even if the staff has a wish to give the patients the time needed, this is mostly impossible due to lack of resources.\textsuperscript{11} It is also not unusual that the patients in question suffer from different, often serious side effects from their medications, such as sleeping disorders, orientation difficulties and hallucinations, which in turn can create insecurity. The lighting in the Intensive care clinic is therefore often reduced. The rooms should speak of quietness and calm but it is very important to avoid them being monotonous and dull. (Meerwein, Rodeck & Mähnke, 1998, p. 119)

TODAY'S INTERIOR textiles for hospitals tend to have a higher focus on the functional qualities (such as being easy to maintain and low price) than the aesthetic expression. The normal interior textiles in a ward are bed linen, curtains, drapery and upholsteries. The main material is cotton and polyester (such as Trevira CS). The colours are often light, mostly white, with a simple pattern of stripes or a small dot or square. (see images 4-7 from the chosen Wards at Södra Älvsborgs Hospital in Borås)

THE SCENARIO for this is set in the years 2015-20, due to the reason that Smart Textiles have to be further developed to be used as interior textile products for the healthcare environment. How the future will look is always hard to predict. Looking at the present situation and the structural change of the healthcare in the last decade with a shift towards a more patient centred ideology\textsuperscript{12} the change is important, in that way that the surroundings are getting a larger focus because of it.

The grain of the change is the view on how to approach the patient, which influences the healthcare organisation, structure as well as design. Hermerén's theories (Hermerén 1994, see Fridell 1998, p. 156f) explains the new theory as viewing the patient as a subject, arguing that everybody is unique and that it should be taken into consideration in relation to treatment, in contrast to the former theories where the patient is seen more as an object, a target for care.

Hospital buildings are being built in line with the new approach, for example, in Sweden the Diagnostic Centre at the Malmö Academic Hospital 2005 (MAS) and the new T-building at Södra Älvsborgs Hospital (SAS) in Borås that will open in 2010. According to an interview with one of the architects, Hjort, behind the new ward at MAS, the important idea underlying the building was flexibility and being able to change the use of the room (Dagens Medicin 38/2005 p. 18). According to the article the grounds for today's architecture for hospitals are: the natural light, orientation, minimalism\textsuperscript{17}(neutral colours and monochrome surface creates a calming atmosphere), conceal technical equipment, beautiful materials (wooden materials and decorative textiles that are easy to change). (Dagens Medicin 38/2005 p. 19) At the T-building at SAS, three different buildings consisting of ten, nine and three floors, each floor holding a different ward, are being built. All the new treatment rooms in the building are single-bed rooms (SWECO, 2006, p. 6) Architect Stakkestad\textsuperscript{14} explains that single-bed rooms diminish the risk for infections and virus to spread in the intinary and that a lot of patients, if they can chose, prefer to be situated in single-bed rooms. Also here as well the idea is a building with high flexibility, where the daytime room can easily be changed into a treatment room. The daytime rooms are quite small and there are several at each floor.\textsuperscript{15}

Both the privacy issue as well as decreasing the infection risk are positive arguments for using single-bed rooms, however, the single-bed-rooms can also increase the isolation for the chosen target group.\textsuperscript{16}

13 This is a free translation from the Swedish words “rena linje” which does not really have a direct translation into English. The direct translation would be “straight lines” but I have interpretive the meaning of the paragraph as the expression wanted is in close relation to the general understanding of the expression of a Minimalism.

14 Stakkestad, Inger, one of the responsible architects at SWECO for the new T-building at SAS, meeting at SWECO 020307

15 Stakkestad, Inger, Architect, SWECO, Gothenburg, Sweden, meeting, 020307.

16 Niveri, Jussie, Head of Department of the Surgical Division at SAS, Borås, Sweden, interview, 020708.
A newly built hospital in Maasland in the Netherlands, which opened October 2008, is another interesting project. The planning of the hospital was designed on the basis of 350 diagnosis focused care programmes in collaboration with a computer driven system. The result is a highly modernised hospital, with only single-bed rooms with enough space for one relative. The rooms are equipped with a personal computer where the patient herself can read her file, search the web for information regarding the illness or order services. As inspiration sources the Orbis medical park team, behind the newly built hospital in Maasland, benchmarked other service areas, such as the car industry for the logistics, catering for the food, airports for orientation signs and hotels for the hospitality. (Göteborgs-Posten 050308, p. 7) By analysing other trades the healthcare will have a lot to gain in the development of the future hospitals.

PATIENT FOCUS and Professionalism are cornerstones for the scenario 2015-20.

Definition of term Patient focus:

The needs of the patients will influence both the medical treatment and the design of the physical environment.

Definition of term Professionalism:

The patient shall feel that he/she gets a high quality treatment, which includes both a good medical treatment and a healthy physical environment. By working with variables such as the lighting, sound levels, the colour and patterns at for example textiles and walls, the hospital indirectly shows the patients that their total wellbeing is of importance.

A positive development against the isolation is the possibility for patients to access information about there illness through a computer by each bed in the patient room. This way the patient can also easier communicate with friends and family, a support that can be of great importance in relation to the recovery. The ward will mainly have single-bed rooms, with a couple of double-rooms, giving the patient the choice if company would be preferable. The view from the bed is the starting point in the furnishing and structure of the room; this being the main thing the patient’s will see. Every room will have a large window, with a lower window frame so one can see the outdoor from the bed. The patient will be able to pull aside the window screen with a control reachable from the bed, as well as dimming the light in the electric fittings. As much as possible of the electronics and machines are hidden from the view of the patient. The colour choices as well as the materials have been designed in the initial state of the planning of the ward, so it co-operates with the overall surrounding. The size of the room is large enough to fit two beds, when one extra is needed either for a relative or when the hospital is overbooked. All rooms have a communicative aesthetic element that works both as a decorative piece for the room as well as a focus point for thoughts. Also here the on and off switch will be controllable by the patient from the bed.

“... BEING ABLE TO shift the focus away from oneself to the environment if the environment contained objects such as... a painting, or a view from a window... cancer could be escaped, if only momentarily... from the self to there objects, and they experienced such environments as aiding them in forgetting themselves, their anxiety and sadness.” (Edvardsson, 2005, p. 45-46)

The Fight/Flight reaction is the human’s biological response in danger situations, which in today’s society is often not needed. The biological system is still active17. To day the fight and flight reactions is not used as a protection for running from wild animals, at least not that often as it were in the early days of mankind. (Barnes, 2002, p. 138-139)
causing people to feel stress in situations when a person can not move, take charge or work. To brake the negative cycle a theory based on the two options “perception” and “reaction” is established, where appropriate therapeutic design can activate the second one. Such activators can for example be spaces that evoke positive responses, relaxing distractions, and opportunities for meditation or self-reflections. (Barnes, 2002, p. 138-139) It is of great importance that the patients themselves can choose if the interaction should be activated or deactivated. It is important for the patient to be able to choose the level of stimuli not to be over stimulated. The right stimuli will help the patient in recovering from mental fatigue. (Kovary, 2002, p. 119)

There are possibilities for Smart Textiles in comparison to more traditional textile materials to reach a higher activity level by changeability effects that can activate human stimulus.

“THE NEW BROADER perspective in medicine, however, requires that the emotional and social needs of patients be given high priority along with traditional biomedical and economic concerns, including disease risk exposure and functional efficiency, in governing the design of healthcare buildings and management of care activities.” (Ulrich, 2002, p. 20)

Ulrich has stated (Ulrich, 2002, p. 20) three different variables for measuring the effect of the healthcare quality, which are: clinical indicator that are observable signs and symptoms related to patients’ conditions, patient-based or subjective measures such as reported satisfaction and the win of economical outcomes. The studies shows that the meeting of the Emotional and the Social needs with for example artefacts, art and nature in the ward are arguments that give validity to healthcare research. They also indicate an economic gain with lesser doses of pain drugs and shorter hospital stays, which also argues for nature inspired artefacts in the patient environment. (Ulrich, 2004, p. 22)

It would be interesting to see if/which economic spin-off effects the changeability of nature inspired Smart Textiles might have in relation to more traditional textiles with an expression inspired from nature. The studies of Barnes give Smart Textiles an added interesting argument for being used as an interior element in hospitals, in relation to the more traditional static textiles.

**INTERFACE**
1 a connection between two pieces of electronic equipment, or between a person and a computer:
2 a situation, way or place where two things come together and affect each other:

(From Cambridge Dictionaries online, http://dictionary.cambridge.org/define.asp?key=41425&dict=CAld1)

Interaction design… designing interactive products to support people in their everyday and working lives.” (Redvers-Mutton & Crockett, 2002, p. 6)

Smart Textiles brings up a discussion regarding the definition of an “interface” and how the aesthetics explores different ways of how information is displayed (Landin & Worbin, 2004). The term “interactive textile solution” in this paper means textiles that have a contact with the patient through an output - displaying information (it can be both measurable and immeasurable information) through colour changes.

Textile interfaces are being used in different applications were the information load as well as the metaphoric level varies. Examples of textile interfaces dealing with different sides of these aspects can be viewed in images 10-14. The “Jacket Antics” shows information on LED displays on the back of the garment. When two people wearing the jackets interact by holding hands the two messages changes into one running between the two displays. The “Jacket Antics” is a playful way of handling information viewable to whoever is present. (Seymour, 2008, p. 64-65) The “the Fabrication Bag” is a project dealing with information in a more subdued way. The colours of the pattern changes when a mobile phone connected inside the bag is receiving a call or a text. The bag is a way of exploring how information is affecting its surrounding without being loud and noisily displayed. (Landin & Worbin, 2004) “The Electronic Tablecloth” displays the information directly on the fabric when the viewers touch the keypad within the textile, which differs from “the Interactive Pillows” which communicates over geographical distance between two people, by hugging one pillow the other one lights up. The information level of the pillows is more symbolic, communicating an act of action rather than any written message. The change of the pillows however, when knowing the background of how they function, subscribes the “display” with an additional more poetic and metaphoric level. (Seymour, 2008, p. 75) (Landin & Worbin, 2004)

“System 1”, where colour change is visualizing electric stimuli mimicking the skins properties of our nervous system, is another more tangible interface. Through the change the surface becomes a communicative display, telling a story of how a system is functioning. Also here the informative level becomes dependent on the narrative symbolic meaning. All of the examples above can be viewed on an aesthetic and dynamic level, where the interactive message does not have to be understood. (Seymour, 2008, p. 183)

The intended display in this thesis is more of a tangible interface due to the fact that the patient will not respond to the information by hands-on feed-back (like when using a computer, TV, mobile or other machine) but rather an emotional one (the colour change aiming to trigger a feeling of being connected to ones surrounding). The patient can in a way internet/respond to the information shown on the interface by changing the levels for the variables (how much movement is needed for triggering the sensor) of the computer program that is controlling the digital or analogue input sensors. This is however more an initial 18 The term “tangible” in tangible interface in this paper means an interface that in several ways touches the general meaning of an interface, but still not being fully equal to it. The interface in this thesis has a more indirect feed-back and there is less focus on the communicative level, as well as an additional importance in the aesthetic expression.
communication rather than a feed-back command to a request/demand. The pattern is dynamic, through its changeability and the interface goes from one position to another. Other examples of this case of interfaces could be a light signal or a sign that is being turned on and off in relation to a given situation. In these examples, however, the information is often informing the user when to act and when not to, like when the light signal tells you when to walk and when to stand still. The traditional interface normally demands an immediate action from the user, in this project, however, the interface rather points out a change to the user. It is up to the patient in what timeframe he/she wants to act on the information. The patient also has the option to turn off the output in the concept "the rhythm of the House, if the information is unwanted.

An information visualization (for example a traditional computer interface or the light signal described above) is meant to carry information as clear as possible, in relation to informative art (art that dynamically reflect and in some way represent information) which purpose rather is to work from an aesthetic point of view, and partly be an art object. The informative art might have a less cognitive load, but in contrast it, through the ideas of slow technology, gives possibilities for more reflection and concentration to understand the informative level. (Redström, Skog and Hallnäs, 2000, p. 111-112) The outcome of the design of the pattern will be an important part for the effect of the intended emotional interaction, and thereby the aesthetic gets an informational substance. The textile surface has however only to be understandable on one level (to read in a change in time and/or space), it can still also allow a freer interpretation (tangling the freedom of a piece of art, like informative art).

The patterns can be stripped of the need of a semiotic level - the change working more indirectly. The colour change can even be designed so discreet and the timeframe for the change so long that the user is not even aware of the change taking place, the change still affecting the patient on a subconscious level (stimulating the wanted need). The understanding level for Informative art is realization of what the piece relates to information wise, and the object itself becomes a connection between its environment and the hidden information. After viewing the artwork the viewer eventually will feel a clear presence of the information being communicated (still of course on a more abstract level). (Redström, Skog and Hallnäs, 2000, p. 111-112) This relating to the concept "the Rhythm of the House", were the patient is being able to "map" movement of presences within the house. The areas of colour change within the pattern communicate movement in different parts of the ward or the whole hospital. The pattern can of course also be seen only as a dynamic pattern and the understanding of the informative level will probably be understood first after being explained. Something that might be optional at an initial state or first later if the patient asks about the changeability. By not informing about the communicative layer directly one might be able to increase the interest for the textile, something that would be positive for the patients due to the time aspect of their hospital stay. First letting them experience the decorative as well as the dynamic level of textile and after having shown interest one can explain the information level and tell about were the different sensors are located within the house and which sensor that activates which area of the pattern.

19 Semiology is a methodology about the study of sign processes, the relation between signs and what they refer to.
THE CONCEPT of the Rhythm of the House and the Rhythm of the Sun are partly ideas that have been developed through earlier projects. In the Industry Related Project spring 2006 two industrial producible silicone-coated knitted window-dividers was constructed. The textiles had an added value through a colour change with an intension to give a notion of the passing of time and to give patients something to think about besides their illness and hospital stay. During the hours of the day the window-divider changes from white to a colour to by night glow in the dark, by the use of Photochromic and Fluorescent materials. Ideas that have been positively met when the prototypes have been discussed and showed to other designers, professionals within the healthcare as well as people in general (see image 9).

During a course in Interaction Design and Smart Textiles during winter 2008 the ideas continued to develop towards getting a more communicative focus. Conceptual ideas were developed, with different scenarios of how a communicative platform could be used as a communication artefact within the patient room. The interactive surface, such as colour changeability in a textile pattern, could for example indicate for an isolated patient that other persons are moving outside the room. With the aim to give the isolated patient a notion of that she/he is not alone. An extension of the idea was that the change of the pattern of the textile in the treatment room could increase in relation to how many persons that were passing in the hallway. The hanging textile, being a textile sensor (motion sensor), in the hallway would activate the colour change in the textile in-...
15-16 Samples from a former project with a higher contrast between the colours. The high contrast was delimited in this project due to wanting to create a more calming expression.

17-18 Tests of getting the sensors to function using diodes and the power supply to power the heat change in the textile.

19 Tests were done with a smaller current adapter to see which the smallest amount of Ampere is needed to heat the textiles.

20-21 Still frames from the visualizing animation to explain the concept “the Rhythm of the Sun”.

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the pistil - the creation that comes from the union with the pollen creates the new generation of life

WHAT TOMORROW HOLDS

MATERIALS - chromatic colour changer
FUTURISTIC PROSPECT - for the chromatics in question
DURING THE MASTER THESIS
collaborations with chemists, as well as
discussions around the chromatic mate-
rial’s chemical structure have taken place.
The multidisciplinary research approach is
essential for the future prospect of the
chromatic materials. The result that can be
the product of a discussion between the
two parties - the designer and the chemists
is of interest for the development of the
possibilities and limitations of the materi-
als. By building a platform for what can be
done today aesthetically with the chromatic
materials (in relation to different techniques
and design applications) and which possi-
bilities could be stressed in the future the
collaboration will contribute to the com-
prehensive research.

THE THERMOCROMIC materi-
als on the market today21 are divided into
two groups, The Thermochromic Liquid
Crystal) (TLC) and the Thermochromic
Leuco Dye22 (TLD). The Thermochromic
is bonded within a binder.

The Thermochromic Liquid Crystal reacts
at lower temperatures and can show the
whole rainbow scheme of colours, but is
much more expensive and becomes irre-
versible after a shorter amount of UV-light
exposure. The TLC needs a UV-absorbing
coated or laminated surface to be more
protected. A more intense hue and a clearer
change are other effects from a shiny sur-
face. To get a more intense colour reaction
the TLC preferably should be printed on a
black background.23

The second is the Thermochromic Leuco
Dye which cost less and is more UV-resist-
ant, but can only change from one colour
to another. (Christie, Robertson and Taylor,
2007, p. 2-3) The TLD on the market still
have fast colour degradation when being ex-
posed by UV-light. The time span of degra-
dation depends on the amount of hours the
materials are exposed with UV-light. This,
however, is already being pushed by research.
Christie with his research team has succeeded
in developing Thermochromic solutions that
have a higher light fastness24 compared to
the Thermochromic materials available at the
contact market. (Christie, 2008, p. 143) Due
to the ability to provide more control over
the tints and to be able to go from one to
another colour the Leuco Dyes will be used
in this project.

When heating the Thermochromic material
it becomes transparent, it looks like the col-
our disappears. By mixing normal pigment
ink together with the Leuco Dye it is possible
to go from colour to colour. Robertson has
not found any fibres that have not worked
to print on. Even wood and metal is fine, as
long as the pigment is mixed with a binder
that binds to the material being printed on-
to.25 It takes a temperature change around

21 At present the manufacturers of
Thermochromes are; TMC (Thermographic
Measurements in UK, Colour Change
Corporation in USA and Matsui in USA
(Christie, Robertson and Taylor, 2007, p. 3).

22 The Leuco Dye consists of three compo-
nents; the colour former (the Leuco Dye), an
acid (or activator) and a low melting solvent.
(Christie, Robertson and Taylor, 2007, p. 2).

23 Christie, Prof. Heriot-Watt University,
UK, meeting, 121008.

24 Light fastness is a colours ability to
maintain its hue on prolonged exposure to
light (Little, 2008, p. 33).

25 Robertson, Sara, Ph.D. student Smart
3°C for the TLD to change. (www.colour-change.com/home%20page, 070320).

The intended tint is dependent on the possibility of being mixed from the TLD’s colours. That means not all tints can be produced. Mixing the TLD with a pigment ink gives a higher level of complexity. The colour that will show when the fabric is cold (colour position 1) is the tint that is created when the TLD and the pigment ink are mixed, and when heating up the fabric (colour position 2) it shows the colour of just the pigment ink. For example if Blue TLD and Yellow pigment ink are mixed, colour position 2 will be a Green tint and colour position 1 will be the Yellow tint the pigment ink had originally. If changing colour position 1, colour position 2 can also change. If one enhances the amount of Blue TLD the Green tint will become darker but the Yellow (position 1) will stay the same, but if the Yellow pigment ink is enhanced then both positions will change.

This means that one has to design two colours within one and this distinguishes the colour process with Thermochromics a lot from the process working with regular pigment inks. To that comes the factor that the TLD have different changing temperatures, which means that one can design more than two colours in one colour, still having the same co-operating relation between all the tints as when using two.

Yellow Pigment Ink + Blue Thermochromic Ink = Green

Colour position 2 (heated) Colour position 1 (not heated)

Robertson has research on how different temperature sensitive inks behave, using the following temperatures °C 15, 27, 28, 29, 30, 31, 40, 47. The tests are done without pigment ink to be able to see how and at which temperature the different colours are changed. The Thermochromic inks used for this thesis were fixed at 130°C for three minutes. The ink should not exceed 140°C. (www.matsui.color.com, 070320)

Test prints with different temperatures were done to see how the different Thermochromic materials respond in relation to the conductive copper thread (see images. 32-34). The Thermochromic that reacts at a higher temperature demands a larger amount of heat loss to change colour on an equal area, which led to the decision to only work with the touch sensitive inks with a changing temperature at 27°C. In other applications possibilities might be better for using different temperature sensitive materials to get an increasing colour change. Something that Robertson also argues for during an interview.

“The Leuco Dyes can go through different changes, by using different dyes that change at different temperatures. One can make them go through four different colours (multicolour changing effect). The important factor is to get the proportions right, so one actually sees when one colour changes into another. Interesting is also to combine the Leuco Dye together with different high temperature sensitive Liquid Crystals, using a black Leuco that reveals something behind it, but it also works as a black background for the TLC. By layering up different layers a very complex surface can be achieved with simple means.”

THE HEAT SOURCE to activate the change can for example be heat loss from electrical resistance, heat elements or body warmth. The parameter with the highest complexity is the conductive material using electricity to heat the material. To get a satisfying colour changing effect the conductive material has to be a bad conductor, so a lot of heat loss is being produced. The conductor can be different conductive metals and yarns such as stainless steel, copper thread and mixed yarns such as Bekaerts VN12 and VN14 thread. The conductive material behaves differently due to the circumstances of how the thread is angled, the closeness of the conductive threads, resistances of a material is measured in Ohm Ω.
by levels of Voltage and current (Ampere), all parameters that have a high influence on the aesthetic outcome. The outcome of the pattern in some parts depends on chance. Even if one can control the different design parameters it is regardless never possible to know exactly how the result will turn out due to the sensitivity in how the currents are moving or the amount of heat loss. This however adds an interesting design variable – the haphazard.

To test how the expression would be altered, when one would not see where the colour change might take place in advance, sketches of laminating in the copper thread were conducted. It added an element of surprise as well as gave a cleaner and calmer expression (due to fewer materials in the design).

Experiments were done to see if a larger area could be heated. The changed areas gave an interesting complement to the linearity of the embroidered and laminated thinner copper threads. Tests were conducted with circuits with conductive copper foil, being heated from embroidered copper yarn running around the foil in an attempt to heat up the copper surface. The result did however not create enough heat loss to heat up the copper foil to a satisfying result. With more extensive experimenting with different currents and circuit designs this might likely be more successful. Due to the time limit of this project this has however to be tested further in another project. (see images 25-28) One can also use custom designed heat elements to change an area. These are however still very expensive to produce, especially for the use of a limited amount of samples, therefore this was not an option for this project. Instead an alternative heating the whole area exemplifies how the expression can be altered. To visualize the wanted effect a layer with wool fabric partly blocks the heat from the heat element.

**THE PHOTOCHROMIC** material is ultraviolet light reactive\(^{29}\). Today’s Photochromics on the market all goes from white/transparent to colour or from one colour to another. The Photochromic material absorbs UV-light, which activates a chemical change in the molecular structure, which creates the colour change. The more UV-light the material absorbs the more intense the second colour appears.\(^{30}\) The materials on the contract market are reversible materials. There is however information that indicates that development is being done with irreversible\(^ {31}\) Photochromic materials. Due to the fact that the prototypes are meant to change back and forth only reversible Photochromics are used. There are both commercial Photochromic printing inks as well as fibre treated yarn. (www.colorchange.com, 07-03-20)

Successfully developed Photochromic dyes that have a longer UV-resistance in relation to the lifetime of the changeability effect have been inferior (Christie, 2008, p. 141-142). To be able to use the intended materials in applications the light fastness has to be solved. Today, the UV-light damages the stability of the chromatic material. It is however very hard to assess quantitatively how light stable the material is, due to the fact that the normal standard methods of assessment for traditional dyes do not apply.\(^ {32}\) The Photochromics and Thermochromics both degrade in the changeability effect as well as decreasing in colour strength. It is also hard to compare the two chromatic materials to each other because the Photochromics goes from transparent to colour and the Thermochromics from colour to transparent. (Little, 2008, p. 63) Little\(^ {33}\) comments in an interview that she would not recommend Photochromic dyes being used in windows, for example, curtains or window screens with the present standard of the lifespan of the reversibility of the material. Having them in a dark place, only taking them out every now and then, can make the material stay changeable for several years.\(^ {34}\) It looks however promising for the future in relation to the research started within this area.

Tests with HALS and UV-absorbers have been done to slow down the degrading time of the Photochromic dyes, and successful results have been done with the HALS (Hindered Amine Light Stabilisors). Levels from 0,05% to 1,0% of HALS works well on both fabrics and in yarns. (Little, 2008, p. 175) The HALS is making the radicals less destructive (Radicals are chemically destructive). (Little, 2008, p. 131)

The UV-absorbers worked less efficiently, compared to the HALS. It might work with a combination of the two, something that is being tested at present at Heriot-Watt University.\(^ {35}\) The dye will not be exposed to the UV-light because the UV-absorbers absorb the UV-light. The result is a reduction

\(^{29}\) The UV irradiation of colourless molecular causes the molecular to a colour species, which reverts thermally to its colourless form. (Christie, 2008, p.141)

\(^{30}\) Christie, Prof. Heriot-Watt University, UK, meeting, 101008.

\(^{31}\) Irreversible (does not change back the colour after the UV-light source are removed) Reversible (change back the colour after the UV-light source are removed) Photochromics (www.colorchange.com, 200308).

\(^{32}\) Standard testing of colour change due to UV-light; the fabric is exposed under a daylight lamp for a certain time. After that the fabric is compared to a standard grading to see how much lighter the colours is.

\(^{33}\) Little is presently publishing her Ph.D. Thesis “An investigations into Textile applications of Photochromic Dyes” and one of the researchers under Prof. Christie.

\(^{34}\) Little, Anna, Ph.D. School of Textiles & Design, Heriot-Watt University, UK, meeting, 100908.

\(^{35}\) Christie, Prof. Heriot-Watt University, UK, meeting, 100908.
in the colour change (a less coloured hue), in relation to the amount of UV that is absorbed. (Little, 2008, p. 46) One might be able to use that in a design aspect to get different hues in a pattern. The UV-absorber extend the lifetime of the yarn, because it encapsulates the UV-radiation. The effect is better on yarns than it is on fabrics.36

Trinuvin 144 was the chosen additive for the test prints for this project in accordance with Little's tests of the two HALS Trinuvin 144 and Trinuvin 770. Studying the colour graphs37 showed a more effective result for 144 in the tints of interests (Aqua Green and Corn Yellow Rush). (Little, 2008, p. 131-136) The initial dye tests38 were mixed according to the following procedure: the dyes and the HALS were mixed with Acetone, the solution were then heated so the dyes dissolved, and finally the solution was mixed with binder (for dye recipe see Appendix 1). Due to that previous tests have shown good colour results at a lower concentration of HALS the chosen quantitative of the additive were 0,50% - 0,25 gram HALS/50 gram binder. With exception of the Rush Yellow that has shown better results first with a higher % HALS (up to 10%). (Little, 2008, p. 210)

The surface resulted in a non-homogeneous expression, with dots in the print. Homogeneous tests were done with mixing up the dye without the HALS, which indicated that the dots in the solution had a connection to the HALS. After discussion with Chemist Prof. Christie and Chemist Ph.D. Little the following changes were done in the dye recipe and the order of mixing the dyes and the HALS were dissolved separately in Acetone. The dye and the HALS were mixed with Acetone, the solution were then heated so the dyes dissolved, but only the dye dissolved properly in the solution.

Another interesting design possibility would be a colour sensitive to a certain amount of UV-radiation; for example only wanting a colour change to activate when it is really sunny. No research regarding this was found. However, its possibility was discussed with Christie during a meeting. If this was possible one might be able to design a material that is reactive to the least unhealthy UV-radiation. Application wise today it is not suitable to use the UV-lamps were heated, but only the dye dissolved properly in the solution.

Today (on the market) there are no Photocromics that change colour in response to a specific wavelength. There is however research being done on Photocromatic dyes that will activate on different wavelengths. Different colours react with different colour intensity to UV-A, UV-B, and UV-C.41 The Photochromic dye was baked fixed in 140°C for five minutes (Little, 2008, p. 211).

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with the damaging radiation, which limits the design options. It would also be interesting to be able to get the fibres more UV-sensitive than the ones that exist on the market today, so a colour change would occur when it is cloudy outside or if the design is placed further from a window.

Research indicates that the colourability of the Photochromics works better on cotton in relation to polyester (Christie, 2008, p. 141). Polyester is UV-absorbing while cotton is UV-reflective, meaning that the colour effect is stronger on cotton compared to polyester. Tendencies also indicate that UV-B is more effective on the cotton and that UV-A works better with the polyester (Little, 2008, p. 191). For the cotton it seems like the UV-light goes into the material as well as bounces back with more strength, actually accelerating the intensity of the colour surface. A flat surface will probably have a more intense colour change compared to a 3-d surface, due to the fact that the UV-radiation will scatter. More light will get lost in all directions, whereas a flat surface would reflect all UV back the same way, like a mirror. Little has not found any material that has not been printable with the Photochromics as long as the binder has been compatible with the material.

The Photochromics react differently regarding how high the temperature is. Repeated experiments done both in the summer and the winter indicated this, due to the fact that the colour change differed even when the test parametric were the same. The conclusion was that the Photochromics have a stronger colour change at a lower temperature. At 200°C the Photochromic becomes Thermochromic (it then goes from white to colour). This is an interesting change in the fibre. It might however not be usable for interior applications due to the very high effect temperature. The Photochromics do not change colour at higher temperatures (>35°C), something that might become of importance if the material is exposed in a window summertime, when temperature inside the glass might rise. One can freeze the Photochromic material to get a permanent colour that does not change (at -60°C), when heating it again the reversible change is activated again. (Little, 2008, p. 81-82).

**THE COLOUR PALETTE** of the commercial yarns is very limited, setting boundaries for design possibilities. Recent experiments have successfully resulted in developing a Photochromic solution printable with a digital printer, this opening up new design possibilities for the use of the chromatic material (Christie, 2008, p. 142). The progress for digital printing with Thermochromics has as far as I have found been less successful. The Thermochromic materials exist as microcapsules which are to big, clogging the nozzles in the heads of the machine. Research has indicated that Thermochromic (it then goes from white to colour). This is an interesting change in the fibre. It might however not be usable for interior applications due to the very high effect temperature. The Photochromics do not change colour at higher temperatures (>35°C), something that might become of importance if the material is exposed in a window summertime, when temperature inside the glass might rise. One can freeze the Photochromic material to get a permanent colour that does not change (at -60°C), when heating it again the reversible change is activated again. (Little, 2008, p. 81-82).

The ability to extrude yarns or to cone dye yarns opens the usability of knitting, weaving or embroider with the Photochromic yarns and still not having to reduce the design to the limitation of the very few commercial colours. Research has successfully been done extruding Photochromic Polypropylene, giving a result with both higher light fastness as well as colourability compared to print (Little, 2008, p. 3, 163 and 170). It will be very interesting to follow the development of the research with other materials.

The width of the material range is a crucial point seen from a design perspective. In an attempt to see if it was possible to Ram-extrude Photochromic yarns with higher colour intensity compared to the one on the contract market collaboration with Ibrahim at the Heriot-Watt University was conducted. A dark green PP yarn, with a dye solution of 0,25 % with the colour dye Aqua Green, was successfully produced (for recipe see Appendix 2). It shows high colour intensity after just one minute of exposure under a UV-daylight lamp and the fading time on the colour was notably slower in comparison to the other samples.

After discussing the design possibilities and applications with extruded Thermochromic yarns, it is interesting to think about the future, where a ram together with heat and pressure, presses the solution through a small hole, creating a monofilament thread. The following dyes were tested Reversacole™ Aqua Green 716-LH01-W1, Reversacole™ Oxford Blue 7024-ML002-W1 and Reversacole™ Rush Yellow 7184-PDO-04-W1, supplied by James Robinson Ltd, UK.
yarns with Christie at the Ambience 2008 conference initial experiments of extruding Thermochromic yarns has been done at The Heriot-Watt University. The first tests with the extrusion with EVA fibres with Thermochromics properties resulted in a non-homogeneous monofilament. The Thermochromic molecules have not mixed so well with the EVA fibre; one can see blue dots in the yarn. The result is a semi-transparent yarn; it changes around 31 °C. The experiment was done with a 2,5% strength Thermochromics, but still gives a rather subtle colour.

In the initial sketching phase in relation to the idea of working with extruded a Thermochromic yarn design ideas with knits were explored. Tests were done to see if it is possible to get a colour change by using embroidery with copper yarn onto a 3-d knitted shape. To visualise the Thermochromic yarn the kitted surface was sprayed with a liquid Thermochromic dye (see images 35-36).

THE ENVIRONMENTAL issues regarding the used Smart Textiles in contrasts with more traditional textile materials at present favours the Thermochromic Leuco dye over the Thermochromic Liquid Crystal. Due to the facts that the TLD is cheaper and a more durable product (more UV-resistant), which is important from a sustainable perspective. Even if the degradation time is being slowed down through research, both when it comes to the Thermochromic as well as the Photochromic materials, this will of course not be a problem for the non-changing traditional textile. In general all textiles, however, degrade in hue given enough time.

In respect to the present research being done the added value of the changeability effect in terms of the possibility to meet the patient’s Social needs will argue against the lifetime aspect, if the material will be improved. The fact that the Thermochromic colour change is activated with the heat loss from electrical current is another debatable environmental issue. Meaning that if the change is being used solely as extra effect the energy has to be produced for this alone. However, one might again argue that the emotional value the informational interaction gives the patient might be beneficial in relation to the energy being used.

In a discussion relating to the energy loss Robertson argues that new knowledge of how the chromatic materials functions by exploring the use of current and the conductive materials research might lead to new solutions of circuit designs that might give more sustainable heating solutions. There is also ongoing research on Electrochromic materials, which changes colour due to electronic current (Biever, 2008). The material needs a very low Voltage to change in contrast to the Thermochromic. The colour change then appears until a new Voltage is led through the material, in contrast to Thermochromic material where the heat has to be kept on until the reversed stage is wanted. This might be a good alternative to the Thermochromic inks if the research is being pushed. In the meantime the Thermochromic material can work as a visualization for a conceptual idea in pushing the use of Smart interior textiles as well as textile in general in hospitals.

The more electronics that is incorporated into the fabric and the more different materials that are bonded/laminated together, the harder it will be to recycle the fabric. The “new” material might not be possible to separate into its original materials after the products lifecycle. At present this project is not far enough to an actual product, making this discussion more theoretical, but it is still important to raise the issue.

There are several question marks to solve in relation to the environmental issues of the chemicals. It is important that we discuss the balance between the impacts of the stress on the environment in relation to the gain of the applications of the materials. At present all the Thermochromic materials I have found have Formaldehyde in the binder. The chemical is however most likely to be non toxic due to the micro encapsulation. To know what will happen if the fabric burns and whether there will be toxic fumes, the material needs to be investigated. Additives such as HALS and Acetone are toxic and flammable.

52 Ibrahim, Wasiim Ph.D., student in chemistry, School of Textiles & Design, Heriot-Watt University, UK, meeting. 130908.

54 Due to the company restrictions it is hard to get information of the exact amounts and parts in dyes.

55 Robertson, Sara, Ph.D. student Smart Textiles, School of Textiles & Design, Heriot-Watt University, UK, interview, 151008.
THE AESTHETIC

EXPRESSN - to think outside the box.

COLOUR - inspiration for freshness and new life.

AEThetics - the carrier of the Emotional needs.

blossom - the fullness of the fields of individuals enriches the scenery in scale.

THE AESTHETIC EXPRESSION - a positive image for healing.

NATURE - a positive image for healing.

COLOUR - inspiration for freshness and new life.

AEThetics - the carrier of the Emotional needs.
“TO THINK OUTSIDE THE BOX” is a well known saying, but how does one really succeed with it? The purpose with the sketching process has been to find new ways to challenge myself in striving to develop an aesthetic expression that meets the keywords “Alive” and “Feeling well” often Mood Board⁵⁶ (see image 57).

To break the boundaries of today one has to know the present as well as the past, but one also has to ignore the rules that the present is shaped by. In 1960th the artist Gernes painted the walls in the hospital Amts in Herlev in Denmark in bright colours (see images 46-51). Before the total hospital was remade a test ward was constructed and used during three months. The evaluation was that the colours had a positive impact on the environment. (Nejst Jensen, www.ugeskriftet.dk, 100507) being an inspiration and a brick in daring how to use colours Amts is still an exception to the rule when it comes to interiors of today’s hospital.

NATURE WAS SET AS an inspiration in finding an expression that might meet the Emotional need of the target group. The nature is said to have a calming effect on patients (lowering blood pressure and slowing down the heart rate) as well as improving the recovery time, something Ulrich states on the foundation of several scientific experiments.

“...of simply viewing nature... stressful or negative emotions such as fear or anger diminish while levels of pleasant feelings increase... physiological changes... in blood pressure and heart activity... looking at built scenes lacking nature... may worsen stress... heart-surgery patients... assigned a picture with landscape scene with trees and water reported less anxiety/stress and needed fewer strong doses of pain drugs that a control group assigned no picture.” (Ulrich, 2004, p. 21)

Research indicates that nature can be used as a parameter in restoration of mental health. When being hospitalised for a long time as the intended target group might be this becomes significant, as well as the factors the isolation brings to the situation. (Keplan and Keplan 1989 and 1998, see Kovary 2002, p. 116.) Studies also indicate that a picture of a landscape with trees and water resulted in a patient undergoing surgery reporting less pain than the one watching no photography (Ulrich, 2004, p. 21).

Different flowers and leaves were studied and sketched to understand the shapes and expression of nature. The idea of the concept of the House of Giving Life⁵⁷ was hatched during this analytic process. In Swedish the word hospital’s sjukhus which would be translated into the House of the Sick, a word that itself connotes something depressing and bad. To create a more positive atmosphere in the hospital the change has to start with something as fundamental as the name of the place itself. Instead of talking about diseases we should talk about health and life; making people’s well being the main idea with the hospital as an institution.

The House of Giving Life meant to do just that, give the patient a feeling of security that they will leave the establishment better than when they arrived. Knowing that of course that can not be all cases does not mean it can not be the intention of the atmosphere and what to strive for. Implementing this idea into the expression of the intended product and the sketching phase of the project meant setting three key-words as a frame for the work – the power in Growth, Deliverer of Joy and the Giving of life⁵⁸. Throughout the sketching the Mood Board was moulded into the essence of the key-words, stripping it down to the ideas of the nerves of the leaves and the chlorophyll being nature’s power of growth, the pistil and the bud being the starting point of the life of plants and the joy and completion when the flower has fully come out. (see image 57)

⁵⁶ Mood Board is a term used in design methodology to clarify what emotions and feeling the product is meant to evoke/trigger. Both pictures and key-words are often used to visualize and verbalise the wanted feeling.

⁵⁷ In Swedish: Växtkraft, Glädjespridande and Livgivande
the Power in Growth

the Giving of Life

Deliverer of Joy
REGARDING COLOURS there are different sayings, in relation to what psychological effect they have on us and their cultural and symbolic meanings. The colours of an artefact have an important impact on the reading of the expression. Different researchers state that certain colours can reduce anxiety and that nature motifs more readily catch our attention than an abstract one. Küller argues (Küller, 1995, p. 22-24) on the foundation of his practical colour experiments that humans responds with different physiological measurable effects in relation to different colours and on different colour settings in the room. A blue room has for example a higher increase in the Alfa rhythm \(^{59}\) and the Delta rhythm \(^{60}\), compared to red. Sikvik (Sikvik, 1994, p.48-49) on the other hand states that how we relate to a colour partly have to do with the colour partly the tint (the amount of whiteness, blackness and colourfulness).

The aesthetic expression is of significance for the healing process, where colours and shape, through art and music, can be a working tool (Watson 1979, see Wikström 2003, p. 40). The architectural design is important for the healing process because the architecture can also have a negative effect, such as being stressful. But by creating a harmonic and well balanced environment the effect can be the opposite. (Wikström 2003, p. 60) This aspect is also something that Edvardsson touches in his dissertation (Edvardsson 2005, p. 70) when talking about the importance of the surrounding and how it affects the patient's experience of the hospital environment and the hospital stay.

Using colour psychology as a scientific argument is still being disputed and due to the different schools of thought it becomes hard to give validity to the arguments. To this also comes the wide cultural difference that exists in relation to colour. Even looking at Scandinavia the use of colours differs a lot between areas as close as Sweden and Denmark, the last one often using more intense colours with a high colourfulness in relation to the first one. The cultural differences will of course have an effect of how the patient will read in the chosen colours, making it even more complex using colour psychology as a foundation of the colour choices.

In former projects leading up to this Master thesis colour psychology have met argumentative difficulties in discussions with researchers, designers as well as everyday people. Therefore this project has taken the inspiration and grounds for the colour choices from the concept with the House of Giving Life. The colours chosen in relation to the inspiration pictures and key-words of the Mood Board as well as in relation to the ward being for patients needing more stimuli because of the isolation. To underline freshness and new life the chosen colours have a high colourfulness with less whiteness as well as blackness. (See images 62-63 the Colour Board\(^{61}\))

When working with a range of colours that will apply to Thermochromic colours it is important to already from the beginning have in mind that one is designing two colours in one, that the colour position 1 (the textile is cold) is depending on the colour position 2 (the fabric is heated). The chosen green therefore have to consist of the chosen yellow. The range of colour is also limited by the fact that the Thermochromic colours all tend to be quite cold (also the yellow, orange and red) meaning that the range of colour will be more cold than warm. It would be interesting research wise to look closer to see if this has a chemical or practical reason. The possibility of being able to reach a more wormer set of colours would of course give a wider design aspect.

In relation to the colour shade the Photochromic material as mentioned earlier is limited in the lack of colour intensity. Resaving the desired expression controls the design to the non Photochromic having more intense shades. The colour intensive tints are created with the Thermochromic inks in the samples that are both Thermochromic and Photochromic. While the tints in the samples that are only Photochromic are created with digital print. The more subdued Photochromic colours make the expression more varied and are complementing the intense green hues well, something that is important for the over all expression.

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61 Colour Board is a term used in design methodology to in an early stage clarify the colour shade intended for the product in an attempt to focus the design process. Both pictures with the intended colours and colour samples are often used to visualise and the wanted hues.
The green colours printed with Thermochromic ink on 100% Polyester Non-woven No. 488, 70 gram Cordigarn AB
Colour position 1 and 2, depending on if the samples are heated or cold.

Images: 62-63 The Colour Boards for the pink as well as the green colour shade. In the end only the green was used.

The green colours printed with Pigment ink on 100% Polyester Non-woven No. 488, 70 gram Cordigarn AB
Colour position 1, not heated.
The Puff ink, together with the print (Thermochromic ink and Pigment ink) on 100% Polyester Non-woven No. 488, 70 gram Cordgarn AB.

Colour position 1 and 2, depending on if the samples are heated or cold.

The green colours printed with Photochromic dye on 100% Polyester Non-woven No. 488, 70 gram Cordgarn AB.

Colour position 1 and 2, depending on if the samples are exposed to UV-light or not.
To open up the design possibilities for the materials chemists hopefully can develop the Photochromics to bee more colour intensive. Compared to the extruded Photochromic yarns the Photochromic printing dyes are even less colour intensive. This is also something that Little found a tendency for in her research work.\textsuperscript{62}

There are more design examples done with the Thermochromic inks compared to the Photochromic dyes. No design application were found where a Photochromic print goes from one colour to another, there are however information on the web that it is possible to do (www.matsui.com, 080915). Therefore tests were done to mix pigment ink together with the Photochromic dye after the same principle as when mixing Thermochromic ink together with pigment ink. Having in mind that the two chromatic materials are each other’s opposite in colour changeability, the Thermochromic going from dark to light and the Photochromic from light to dark, this worked well.

Due to the subdued tints of the Photochromic material the pigment ink cannot be too colour intensive. If it is, the colour change becomes too vague to bee noticeable. The final colour sample goes from a yellow to a more light green, when being UV exposed. The change is still more effective outside.\textsuperscript{61} Inside a window the ceiling colour should become too vague to bee noticeable. The final colour sample goes from a yellow to a more light green, when being UV exposed. The change is still more effective outside.\textsuperscript{61}

Different application areas within the room were tested. There was not the ceiling was delimited due to the intense colours, the pattern give a slight claustrophobic atmosphere to the room, an expression that is opposite to the desired one. The sketches having an image covering a whole or a big part of the wall got the most positive response in discussions with others. The size of the image added to giving a feeling of the textile being an architectural element rather than a traditional added textile product. (see images 101-110)

\textbf{SEVERAL STAGES AND CHANGES}

of the sketches forced the process onward. Having the motto “\textit{Think outside the Box}” in mind, new ways to approach the sketching was thought of. The sketching process resulted in tryouts in a variety of techniques such as drawing with different pencils and watercolours, moulding shapes with materials from everything from tissue-paper, plastic mugs, paper plates to different qualities of Non-woven and felted fabrics to knitted metallic fabrics, knitting and crouching different shapes, projecting photos of flowers and leaves onto the different shaped materials as well as CAD simulations of both structures and shapes of the materials. (see images 64-87, 92-96 & 98-115) To get a comprehension of the outcome of the effect of the expression and due to the scenario several of the sketches were in scale 1:1.

\textbf{IMAGES pages 32: 64, 66 \& 69 Sketches with paper plates of different shaped flowers to find if an interesting expression could be built through a lot of similar smaller shapes. 67 A visualization of how to use large fabric leaves to create a 3-d wall. 65 \& 68 Sketches with Non-woven and Ruben yarn in full scale too see how to create a leaf structure that expresses the wanted feeling.}

\textbf{IMAGES pages 33-34: 70-72 3-d moulded leaf structures with different copper flat knitted materials. 73 The different flat knitted metalised used in the sketching process. 74 Full scale leaf structure with Non-woven and plastic tubes. 75 \& 79 Sketch of leaf structure in with Non-woven and shaped flat knitted copper material. 76 \& 78 Cotton thread and needles building up a delicate structure, mapping the nerves from a Rose leaf. 79 Hand crouched Ruben yarn to symbolize the nerves in the leaf. 80 Projections onto the wall to try out the full scale impact of the motifs. 81 A feeling of a small relief structure on the Non-woven material was created when the images were projected onto the textile surfaces. 82 The projections were also tested onto different 3-d structures, to find a balance between the bigger shape and the pattern.}

\textsuperscript{62} Little, Ph.D. School of Textile and Design, Heriot-Watt University, UK, meeting, 100908.
KEEPING THE CHROMATIC materials in mind during the sketching process, the different expressions were evaluated in relation to how the materials would be applicable within the design. The example to the left is a part of the analysing development that continuously took part throughout the design process, to exemplify the usability of the chromatic materials.

After several sketches with different sizes of the vanes of the leaves a decision was made to work further with thinner threads/vanes, to get the expression of fragility of a leave, without losing the organic feeling of life and growth. A decision to delimit the techniques to printing and embroidering was made after testing different knits and discussing the knitted sketches with other designers, persons in general and some working nurses in SÄs in Borås (see images 83-87). The sketches indicated difficulties in associating the 3-d knitted shape with the pistil of the flower. The importance to get the shape exactly right and that it is irregular is high (otherwise it looks more like finger gloves and fallsow symbols). Today there are limitations of what can be done on the industrial knitting machines in relation to reaching a more organic and irregular 3-d shape (Jansen, 2008, p. 47). Adding the timeframe of the project, the limitation on only using one technique gave a chance to get deeper into that technique, to further explore how that technique can be used to push the colour changeability effect.

The 3-d surface however ads an interesting expression with the play with sun and shadow, that gives a feeling of life into the structure (which is suitable for the nature inspiration). Sketches were made to see how this still could be met through a small relief structure with embroidery and puff print. The Puff ink created interesting relief structures which added a hepatic feeling, suitable for the touch sensor, (the window screen). To get a balance the expression test was done with larger areas of the surface covered with the Puff print to only using it to accentuate. The larger areas tended to feel more plastic and were therefore delimited (see images 88-91). The embroidery however did not create enough relief to gain a satisfying result.

Due to the fact that a high percent of the target group are spending most their time bound to the bed, added reasons for delims...
IMAGES: 83-86 Visualizations of 3d knitted pastis in the room, as well of the scale of the shapes. 87 3-d knitted sketches.
iting the 3-d surface, the patient's mostly using the visual sense and not the touch. It is more important that the surface looks 3-d rather than actually being 3-d. To not overload the expression fewer parameters is preferable. A 3-d structure often has a bigger expression impact in comparison to a flatter structure.

After testes with mixing both the Thermochromic inks and the Photochromic dyes with the Puff binder a decision was made to mix the Puff with a normal pigment ink. Today the aesthetics and changeability effect with the chromatic material and the puff binder are not there yet. The Puff binder demands a higher amount of pigment to get a coloured tint in relation to traditional pigment binder.63 The Puff binders' beige-yellowish colour64 does not look so interesting. This resolves in a need to mix the chromatic materials with pigment ink otherwise the hot position and non UV-exposed position will show a rather unattractive colour (the tint of the Puff binder). Due to the problem that the Puff binder demands more ink to get a more intensive colour this makes the percentage of chromatic ink and dye used in the mix rather small, which gives a vague colour result with a small colour change (see images 37-38).

The Thermochromic ink works better than the Photochromic, where the colour change almost disappears. Due to the expenses of the materials the amount of reaction does not feel motivated. It would however be interesting to see if one can find an alternative Puff binder that is more transparent. The binder of today also gives a yellowish tone to the tints, which one has to think of when mixing up the wanted colour.

63 This might be solved with some other binder on the market than what I have found.
64 There might be a more transparent binder on the market than what that I have found.

IMAGES: 88-91 Test prints to find a balance for the amount of Puff being used in relation to the printed pattern and the embroidered surfaces.
chromatic chlorophyll
THE CHOICE OF PATTERN, being a naturalistic and organic image, was made based on the research that nature has a calming effect on patients. Several images were tested and discussed with external partners in an attempt to find a pattern that connoted a feeling of “Alive” and “Well.” Some images were delimited for being possible to associate with neat or unsure directions. The final image of the leaf in question was chosen because several of the discussion partners felt it was calming with its straight linearity, but still active due to the upwards striving direction of the image (from lower left towards upper right) (see image 98). Initially the idea was to let the two concepts be visualized through different images and colours (the pink flower in image 92 as well as the green leaf in image 98). To clarify the difference between the two chromatic materials when designing with them, both colour wise as well as a material, a decision was made to only use the leaf image and green colour range.

Stressing the expression to easily be associated towards nature, led to the idea to test if it was possible to get a satisfying result with combining digital and manual printing techniques. Experiments were conducted to see how the expression of the digital print and the screen print worked together (see image 97). The digital printing company Danish Ship Decor, who has developed a digital printing technique with Disperse dyes to get more intense colours than digital pigment printers normally does, was consulted. Danish Ship Decor has also successfully got an even printing expression without the lines in the image that often occurs with a digital pigment print. Test prints were done on the Polyester Non-woven, and the result was quite satisfying. The material has not been pre-treated or fixed after.

Due to the transparency of the material on a light Silk Organza tests with digital printing with Reactive dyes turned out rather subtle. The samples have been steam fixed in 140 °C for five minutes and then first hot washed and then cold washed. Therefore tests were done in combining the more subtle expression of Thermochromics with a higher colourfulness. The samples letting the Sun’s heat change the Thermochromatic area (the surface functioning as a touch sensor) were thoughts that were developed from these tests. During the test prints the design was simplified to create a balanced expression, resulting in the digital print being combined with either the Photochromic or the Thermochromic print.

During a tryout to visualize the digital print onto the Polyester Non-woven an interesting discovery with pigment binder was done. The lack of access to a digital printer for Disperse dyes resulted in a print with Acid dyes onto the Polyester. The colourfulness in the print became quite low in relation to the image on the screen. Due to the Acid dyes the fabric could not be fixed and can not take any water (the ink will fade out). Printing a Photochromic layer onto the digitally printed sample a small bleed accrued into the digital ink. The Acid dye reacted with the Photochromic dye giving a lining of a shade with high colourfulness, which raised the question whether something in the Photochromic dye had reacted with the Acid dye. The Photochromic dye consisted of the dye, Acetone and regular printing binder. To secure that the reaction was triggered by the pigment binder a test print with only the binder was conducted. The shade of the colours after coating the sample then transferred to full colourfulness in relation to the image of the computer screen (see image 97). The phenomenon can not at present be explained but it would be interesting to see what developments that could be drawn from it, and to see if this could be a way to print with Acid dyes onto man-made fibre.

66 The screen used is rather well calibrated towards the printer being used, with a rather low colour difference from the image on the screen and the actual print.
67 Consultant with Christie, Prof. & Kaimouz, Ph.D. student in Chemistry, School of Textiles & Design, Heriot-Watt University, UK, 231008.

IMAGES pages 39-40: 92-96 Visualizations of the flower pattern in a room, as well as sketches of the abstraction of the pattern. 97 Digital Acid printed samples, binder coated and uncoated. The one with a high colourfulness in the right the first one and the one with a more subtle one to the left the second one.
IMAGES pages 41-42: 98-100 Inspiration photos of leaf structures. 101-110 Visualizations of different application areas with the pattern, as well as sketches of the abstraction level of the leaf pattern. 111-113 Visualizations of the colour change from green to yellow through the nerve structure in the pattern.
THE EMBROIDERY is being used to build a light relief structure of the surface, to get a more interesting hepatic experience but also giving a contrasting visual effect with the more flat printed surface. To reach a more exact expression the embroidery machine was used. The thicker multifilament copper thread can however not be used in the machines, which led to sketches with machine embroidery together with hand embroidered copper threads, to only hand embroider copper threads. The expression between the two techniques differs, making a collision of the fine and exactness of the machine embroidery and the rougher and the freer of the hand work (see images 122 & 136).

It was considered if pushing the technique into more of a handcrafted expression might give a positive effect on the patients. That if the notion of knowing that someone has put time and energy into the making of that specific piece could give the patient a feeling that the person had done it for them was discussed with others. However the handcrafted expression was overruled by the crispiness of the expression of the exactness the machine embroidery was adding. An expression that felt closer to the initial feeling of the Mood Board.

The embroidery with the Viscose yarn also functions as one or several extra hues for the samples, without adding extra printing screens. By using the embroidery with the Viscose yarn the aesthetic expression gains a bigger flexibility. Here final hues are not set at the printing stage and can therefore be varied between the samples. The chosen Honeycomb stitch creates an optical colour mix, which makes us see an added hue in relation to the printed surface the stitch is embroidered onto. This also of course gives added hues in the colour-changed position, making the colour work more complex (see images 131-132). Several different stitches and sizes of the stitch were tested to get the right effect and expression before the final one was chosen (see images 124-126).

To see how the materials worked together experiments with embroidering onto the different materials were done. The larger embroidered areas only worked together with the Non-woven; the lighter Organza not being stiff enough (see images 116 & 118). The linear stitch worked well on all the materials. The linear free-hand stitches
Images: 116 Test sample from experiments too find a balance between the embroidery and the printed surface. 117 The stitches create a visual linearity, when stitching with the copper thread onto the thin Organza. Resulting in a delicate expression, when the Sun is going through the material. 118-119 The thin Organza is not stable enough for the denser and larger areas of embroidery, making the linear free-hand stitches a better option. 120 Tests of various patterns of the embroidery, from covering bigger surfaces to more fragmentized areas. 121 Tests of combining the multifilament copper yarn with areas with Puff. 122 The combination with the machine stitched Viscose yarn and the rougher hand-stitched copper thread, makes the hand-work look simpler, and was therefore not combined within the same sample. 123 Embroidery machine stitching test samples with a Viscose yarn. 124-126 Samples of stitching experiments done during the process.
A rather small contrast is created when a darker blue-green Viscose thread is embroidered on a darker green Thermochromic printed surface. The contrast increases between the two when the fabric is heated and the Thermochromic inks turn into a lighter yellow. The yellow Viscose Honeycomb pattern is more differentiated with the Thermochromic printed darker green background and after the colour change it fuses together with the yellow colour. The chosen Honeycomb stitch creates an optical colour mix adding an extra hue; this appears both in the unchanged and the changed colour position.

IMAGES: (page 46) In finding an expression for the glittering effect of the leaf when the Sun shines on it test prints with a shiny Non-woven material were done. Softness and a feeling of depth is created by bonging together the two layers the thinner Silk Organza and the Polyester Non-woven. 

IMAGES: (page 47-48) Visualization from the bed in the patient room with the concept “the Rhythm of the House”. Hand embroidered copper thread on the Non-woven material.
created an interesting crisp expression that talked well together with the freshness from the leaf in the Mood Board (see image 119). The more heavy embroidered surfaces created a denser and more compact expression, making the lighter Honeycomb stitch more suitable. The mathematic structure of the Honeycomb also makes an interesting contrast to the more organic printed pattern, having in mind that the Honeycomb is a pattern from nature, makes that union quite natural. (see images 120 & 127-130)

The embroidery also creates a possibility to play with the changeability effect, thought either using a contrasting colour on the stitch in relation to the colour for colour position 1 (not changed) or for colour poison 2 (changed). The samples both show the change from a higher contrast to a more subtle one as well as the opposite letting the Honeycomb pattern first fuse together with the background and after the colour change become more differentiated (see images 127-130).

**THE MATERIALS AESTHETICS** from analysing the qualities of the Leaf, which then has been translated into the materials.

**The Leaf**
- Stiffness, being crispy (low drape ability)
- A glittering shiny topside and duller backside
- Low stretch breaks rather easily
- High transparency, except through the nerves, they are opaque
- Rustling noise

The leaf is fragile and sensitive but at the same time stable and strong, which applies more to thinner threads and a more even surface, than rough and thicker threads. A woolly material for example gives more associations to a dry material (which when it comes to leaves = death). The leaf has a feeling of almost being wet from the glossiness of the surface, which might be achieved by the use of laminating or coating parts of the material or by using threads with a higher glare. A medium stiff 100% Polyester Non-woven, gives a feeling of the stiffness and the crispiness of the leaf. When using 68% 100% Polyester Non-woven, No. 488, 70 gram, Cordgarn AB, fibre treated to a lighter flame retardant level.

The Non-woven in the window the sun creates a glittering surface effect. To get an even shinier feeling 100% Viscose embroidery threads were used. The other layer of material is a light Silk Organza, which symbolises the quality of high transparency when the light shines through the leaf. Also here the base materials shiny surface adds to the glittering effects. The silk is however not so UV-resistant and is not the best solution for the window screens. At this stage the choice with the silk communicates the aesthetic expression and from a material point of view it would probably in a production be changed into a Trevira CS with similar visual and hepatic qualities.
wither - the decay of the plants creates the platform of evolutionary possibilities

THE FINAL MOMENT

THE CONCLUSION - of the thesis
THERMOCHROMIC - the now and the tomorrow
PHOTOCHROMIC - the now and the tomorrow
REFERENCES - for further investigations
APPENDIX - additional knowledge
THE DISCUSSION around the healthcare environment, and the still existing lack of aesthetic and humanistic values of the interior of today’s hospital environment has to come up to a university as well as a political level to be taken into action, as well as being conducted with the employees at the healthcare institutions. To be able to change the view and the situation of the interior’s role of tomorrow’s hospitals one has to discuss the reasons and arguments for the need to do so, and to that the professionalism of the designer’s perspective adds an important factor. Designers are having an understanding of the influence the aesthetic expressions have on people. The exemplifying sample at this stage becomes artefacts to lead the discussion rather than being ideas for prototypes for production. At this stage the selection of a specific application, such as curtains, carpets, wall panels or window screens is partly irrelevant as long as the objects work as a communicative platform in visualizing the viewpoint of the conceptual idea.

THE CONCLUSION OF the usability of the materials and the possibilities for further designing with them are structured in the following tables. The idea with the structure is to make the statements/points easier to overview, so interested parties can discuss the result. The aim with this work is to initiate a discussion around the materials, and form a platform were we could share information and usability of chromatics and to find constructive and exiting application areas. To be able to develop the materials further it is important to be open about knowledge, experiences and research around the materials, hoping that others will add to my knowledge. The points in the conclusion are my thoughts and experiences from working with these materials over the last two years. The conclusions are in relation to the chosen environment and application, as well as the information of research. Some of the problems or questions with limitations of the materials will probably not a cline for other situations, and more persons can of course cover more knowledge. Therefore it is essential to get the views and experiences of the materials from other designers/ researchers/ chemists/ technicians as well, to further understand the materials and how we can use them in the future.

Today one might think that the chromatic materials have more limitations and problems than possibilities for being useable in products. The materials still have several issues that need to be solved before we can see commercial products on the market, but the ongoing research of the materials is pointing towards both actual solutions as well as an interest in improvement. The thesis started with statements for why the chromatics has been used for these specific applications (even though for example the Photochromic material is not at present recommended for being used for window-screens). Throughout the text arguments has been raised for backing up the thesis. Above the reasons for the discussions that the chromatics would be an interesting solution for visualizing the change within a tangible textile interface, the reason for the choices of application is to set up some parametric to be able to begin to evaluate the Thermochromic and the Photochromic materials and to introduce a discussion to where a development of the material might be of interest.

THERMOCHROMIC · LUECO DYE

<table>
<thead>
<tr>
<th>WORKING TODAY</th>
<th>LIMITATIONS TODAY</th>
<th>POSSIBILITIES FOR THE FUTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The Thermochromic can with success change from colour to transparent.</td>
<td>• The colour range is overall rather cold, which makes it harder to mix warmer hues.</td>
<td>• The present research points towards a possible development of products that uses the colour changeability in the design expression for example communicating information, create surprising effects or humoristic elements, which traditional inks and yarns can not do.</td>
</tr>
<tr>
<td>• The Thermochromic can with success change from colour to colour, through mixing them with Pigment ink.</td>
<td>• Sometimes a shadow print is left when the Thermochromic ink is heated when it gets transparent (for example in a pinkish colour).</td>
<td>• Research is being done to develop the Thermochromic material to be more UV-resistant, pointing towards improving the lifetime of future products.</td>
</tr>
<tr>
<td>• To visualizing ideas that uses the colour changeability in the design expression to communicate information, create surprising effects or humoristic elements, which traditional inks and yarns can not do.</td>
<td>• It is difficult to control the changeability effect through the embroidered, knitted or woven conductive thread, due to how uneven the conductive material behaves in relation to the textile construction technique. A straight line gives more even heat-loss, but then there might not be enough resistant in the material. This might be used design wise as a haphazard factor.</td>
<td>• Research is being done to develop Thermochromic threads, which would open up a whole new design aspect.</td>
</tr>
<tr>
<td>• Wide colour range; the Thermochromics can get a high colourfulness as well as more subdued.</td>
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<tr>
<td>WORKING TODAY</td>
<td>LIMITATIONS TODAY</td>
<td>POSSIBILITIES FOR THE FUTURE</td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>• Presently the Thermochromatic colour change is easier to control than the</td>
<td>• Conductive threads and specially made circuit designs are still rather expensive</td>
<td>• Using the heat-loss and energy to change the colour can be a way of understanding the</td>
</tr>
<tr>
<td>Photochromic, due to the fact that it is easier to control the heat than the</td>
<td>solutions.</td>
<td>changeability of the material, that might lead to finding more energy saving and sustainable</td>
</tr>
<tr>
<td>UV-light. The later at presently needs the Sun or a lamp, while the first ones</td>
<td>• Using the heat-loss and energy to change the colour is environmental discussible.</td>
<td>heating solutions, pushing and question today’s circuit design.</td>
</tr>
<tr>
<td>heating element can be integrated into the actual textile structure.</td>
<td>• To get a clear colour change, when using the conductive treads, colours in position</td>
<td>• The Thermochromic ink can also be used to point out an energy loss or over consumption</td>
</tr>
<tr>
<td></td>
<td>1 and 2 have to have a rather high colour contrast, or the base material have to</td>
<td>(the Interactive Institute in Sweden have done projects that are good examples).</td>
</tr>
<tr>
<td></td>
<td>be able to endure a rather high Volt (more heat).</td>
<td>• It would be interesting to discuss how discreet a colour change can be and still affect</td>
</tr>
<tr>
<td>• There are several ways to control the colour change; body heat, the heat</td>
<td>• The Thermochromic material degrades through UV-light.</td>
<td>a person.</td>
</tr>
<tr>
<td>from the sunlight, heat-cushions, radiators, hot water/steam, conductive</td>
<td>• The Thermochromic ink is quite sensitive to chemicals, for example limiting the</td>
<td>• It would be interesting to discuss what is gained in relation to the extra cost for a</td>
</tr>
<tr>
<td>threads, circuit designs etc.</td>
<td>possibility for washing the textile (important for the application area in question).</td>
<td>product being dynamic in relation to a static one, the first one being able to change and</td>
</tr>
<tr>
<td>• The electronic heat changing systems is not season related, and can be</td>
<td>• I have not found any Thermochromic treads on the contract market.</td>
<td>give an informative feed-back to a situation, which the later one can not.</td>
</tr>
<tr>
<td>used any time of the day.</td>
<td>• I have not found any dyes to cone dye Thermochromic yarns on the contract market or</td>
<td>• The research around the development of circuit design introduces new solutions to heat</td>
</tr>
<tr>
<td>• If wanting a more sublet colour change one can also use thinner more heat</td>
<td>any research of developments of dyes like this.</td>
<td>shape-designed areas of the patterns and structures. This adding possibility when working</td>
</tr>
<tr>
<td>sensitive materials as base materials, as well as embroidering, knitting,</td>
<td>• It is hard to get a distinct colour change with Puff binder, due to that the Puff</td>
<td>with more subtle colour changes, to more clearly communicate the colour change without</td>
</tr>
<tr>
<td>bonding in a thinner conductive material. The area that will change due to the</td>
<td>binder is whiter (in relation to for example normal pigment binder). The colour of the</td>
<td>increasing in colour contrast.</td>
</tr>
<tr>
<td>heat will be rather narrow to the conductive thread.</td>
<td>Puff binder without any added colours is white-beige, which might not be so attractive.</td>
<td></td>
</tr>
<tr>
<td>• Sensors (both textiles and non-textiles) can be used to control the colour</td>
<td>• The environmental issues with the chemicals used within or together with the</td>
<td>• The development with sensors (both textiles and non-textiles) indicates a positive tendency</td>
</tr>
<tr>
<td>changeability. When the heat is suppose to be turned on or off, which Volt</td>
<td>Thermochromic material, for example Formaldehyde.</td>
<td>for controlling the colour change in future applications.</td>
</tr>
<tr>
<td>that will be used, amount of Ampere are all factors that will have an</td>
<td>• The environmental issues with the chemicals used within or together with the</td>
<td>• The chemistry research around the materials is important for understanding the environmental</td>
</tr>
<tr>
<td>affect on the aesthetics as well as for the conceptual part.</td>
<td>Thermochromic material, for example Formaldehyde.</td>
<td>stress of the material and to find better solutions, but also to discuss the balance of the</td>
</tr>
<tr>
<td>• There is different temperature sensitive Thermochromic inks on the</td>
<td>• The Thermochromic ink can be printed onto a verity of materials, if one finds a</td>
<td>environmental issues in relation to the gain of use of the material within applications.</td>
</tr>
<tr>
<td>market, which makes it possible to design the Thermochromic to change</td>
<td>compatible printing binder.</td>
<td>• The price will probably improve if the demand of the products increases.</td>
</tr>
<tr>
<td>through several layers of colours. Adding Pigment inks adds additional colour</td>
<td>• The colour changing effect works also after the printed surfaces has been laminated</td>
<td>•</td>
</tr>
</tbody>
</table>
### PHOTOCHROMICIC DYESTRIPES

#### WORKING TODAY

- The Photochromic can change from transparent to colour.
- The Thermochromic can partly change from colour to another colour, through mixing them with Pigment ink.
- To visualize ideas that uses the colour changeability in the design expression to create surprising effects or humoristic elements, which traditional inks and yarns can not do.
- The colour change works best outside in direct sunlight, presently limiting the applications for indoor use.
- There is no extra environmental or chemical stress needed when using the UV-light from the Sun to activate the colour change, the Sun is there anyway.
- There are Photochromic threads on the contract market.
- The colour changing effect works also after the printed surfaces has been laminated or silicone coated (all the materials I have tested has worked fine).
- The Photochromic dye can be printed onto a verity of materials, if one finds a compatible printing binder.

#### LIMITATIONS TODAY

- The colour range gained through the change is rather subtle; it is hard to create colours with a high colourfulness.
- Sometimes a very light shadow print is left when the Photochromic dye is transparent and is not activated with UV-light.
- The colour change from colour to colour becomes even more subtle compared to from transparent to colour, due to that the Pigment ink has a minimum colour to start with.
- To control the colour change the Photochromic presently needs the Sun or a lamp, in relation to the Thermochromics heating element that can be integrated into the actual textile structure.
- The Photochromic dyes available are all sensitive to the same wavelength.
- The window screen eliminates parts of the UV-light, making the colour change more subordinate inside compared to outside. It would be interesting if we could make the material more sensitive so it would react on less amount UV-light. I have not found any research being done in this area.
- The colour changing is season as well as time of the day related, when being activated by the UV-light from the Sun. Making it discussable how well the material at present is for an all around the year application for more northern climate zones. One can of course make design solutions with a UV-light lamp to work around the problem.
- The UV-lamp I have found that has a satisfying changeability effect on the material all glow with a bluish light, which might not be wanted for the design expression.

#### POSSIBILITIES FOR THE FUTURE

- The present research points towards an interesting development of products that uses the colour changeability in the design expression; for example too create surprising effects or humoristic elements, which traditional inks and yarns can not do.
- Research is being done to develop the Photochromic material to be more UV-resistant, with for example HALS and UV-absorbers. This pointing towards being able to design for application areas such as window screens and curtains that today is not recommended.
- There is research being done to produce photochromic dyes that are sensitive to different wavelength UV-light, which would open up for new design possibilities.
- There are research being done to produce Photochromic threads that are sensitive to different wavelength UV-light, which would open up for new design possibilities.
- It would be interesting to discuss how discreet a colour change can be to still affect a person.
- It would be interesting to discuss what is gained in relation to the extra cost for a product being dynamic in relation to a static one, the first one being able to change and give an informative feed-back to a situation, which the later one can not.
- The chemistry research around the materials is important for understanding the environmental stress of the material and to find better solutions, but also to discuss the balance of the environmental issues in relation to the gain of use of the material within applications.
### PHOTOCHROMICIC · DYE

<table>
<thead>
<tr>
<th>WORKING TODAY</th>
<th>LIMITATIONS TODAY</th>
<th>POSSIBILITIES FOR THE FUTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• The discussion around health issues with exposure to UV-light; the Photochromic is however activated by the healthiest radiation.</td>
<td>• The price will probably improve if the demand of the products increases.</td>
</tr>
<tr>
<td></td>
<td>• The Photochromic material degrades through UV-light.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The Photochromic material is quite sensitive to chemicals.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• There are only very few Photochromic treads on the contract market, limiting the design possibilities.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• I have not found any dyes to cone dye Photochromic yarns on the contract market or any research around a development of dyes like this.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• It is hard to get a distinct colour change with Puff binder, due to that the Puff binder is whiter (in relation to for example normal pigment binder). The colour of the Puff binder without any added colours is white-beige, which might not be so attractive. If one want to use the Puff effect and go from one colour to another, this results in rather subtle colours as well as an almost non-visible degree of the change.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The environmental issues with the chemicals used within or together with the Photochromic material, for example the HALS, UV-absorbers and Acetone.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The Photochromic ink is rather expansive in relation to Pigment ink.</td>
<td></td>
</tr>
</tbody>
</table>
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Books


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Landin, Hanna & Worbin, Linda (2004). (Electronic) the Fabrication Bag - an accessory ti a mobile phone. In Pixel, Raiders2, Sheffield Hallam University, UK.


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Dr. Barbara Lane, Electronic and Smart Textiles, Weave & Workshop, at Swedish School of Textile, University College of Borås, Borås, Sweden (220207-270207).

pictures, 3-d and animation


Photography, Robertson, Sara, images: 25-27.


Gernes, Ulrikka S. & Hornung, Peter Michael (2003). The Medicine of colours – Paul Gernes and the Amt Hospital in Herlev, Copenhagen Valby, Denmark: Borgen, images: (p. 6), 47 (p. 8), 48 (p. 9), 49 (p. 16), 59 (p. 17) & 51 (p. 29).


3-D and animation, 2008, Bengtsson, Henrik, Imaginara (DVD).
APPENDIX · ONE

Photochromic dye recipe for printing, test 1
0,025 gram Dye
10ml Acetone
0,25 gram HALS – Tinuvin 770
50 gram Binder
(Little, 2008, p. 210)

Photochromic dye recipe for printing, test 2
0,025 gram Dye + 10ml Acetone
0,25 gram HALS – Tinuvin 770 + 5m3 Acetone
50 gram Binder

Photochromic dye recipe for printing, test 3
0,025 gram Dye + 10ml Acetone
0,25 gram HALS – Tinuvin 770
50 gram Binder

All samples are fixed in oven at 140°C for five minutes.

APPENDIX · TWO

Photochromic dye recipe for extrusion, test 1
0,25 gram Dye
100 gram Polypropylene grain (PP)

Pressure, 600
Temperature 230°C

APPENDIX · THREE

Thermochromic ink recipe for printing (100 gram mixed ink)
30 gram Thermochromic ink
70 gram Regular Print Binder

All samples are fixed in oven at 130°C for three minutes.

APPENDIX · FOUR

Thermochromic ink recipe for printing (100 gram mixed ink)
30 gram Pigment ink
70 gram Puff Binder

Raising the Puff all samples are ironed (3 dots).

APPENDIX · FIVE

Embroidery: Honey-comb 1a - the smaller pattern
Stitch height: 5,0 mm
Stitch width: 6,0 mm
Direction angle: 116 degrees

Embroidery: Honey-comb 1b - the smaller pattern
Stitch height: 5,0 mm
Stitch width: 6,0 mm
Direction angle: 280 degrees

APPENDIX · SIX

Embroidery: Honey-comb 2- the larger pattern
Stitch height: 9,6 mm
Stitch width: 10,0 mm
Direction angle: 349 degrees
Scale 1:15
The chosen eight final samples for the two concepts.
For information of materials, techniques and inks/dyes see App. 8

SAMPLES FOR THE WALL HANGING  
SAMPLES FOR THE WINDOW SCREEN
## APPENDIX · EIGHT

### SAMPLES FOR THE WALL HANGING

<table>
<thead>
<tr>
<th>MATERIALS/THREADS (SUPPLIER)</th>
<th>TECHNIQUES</th>
<th>INKS/DYES (SUPPLIER)</th>
</tr>
</thead>
</table>
| **ONE**
  Non-woven, 100% Polyester, No. 488, 70 gram, fibre treated to a lighter flame retardant level (Cordgarn AB, Sweden)
  Weave, 100% Silk Organza, not flame retardant (Heriot-Watt Uni., UK) |
  Screen printing (four screens)
  Digital printing; Acid dye
  Bonded; with Puff print |
  Thermochromic ink (recipe App. 3) (Matsui, by Zijdelings, the Netherlands)
  Pigment ink (Heriot-Watt Uni., UK)
  Puff print (recipe App. 4) (Heriot-Watt Uni., UK) |
| **TWO**
  Non-woven, 100% Polyester, No. 488, 70 gram, fibre treated to a lighter flame retardant level (Cordgarn AB, Sweden)
  Machine embroidery threads, 100% Viscose, Rayon 40, 200m-220 yds/vgs, Sulky CA 02776 - green Col1046 (Gütermann, Germany) |
  Screen printing (three screens)
  Machine embroidery, pattern Honey-comb 1b (for detail information see App. 5)
  Heated by heat element (back layer) |
  Thermochromic ink (recipe App. 2) (Matsui, by Zijdelings, the Netherlands)
  Pigment ink (Heriot-Watt Uni., UK) |
| **THREE**
  Non-woven, 100% Polyester, No. 488, 70 gram, fibre treated to a lighter flame retardant level (Cordgarn AB, Sweden)
  Multifilament copper yarn, 14 of 0,05 mm threads, (Neckelman, Germany) |
  Screen printing (four screens)
  Hand embroidery, Copper yarn
  Heated by resistance from the current through the copper thread |
  Thermochromic ink (recipe App. 2) (Matsui, by Zijdelings, the Netherlands)
  Pigment ink (Heriot-Watt Uni., UK)
  Puff print (recipe App. 4) (Heriot-Watt Uni., UK) |
| **FOUR**
  Non-woven, 100% Polyester, No. 488, 70 gram, fibre treated to a lighter flame retardant level (Cordgarn AB, Sweden)
  Machine embroidery threads, 100% Viscose, Rayon 40, 200m-220 yds/vgs, Sulky CA 02776 - green Col1046 (Gütermann, Germany)
  Multifilament copper yarn, 14 of 0,05 mm threads, (Neckelman, Germany)
  Lamination web, Co-polyamide, 12 gram/m², melting point 110-120 °C, machine wash up tp 90 °C (Jirotex, Sweden) |
  Screen printing (three screens)
  Machine embroidery, pattern Honey-comb 2 (for detail information see App. 4)
  Hand embroidery, Copper yarn (second layer)
  Bonded with lamination web
  Heated by resistance from the current through the copper thread |
  Thermochromic ink (recipe App. 3) (Matsui, by Zijdelings, the Netherlands)
  Pigment ink (Heriot-Watt Uni., UK) |
**SAMPLES FOR THE WINDOW SCREEN**

<table>
<thead>
<tr>
<th>ONE</th>
<th>MATERIALS/THREADS (SUPPLIER)</th>
<th>TECHNIQUES</th>
<th>INKS/DYES (SUPPLIER)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-woven, 100% Polyester, No. 488, 70 gram, fibre treated to a lighter flame retardant level (Cordgarn AB, Sweden)</td>
<td>Screen printing (four screens)</td>
<td>Thermochromic ink (recipe App. 3) (Matsui, by Zijdelings, the Netherlands)</td>
</tr>
<tr>
<td></td>
<td>Weave, 100% Silk Organza, not flame retardant (Heriot-Watt Uni., UK)</td>
<td>Digital printing; Acid dye</td>
<td>Pigment ink (Heriot-Watt Uni., UK)</td>
</tr>
<tr>
<td></td>
<td>Machine embroidery threads, 100% Viscose, Rayon 40, 200m-220 yds/vgs, Sulky CA 02776 - green Col 11046 (Gütermann, Germany)</td>
<td>Bonded with Machine embroidery, free-hand stitch</td>
<td>Puff print (recipe App. 4) (Heriot-Watt Uni., UK)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heated by heat element (back layer)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TWO</th>
<th>MATERIALS/THREADS (SUPPLIER)</th>
<th>TECHNIQUES</th>
<th>INKS/DYES (SUPPLIER)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-woven, 100% Polyester, No. 488, 70 gram, fibre treated to a lighter flame retardant level (Cordgarn AB, Sweden)</td>
<td>Screen printing (four screens)</td>
<td>Photochromic dye (recipe App. 1) (James Robinson, UK)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Thermochromic ink (recipe App. 3) (Matsui, by Zijdelings, the Netherlands)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pigment ink (Heriot-Watt Uni., UK)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Puff print (recipe App. 4) (Heriot-Watt Uni., UK)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>THREE</th>
<th>MATERIALS/THREADS (SUPPLIER)</th>
<th>TECHNIQUES</th>
<th>INKS/DYES (SUPPLIER)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-woven, 100% Polyester, No. 488, 70 gram, fibre treated to a lighter flame retardant level (Cordgarn AB, Sweden)</td>
<td>Screen printing (four screens)</td>
<td>Photochromic dye (recipe App. 1) (James Robinson, UK)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Thermochromic ink (recipe App. 3) (Matsui, by Zijdelings, the Netherlands)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pigment ink (Heriot-Watt Uni., UK)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Puff print (recipe App. 4) (Heriot-Watt Uni., UK)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FOUR</th>
<th>MATERIALS/THREADS (SUPPLIER)</th>
<th>TECHNIQUES</th>
<th>INKS/DYES (SUPPLIER)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-woven, 100% Polyester, No. 488, 70 gram, fibre treated to a lighter flame retardant level (Cordgarn AB, Sweden)</td>
<td>Screen printing (four screens)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Machine embroidery threads, 100% Viscose, Rayon 40, 200m-220 yds/vgs, Sulky CA 02776 - green Col 11510 and yellow Col 1187 (Gütermann, Germany)</td>
<td>Digital printing; Acid dye</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Photochromic embroidery threads, 100% Polypropylene Aqua Green, (recipe App. 2) (Extruded at Heriot-Watt Uni., UK)</td>
<td>Coated; Regulat print binder</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Machine embroidery, pattern Honey-comb 1a and Honey-comb 2 (for detail information see App. 4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hand embroidery, Photochromic yarn</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX · NINE

THE SCREENS FOR THE TWO CUT OUTS OF THE IMAGE
SCALE 1:10

Cut outs for the digital prints as well as for the screens

APPENDIX · TEN

THE IMAGE
SCALE 1:20

The pattern used for the Wall hanging  
The pattern used for the Window screen
APPENDIX · ELEVEN

PART OF A CUT OUT OF THE IMAGES
SCALE 1:1
Wiring diagram for the IR-sensor,

Model: Sharp GP2D12
- Analogous (a continuous range of multiple states is considered)
- Continuously sending IR-signals
- Requires around 25mA of continuous current
- Range of 10 cm - 80 cm

The IR-sensor

Sensor's zone of sensitivity

This person is not detected

This person is detected by the sensor

The corridor

Wanted degree of freedom = 0

APPENDIX · THIRTEEN