Composing over time, temporal patterns

in Textile Design

BARBARA JANSEN
Composing over time, temporal patterns
– in Textile Design

BARBARA JANSEN
Composing over time, temporal patterns
– in Textile Design

BARBARA JANSEN
Dear Reader,

I am delighted you are my audience today. Warm welcome to a journey through my thesis work, which summarise my research work on light emitting textiles of the recent years.

The work presented in this thesis investigates through practice a new field of textile design exploring the visual effects of moving light as a continuous time-based medium. Thereby, the textile design pattern reveals its composition, not in one moment of time any more, but in fact over time.

The thesis consist of four parts: a solo exhibition at the Textile Museum in Borås from 17th February- 28th March 2015, five posters, an interactive thesis including 48 films (download file) and present thesis book.

The artefacts displayed in the thesis show a varying range of examples which explore aesthetical possibilities of how light can be integrated as an active part into textile structures, ranging from weaving to braiding techniques, both hand crafted, as well as industrial produced. Thereby three main groups of experiments: colour flow, rhythm exercise, sound_light experiment explore and discuss a range of different time-based expressions. Thus define and establish relevant new design variables and notions, whilst working with time-based design processes. In the following descriptions of these experiments two forms of writing have been used to describe the experiments. One is purely descriptive, neutral form to describe the experiments as such, whereas text titled Research Diary Notes includes reflections and personal comments on the experiences during work on the experiments.

The interactive thesis and the exhibited artefacts are an invitation to view new textiles expressions and are an initial guide on the road toward future time-based design works, particularly in the area of light emitting textiles.

[Due to limitations in printing processes and digital media are the actual light colours displayed inside the textile structures not shown correctly in printed graphics and film material. They are approximations. Yet, the interactive thesis displays a better colour rendering in the graphic material.]

Please view the interactive thesis first, to be downloaded at:
http://hdl.handle.net/2320/14360

Enjoy,

[Signature]
GLOSSARY........................................ 228
REFERENCES................................. 230
FIGURES/VIDEOS............................ 240
APPENDIX 1................................. 244
    Optical fibres............................... 245
    Previous work............................. 247
    woven light............................... 247
    Industrial weaving........................ 268
    Light Shell............................... 278
    Light and Shadow Play.................. 286
    Different forms of light expression..... 300
    Esparteria.................................. 306
    Sun Sails................................... 312

APPENDIX 2: Posters 1 – 5
APPENDIX 3: Interactive thesis
PUBLICATIONS


JANSEN, B. 2009c. *Light Shell*, 3D knitted textile objects: light installation, 'Is it possible' by The Swedish School of Textiles, University of Borås, held

JANSEN, B. 2009a. *Light Shell*, 3D knitted textile objects: light installation, 'Responsive' by Material Sense, held at CeBit, Hannover/ Germany, April 2009


PRELUDE
Textiles

With the beginning of the era of Smart Textiles, the textile designer is challenged with a range of materials which are characterized by their ability to change expressional and functional properties. These materials respond to environmental stimuli, user interaction and pre-programmed parameters and visualize their responses to the viewer. For example colour change dye systems and light-emitting technologies open up opportunities to explore new colour palettes and behaviours, and also the potential for designing with novel and complex properties and aesthetics (Berzina, 2011, Krogh, N.D., Layne, N.D., Taylor, 2010, Wingfield, N.D., Worbin, 2010). The availability of these new materials changes the conditions of conventional textile design; a textile pattern expression is no longer static, it once had one face, one gestalt or expression, whereas now it can show different expressions, a definite or indefinite number of times.

Up until recently the physical dimension of a textile piece, together with a specific design brief for expression and functional needs, set the parameters that frame the design work. First projects have been created, where time as a design element has been started to be explored, even though it has not always been pointed out as such (Berzina, 2011, Fiber Optic Tapestry [video], 2010, Gullickson, 2012, Hietanen, N.D., Hauan Johnsen and Urstad, 2008, Hauan Johnsen and Urstad, 2012, Krogh, N.D., Layne, N.D., LBM, N.D.b, Ligorano, N.D., Luminex, N.D., Nordfeldt Iversen, N.D., Nordfeldt Iversen, 2006, Taylor, 2010, Wingfield, N.D., Worbin, 2010). In the present research work, the relevant parameter is time and the temporal frame, within which changes will occur and dominate the starting point of the design. Time as a design element or a material, is still a new element for a textile designer to work with. This is the reason the research work conducted in this thesis aims to expand an understanding about time as a design material, in order to allow designers to compose time-based patterns when designing light integrated into textile structures.

As a textile designer I am trained to work with colour, form, structure, material aesthetics and tactility. These design elements interact within a physical two-dimensional or three-dimensional textile structure. For instance first examples of colour changing materials have a strong focus on two or several different expressions, that appear one after the other. In the case of thermo chromic colour change dye systems, the change of colour is affected
by changes of temperature caused by the environment, user interaction, or pre-programmed parameters. The designer develops one pattern, one design expression, for the base temperature and one for the changed temperature state. You still could say the designer creates two static images, which will appear independent from each other (Worbin, 2006, Worbin, 2010). Likewise examples of light-emitting textile surfaces are either switched on or off depending on changes in the environment (e.g. decreasing levels of light), user interaction or settings made in programming. The viewer is able to observe daylight and night expressions, two static expressions perceivable at different moments in time (Jansen, 2007b, Jansen, 2008b, Jansen, 2009d). Turning to the current work carried out in this thesis, new forms of expressions appear as textile surfaces (woven and braided, integrating PMMA optical fibres as light-emitting material) emit light sequences, that continuously shift and change the levels of light intensity and the colour of the light. (Introduction to PMMA optical fibres, Appendix 1: )

Light

The following will briefly introduce the main characteristics of natural and artificial light and their impact on the human wellbeing. Thus, a background is provided that explains the author’s interest in working with dynamic lighting. “Light is the most important source of life of the planet, it is the energy that makes the heart of the world tick at its daily, seasonal and yearly rhythm. In the natural world one is the element that provides all the information about time: day and night, represented by the cycle of light and darkness. Light variations are thus the basic agents of transformation of the environment and we have been exposed to these conditions for millions of years.” (Favero, 2008, p. 5) Light is essential to the human body (Boyce, 2003, Cimo, 2006, Dess, 2007, Ehrenstein, 2008, Marano, 2003).

The main characteristic of natural light is its variability. Natural light is received on earth either directly from the sun or is reflected from the moon. Daylight varies with latitude, weather conditions, time of day and season of the year, etc. Daylight exists in two forms, direct sunlight and skylight. Direct sunlight is the uninterrupted beams of light that reaches the earth directly, whereas skylight is diffused ambient light in the atmosphere around us. “The illuminance of a bright sunshine is steady; however the skylight can differ
from minute to minute as clouds occurs, change form, get carried away from the wind, or evaporate. “ (Jansen, 2008a, p.34) (Boyce, 2003, p. 27-28, Tregenza, 1998, p. 31-36)

“Daylight covers all the wave lengths of the visible light radiation in a continuously light spectrum. … Beside that, it is characterized through smooth changes of light over the day: from night to day and vice versa, passing from one phase to the other through twilight phases. Morning light is characterised by its high amount of short wavelength – blue light – and evening through their high amount of long wave lengths – red light. These changeovers from blue light domination to red light domination, has a crucial impact on the circadian dominated body processes.” (Jansen, 2008a, p. 34) Light has various effects on the human body: from the impact of non-visual light, such as UV radiation and infrared light, to the visible spectrum of light. Until a few years ago the lighting industry mainly focused on the production of light sources that would provide optimum lighting conditions for performing visual tasks. Just recently research has shown that the natural rhythm of daylight has more profound impact on the human body than merely satisfying visual tasks. Daylight is a strong trigger for our circadian body systems. “The circadian system – or biological body clock – controls different processes in the body in 24-hour time rhythms, for example the sleep-awake cycle.” (Jansen, 2008a, p. 36) Today, it has been established that short wavelength light (blue spectrum) exposure represses melatonin production and stimulates alertness. The impact for this has been investigated in different areas such as sleeping problems, indoor working places, where employees often are not exposed to enough daylight, shift workers, SAD, etc. (Boyce, 2003, p. 95-97, 103, 458, 478-479, 487, Cimo, 2006, Dess, 2007, Lighting Research Center, 1995-2008, Marano, 2003, NOSAD, N:D:; Technische Universität Berlin, 2008, Tregenza, 1998, p.19). Ehrenstein comments that especially the twilight phases seem to produce an effective time-impulse on the circadian system, although this has not been entirely clarified yet. (Ehrenstein, 2008, p.43).

Artificial light sources can be grouped into four families: incandescent light sources (an electric current passing through a wire causing it to glow), discharge light sources (an electric discharge is sent through a tube filled with gas), luminescent light sources (LEDs, a semiconductor charged with electricity will emit light), and induction light sources (energizing a discharge using a magnetic field). Currently only incandescent light bulbs emit
light continuously over the whole spectrum, therefore they come close to the perception of daylight, even though the colour temperature is not identical. Discharge light sources feature mostly through irregular amplitudes of the light spectrum, and LEDs have very narrow spectrum of the light emission, thus producing a more monochromatic light (Boyce, 2003, p.31-32, Hennig, 2008, Hennig, 2011). None of the current light sources is able to span the daylight wavelength spectrum or provides the same flexibility to change the level of light intensity.

Research into light and human wellbeing has shown that future artificial light sources should be adapted to knowledge on the biological impact of light on the human body. Consequently, future light systems should incorporate daylight as much as possible and, when daylight is not sufficient, artificial light should include: an optimized light spectrum (this means a continuous and full light spectrum), changing over the day from short wavelengths in morning and daytime to long wavelengths in the evening, and also changing of light illuminance over day from i.e. increasing in the morning and decreasing in evening. This also includes large-area light sources that cover extensive the field of sight, especially from above a 45°–90° light wave angle to support an optimal lighting for the eye (Dehoff, 2008, see graphics below), and an interactive individual controllable lighting system for the user.

Hence, light is an indispensable field of design both today and in the future. It also offers designers and artists an interesting field to work in. Although this thesis doesn’t aim to improve wellbeing through light design, scientific research strongly encourages a designer working with artificial lighting to
develop an understanding for dynamic light. Yet, in earlier projects such as woven light – powered by sun light (2005-2006) and especially in Light Shell (2008) and Light and Shadow Play – the sun as an trigger for urban textiles (2009-2011) the natural rhythm of the sun has been placed at the centre for new concepts, using it as part of the expresional and functional possibilities in design (Jansen, 2007b, Jansen, 2008a, Jansen and Ledendal, 2011). See Appendix 1: ▶▶▶.

Nevertheless qualities of daylight expression, for example the very uniform and smooth transition from light colour to light colour over the day (change of colour temperature), has influenced how the design of artificial lighting has been explored, especially at the beginning of the colour flow experiments, see page 35 and 42ff.

Light and Textiles

Integration of light into textile surfaces opens up new possibilities in lighting design, as textile surfaces are flexible as media and materials. In recent years, a range of light-emitting materials have been investigated in textile applications by artists, designers, researchers and companies. The integration of LEDs, electroluminescent wires, fluorescent and phosphorescent materials, as well as optical fibres have been tested and first prototypes, art pieces, site-specific installations and products have reached different audiences and the market, both craft and industrially produced (Glofab, N.D., Gullickson, 2012, Hauan Johnsen and Urstad, 2012, Hauan Johnsen and Urstad, 2008 Nordfeldt Iversen, N.D., Nordfeldt Iversen, 2006, Layne, N.D., LBM, N.D.a, Lumalive, 2004-2008, Luminex, N.D., Wingfield, N.D., Worbin, 2010).

Each of the light-emitting materials supports different forms of light expressions. Three main forms of expressions can be observed and created inside textile structures: dotted, pixel like (created via LEDs), linear (created via electroluminescent wire or optical fibres), and even light surface (created via electroluminescent film or optical fibres). For example the work of Barbara Layne (Layne, N.D.) features messages emitted via LEDs embedded in woven structures, Spår (Traces) by Anna Persson and Linda Worbin (Worbin, 2010) incorporates electroluminescent wire inside woven carpet, as well as Moonlighter by Delia Dumitrescu (Dumitrescu, 2013) inside a knitted structure. Dimma (Foggy) by Persson and Worbin (Worbin, 2010) involves elec-
troluminescent film under a tufted structure and *Inner Light* by Sarah Taylor (Taylor, 2010), *Ikat I-III* by Astrid Krogh (Krogh, N.D.) and works by Barbara Jansen (Jansen, 2007b, Jansen, 2008b, Jansen, 2009d) involves integration of optical fibres inside woven structures. See examples in Appendix 1: ▶️.


Especially in recent works, Sarah Taylor, Astrid Krogh, and Ligorano/Reese explore similar materials (particularly Taylor and Krogh, who use PMMA optical fibres in combination with paper yarns/materials) and expressions, in the form of dynamic colour-changes displayed in hand woven structures, to those investigated in this thesis. The collaboration of Hilde Hauan Johnsen and Maia Urstad has led to a series of audio-textile installations where bundles of optical fibres are triggered through sound, both exhibited in gallery spaces, as well as in sight specific outdoor locations. Several meter long bundle of fibre optics is stretched across the space, pulsating light triggered through filtered sounds. “The installation is a visual representation of the invisible universe of information circulating in our global telecommunication systems; ... We have collected signals from this global network and transformed them into a sonic web using fibre optics.”(Hauan Johnsen and Urstad, 2008) The latest piece *Horizon*, 2012, integrates optical fibres in a hand-woven structure. (Hauan Johnsen and Urstad, 2008, Hauan Johnsen and Urstad, 2012, Gullickson, 2012)

The works of these designers and artists feature as art pieces and site-specific installations. Unfortunately, almost no information has been published about these works that discuss their inspiration, design process and technical realization of the colour-changing sequences, or the textile structures them-
selves. Their works present themselves as pure inspiration for their audience and aim open up the perception towards new textile expressions. However, the research work presented in this thesis aims to provide other designers with the necessary insights in order to be able to create their own time-based works, especially in the area of light-emitting textiles.

The light-emitting material used in this project is PMMA (PolyMethylMethAcrylate) optical fibres. This type of fibres have been integrated into both industrially woven and hand braided structures, and emit light through the use of white LEDs and RGB-LEDs (light-emitting diodes, each RGB-LED incorporates one red, green and blue LED) which are controlled by microcontroller digital interfaces. There are three main reasons why I continue to use optical fibres as light-emitting materials in my work. The first two concern the structural integration of the light-emitting material (optical fibres) into textiles, and the last concerns the light quality as such.

Textile + Light = one: from a design perspective, PMMA optical fibres are interesting to use as a light-emitting material in a textile context, as they are in their appearance quite close to a transparent thread. Using a “light thread” offers an opportunity to make light become a textile piece in itself. In this way light and textile structure melt into each other and become indivisible.

Light expression – even light-emitting surface: especially the integration of optical fibres into woven structures allows for creation of dense surfaces that spreads light evenly. Optical fibres were the first light-emitting materials that crossed my path and I have explored different structural forms of integration of the fibres. The intuitive creation of an even light-emitting surface quickly became my main goal. Explorations in hand weaving have been continued into machine weaving. As more background research into light and health was made (see section Light) it confirmed the need to continue to develop light-emitting surfaces that spreads light evenly, because they may one day make contributions in a light and wellbeing context. Woven structures could easily be applied as horizontal surfaces or applied to ceilings in context of interior design. The woven structures in colour flow and the light_sound experiment are two example of these even light-emitting surfaces.

Light quality – variation in light: also in this aspect, research into light and health supports the use of optical fibres. As they are nothing more than light-transmitting media they may be connected to a range of different light sources. They allow the surface to be connected directly to daylight via the
Parans Solar System (Jansen, 2008a, p.8, 14, 42, Parans, N.D.) in future applications. Besides that for this thesis the fibres are lit up by LEDs, which can be controlled and programmed through different digital interfaces (see colour flow, rhythm exercise and sound_light experiment).

When I began working with PMMA optical fibres 2005, a white light source (LED lamp) was used to light up the structures, in order to investigate the pure structural and material impact on the light effect. Already at early stage, it became clear that using coloured materials in combination with the optical fibres are colouring/shading the light effect, which would have been less obvious, if coloured light would have been introduced too fast. During that stage the lighting mechanism was either switched on at night and off in daytime, showing two independent static expressions. However, the wish to display changing light inside the structures soon appeared. A standard light projector (Halogen) for optical fibre applications with a colour wheel was tried out and equipped with five to seven colours at that time 2006. As colours were screamingly loud and the tempo too fast instantly grew the wish to define the speed and colour myself. Next, videos were projected into the optical fibres (Light Shell, 2008). Although this allowed me to create my own colour range and tempo, it still lacked real precision in respect of colour choice, where in the structure which colour is displayed, as well as timing of changing light colours. This led to the research work presented in this thesis and the introduction of LEDs controlled through a digital interface, into my work. There is no standard LED system on the market today that is able to connect to textile applications (incorporating optical fibres). The present work uses a special customized LED lighting device system, which has been developed in collaboration with UK based electronic specialists, Circatron Ltd. It is a further developed version of the lighting device system used by Sarah Taylor for Inner Light (Taylor, 2010). The system allows coupling of the optical fibre ends to the LEDs and a digital Mix (DMX) replay system controls the lighting sequence via various programming processes. Hence, it facilitates the research work presented in this thesis.

Movement

Inspiration for different forms of expressions of movement is found in the field of kinetic art and Avant-Garde filmmaking of the 20th century. With
the beginning of the 20th century movement and time-based forms of art entered the field. In the Realistic Manifesto created by Naum Gabo and Antoine Pevsner in 1920, they state that they, “recognize in the arts a new element, the kinetic rhythms, as a base form of our perception of the real time”. (Popper, 1975, p. 29, author’s translation) Schmied also describes that the most important theme of the 20th century is movement. “Movement, that means the interlacing from space and time, the multiplication of perspectives, the metamorphosis from material in energies.” (Schmied, 1972, p. 13, author’s translation) Artists such as Naum Gabo, Marcel Duchamp, Moholy-Nagy, Alexander Calder, Jean Tinguely and George Rickey are well-known for their kinetic work, establishing kinetic art in the 1920-1930 and 1950-1960.

Also the early abstract Avant-Garde films from the 1920 and 1930 are inspired mainly by the search for notations of time and movement in painting. This search led artists such as Hans Richter, Oskar Fischinger and Vikking Eggeling to filmmaking and made it a part of modern art (MACBA, 2000).

One artist who bridged the areas of kinetic art and abstract filmmaking in an outstanding manner was Len Lye. He investigated how “to compose pure figures of motions” his entire life. Throught his artistic career he studied and observed movement and brilliantly expressed his unique understanding of it in his films and kinetic sculptures (Bouhours, 2000, Horrocks, 1979, Horrocks, 1981, Horrocks, 2001, Len Lye rhythms [video], 2000, Len Lye talks about art [video], 2003, MACBA, 2000). His exploration of motion always involved direct physical interaction between his body and the materials involved. He developed his own way of sketching, doodling, as a form of automated drawing, in an attempt to switch off the conscious mind whilst working, scrabbling, doodling around inspired by a deep inner bodily involvement. This form of physical involvement in the creative act, assigns a central role to the physical process of becoming, which is similar as the action painting of the abstract expressionists. He scratched, painted and printed directly on the film strip. Springy steel in its raw form, tube, rode or flat stripe were all twisted and swung in his hands, until they create a range of unique forms of movement and movement characters. Wild and dynamic as Blade, reposing in itself, slowly circulating as Universe, loaded with energy, dynamic dancing with upraised head in Bell Dance...

I guess this is what I am looking for: I am trying to find a way to compose different forms of unique movement characters. However, first I will need to learn how to “walk”, i.e. to create movement at all. From Lye’s point of view
I am still not doing proper composing or sketching of movement at all, as the movement of light is inside my textile structures and the structures themselves are still. Additionally, my working process is far from his unconscious forms of doodling. At least, a last “hands on” moment is maintained as I draw time lines and events by hand. Today, this is still a very controlled process as drawings are to be translated into the language of programming, which demands a high level of precision. My hope is that one day I will be able to compose over time in a more playful and intuitive way. It is rather the process of developing the physical textile structures, i.e. playing around with the fibres in an early explorative state, that feels similar to Lye’s way of working. Feeling the weight, flexibility and resistance of the materials, and trying out different forms (braiding, weaving and variations of these techniques) they can be molded to.

However, the introduction of Smart Materials into the field of textiles allows movement-based and time-based expressions to finally enter the field of textile design and art.

Rhythm

“Life is rhythm - At the heart of every life form there is rhythm. Movement, flow, change, renewal and repetition are all based in rhythm. It is only in rhythm, that we can experience time. Without vibration, without oscillation, there is statis. There is nothing. Stability and solidity are illusions. Everything oscillates and vibrates – from the bridge of steel and concrete, to the energy shells around an atom. Even colors oscillate at different frequencies. We recognize and experience our world through rhythm. Everything vibrates – everything “speaks”. It is, in essence, a universe of sound.”

[Touch the Sound, 2004]

What is rhythm? As much as time and light are intrinsically tied together in this body of research work, as inseparable is rhythm. In the following diverse definitions and descriptions of rhythm will be laid out as the cognitive framework in which analogies are drawn with my own search for rhythm in my time-based work. Thereby rhythm seems to play a key role in the creation of movement, i.e. time-based succession.
Rhythm in music terminology has been defined as follows: 
“temporal order of tones” (Musiklexikon, N.D., author’s translation) 
“the different durations of tones” (Ziegenrücker, 1997, author’s translation) 
“The subdivision of a space of time into a defined, repeated pattern. 
Rhythm is the controlled movement of music in time. It may be defined as the division of music into regular metric portions; the regular pulsation of music.” (OnMusicDictionary, N.D.-a) 
“A strong, regular repeated pattern of movement or sound … 
A particular pattern formed by musical rhythm… 
A regularly recurring sequence of events or processes”(Oxford Dictionaries, N.D.-a)

Do all these describe the same, I wonder? The definitions of rhythm are so diverse, nor do they give a hint of: what does this mean in practice? How to create rhythmic structures? It is rather in the words of Thomas Riedelsheimer and Evelyn Glennie in Touch the Sound and the words of Henri Lefebvre I find closest to what I am looking for. It is not just a general definition of rhythm and an instruction how to create it; it is rather a specific quality to it which has been searched for throughout the work.

“Everywhere where there is interaction between a place, a time, and an expenditure of energy, there is rhythm”. (Lefebvre, 2004, p. xv) “Rhythm, for Lefebvre, is something inseparable from understandings of time, in particular repetition.” (Lefebvre, 2004, p. viii) Thereby he defines two forms of time and rhythm, the linear and cyclical time, “the contrast between the clock time and the lived time”(Lefebvre, 2004, p.x), and the linear and cyclical repetitions, i.e. rhythms.

“… rhythms imply repetitions and can be defined as movements and differences within repetition.”(Lefebvre, 2004, p. 90) “For there to be rhythm, there must be repetition in a movement, but not just any repetition. The monotonous return of the same, self-identical, noise no more forms a rhythm than does some moving object on its trajectory, for example a falling stone; … For there to be rhythm, strong times and weak times, which return in accordance with a rule or law – long and short times, recurring in a recognisable way, stops, silences, blanks, resumptions and intervals in accordance with regularity, must appear in a movement. Rhythm therefore brings with it a differentiated time, a qualified duration.” (Lefebvre, 2004, p.78)
Analysing rhythms in the world, the everyday life, cyclical and linear repetitions can be defined even though they “interfere with one another constantly. The cyclical originates in the cosmic, in nature: days, nights, seasons, the waves and tides of the sea, monthly cycles etc. ” (Lefebvre, 2004, p.8 )“The linear, by contrast, defines itself through the consecution and reproduction of the same phenomenon, almost identical, if not identical, at roughly similar intervals; for example a series of hammer blows, a repetitive series into which are introduced harder and softer blows, and even silences, though at regular intervals. The metronome also provides an example of linear rhythm. … It is the point of departure for all that is mechanical.” (Lefebvre, 2004, p.90)

It is both rhythms in nature (daylight, water and wind), with special interest on their cyclical qualities, as well as music, which has been looked at in order to achieve an understanding of time and the “temporal organization”(Cooper, 1960, p. 1, 3) of it in order to get an idea of how to design and develop time-based designs. As both, rhythms in nature and music, unfold, change and develop over time.

Natures rhythms have been observed and collected (via sound recording, photo series, video, and writing) with the inherent aim to define and discover their intrinsic qualities in order to create similar qualities, expressions, thereby being inspiration for the overall form of expression. There as music – an example of art which unfolds over time, has been explored from a composing point of view, as an inspiration for doing/composing. Both nature and music can be looked at, perceived from a without/outside view, the audience view, the perceiver. Thereby both also invite to a search for the inside view, how the things – nature or music – have been created. It is this within this work is trying to reach an understanding from in order to create my own time-based work. Gaining the inside perspective of nature has been started via recording and collecting natural phenomena, i.e. rhythms, there as for music through reading music theory and looking at music notation (a form of notation documenting progression over time).

Both art and design can be looked at from the review, as well as the inside view. Thus music and dance for example allow for a further perspective, the performing. Been familiar with playing music and therefore with parts of its terminology, it was hoped to get an easier grip and insight into the within. Nevertheless it showed that being able to play music and composing it lie worlds apart. However it presented an opportunity for new notions, vocabu-
lary, to be used in the frame of time-based design processes.

Coming back to Lefebvre’s work, it is also strongly influenced by musical metaphors, thereby he is pointing out that rhythm, as music illustrates, “raises issues of change and repetition, identity and difference and contrast and continuity.” (Lefebvre, 2004, p. xii). Furthermore that aspects of the cyclical (natural and corporal) rhythms, as well as linear (mechanistic) rhythms can be found in music. (Lefebvre, 2004, p. xii) Throughout this research work music terminology has been adapted whilst simultaneously striving for cyclical qualities of expressions.

Throughout the different experiments rhythm has been searched for, and has been explored in different ways as an element of “temporal organization” (Cooper, 1960, p. 1, 3) of time. Most explicitly it has been explored in the experimental series rhythm exercise and the sound_light experiments (Sinus 90 + blue and Sinus 64 + blue).
The work presented in this thesis investigates through practice a new field of textile design exploring the visual effects of movement using light as a continuous time-based medium. Composing over time, temporal patterns - in Textile Design is a practice based research project that investigates the following research question: What does it mean, if time and change – constant movement – become part of the textile design expression? The research question has been investigated in a number of experiments that explore the visual effects of movement using light integrated into textile structures as a medium. Thereby, the textile design pattern reveals its composition, not in one moment of time any more, but in fact over time. This thesis aims to create time-based textiles with an emphasis on developing aesthetics of movement – or to establish movement as an aesthetic moment in textile design.

Three distinct groups of experiments, colour flow, rhythm exercise, and sound_light experiment explore a range of different time-based expressions. Currently, this series of experiments consists of eleven parts (three for colour flow, six for rhythm exercise, and two for sound_light experiment) and investigates most elemental building blocks, in order to understand how to build and create complex patterns, i.e. compositions evolving over time. The experiments are driven by the need to understand how to build rhythmic structures in order to be able to fully explore the aesthetic potential of time-based patterns. Colour flow is a series of experiments looking into creating sequences of coloured light, whereas the design aim is to explore how to lead over from one action to another, how to change over from one colour to the next. The transition over time is the main focus here, i.e. how to lead from a colour before, to an in-between phase to the colour after. Rhythm exercise looks into the creation of rhythmic light sequences, whereas the design aim is to examine different ways of dividing time to facilitate the creation of different rhythms, speeds, dynamics and tensions in the composition of movement, using monochrome white light. Sound_light experiment is exploring how sound can trigger and create a dialog with light. Different sounds produce different forms of coloured movement. Applying working methods from composing music allows generating increased complexity of movements, furthermore opening up for several movements being able to appear in one area of the textile structure at the same time.
The experiments have been displayed and explored using woven and braided textile structures which have been construct mainly through the integration of PMMA optical fibres. (Cf. the introduction to optical fibres Appendix 1:).

The research in this thesis is developing an extended palette of textile expressions and by doing so questioning the design process for textiles whose expressions evolve over time. The challenge of creating new aesthetics implies developing new design processes for the use within the field, which in this case does not automatically grow out of textile traditions (as, traditionally, the research area in this thesis has not been explored in the field of textile design).

The development of new expressions, demonstrated through a variety of textile objects, forms the basis for analysis in this thesis. Analysis of these expressions and their preceding design processes define new design dimensions that will have to be incorporated in textiles, when considering expressing movement in a conscious and considered way. This provides the basis for strategies to effectively design with movement in textiles, and also for the technical/mechanical translation of the design process into physical objects, viz. the development of technical proceedings (producing cloth, connecting electronics to textile structures, programming integrated light sources, etc.) to allow bringing movement into cloth. New expressions, working methods and technical proceedings displayed via physical objects, on film, in visual media and through text, demonstrate that the research is necessary to extend the textile field towards the expression of movement.
EXPRESSIONS
“The work of designing light is always to structure the flow of time”
(Mende, 2000, p.15)
EXPERIMENTS
Colour flow

Introduction

Colour flow is the initial series of experiments that investigate time-based patterns, as an opening to compose over time. The series explores the creation of sequences of coloured light and the aim is to explore how to lead over from one action to another, to change from one colour to the next. The main focus here is transitions over time, i.e. how to design a transition from one colour to another via an in-between state.

This will be displayed through experiments made in a woven textile. The woven structure is built up through the integration of PMMA optical fibres in the weft direction. Thus, individual sections of the textile structure are connected to individual RGB-LEDs (light emitting diodes that each contain three LEDs, one red, green and blue which through additive colour mixing allow displaying a wide range of custom colours) and independently programmed to create moving patterns of coloured light using a microcontroller and a digital interface.

A newly developed lighting device system, developed in collaboration with UK based electronic specialists Circatron Ltd., allows coupling of optical fibre ends (bundled in to several independent strings) to the LEDs and a digital Mix (DMX) replay system controls the lighting sequence via various programming processes, in this case the Easy Stand Alone lighting software.

The lighting device system is a further developed version of the lighting device system Sara Taylor used for Inner Light (Taylor, 2010).

In the following descriptions of the experiments of colour flow, rhythm exercise and sound_light experiments two forms of writing have been used to describe the experiments. One is purely descriptive, neutral form to describe the experiments as such, whereas text titled Research Diary Notes includes reflections and personal comments on the experiences during work on the experiments. Most of the latter form of writing comes from my sketchbooks, in which I continuously documented the work processes.
colour flow_part 1

Experimental Set-up:

- Laptop
- Microcontroller (DMX 512)
- Driver
- RGB LED: 1
- Woven structure
An RGB LED is built up of three LEDs, one red, one green and one blue. Each LED has a dimming range from 0 - 255:
0 = light off, or light intensity = 0
255 = light full on, or light intensity = 255
Together the three LEDs can mix together an endless range of colours (additive colour mixing).

The software (Easy Stand Alone) facilitates individual control of a range of individual light fixtures. In total, it is able to control up to 512 individual channels; however different light fixtures require a different amount of channels to be steered. An RGB LED requires three channels (each LED = one channel).

Via the software, dynamic light sequences can be programmed, so called scenes. Each scene is built up of a series of steps. A scene can either be played once or be looped. Additionally a group of different scenes can be played behind each other.
There are two ways in which the LEDs can be switched on or off:

– via holding time: The change in light intensity occurs in distinct steps. Below, four values of light intensity, 0, 87, 175, and 255, have been used to build a simple phrase:

voice 1:

<table>
<thead>
<tr>
<th>R</th>
<th>G</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>255</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>255</td>
<td>255</td>
<td>255</td>
</tr>
<tr>
<td>255</td>
<td>255</td>
<td>255</td>
</tr>
<tr>
<td>255</td>
<td>87</td>
<td>87</td>
</tr>
<tr>
<td>175</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

– via fading time: The change in light intensity occurs through a dimming/fading process with a scale range of 0–255. Below the following scale ranges have been used to create a simple phrase:

voice 1:

<table>
<thead>
<tr>
<th>R</th>
<th>G</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>255</td>
<td>255</td>
<td>255</td>
</tr>
<tr>
<td>255</td>
<td>255</td>
<td>255</td>
</tr>
<tr>
<td>255</td>
<td>175</td>
<td>87</td>
</tr>
<tr>
<td>255</td>
<td>255</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>R</th>
<th>G</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>255</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>255</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>255</td>
</tr>
<tr>
<td>0</td>
<td>87</td>
<td>87</td>
</tr>
<tr>
<td>0</td>
<td>175</td>
<td>175</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
play

play
There are two ways in which the LEDs can be switched on or off:
– or a combination between holding and fading time:

voice 1:

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>R</td>
<td>0 →</td>
<td>255</td>
<td>255</td>
<td>→</td>
<td>0</td>
<td>0,</td>
<td>0</td>
</tr>
<tr>
<td>G</td>
<td>0</td>
<td>0,</td>
<td>255</td>
<td>0</td>
<td>→</td>
<td>255</td>
<td>175</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>0,</td>
<td>0,</td>
<td>255</td>
<td>→</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
EXPERIMENTS

colour flow_part 1

The following three sections will introduce colour flow. Each section is a series of experiments exploring several perspectives on how to make a transition from one colour to the next. The first section, part_1, comprises the initial group of experiments of colour flow.

To start with a photo was selected as an inspiration for the choice of colour range. Fifteen colours were randomly chosen in an attempt to sample the entire colour spectrum of the photo. Photoshop and the tool “colour picker” were used to select the colours and the RGB values of the colours were noted. The first time-line or light sequence was created by using the initial selection of colours arranged in random order. This order will be referred to in the following as colour order 1.
colour order 1

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
EXPERIMENTS

The first time-line, or scene as it is called in the Easy Stand Alone software, was created by lighting up one colour after the other (1-15) in clear distinct steps. Each colour appears for two seconds, using only holding time.

Research Diary Note: zack, zack, zack, as if a roboter were to lift his arms: zick, zack, zack, …
The second scene was programmed to create fluidity between the colours. Introducing fading time (F) and holding time (H), two seconds remain the ground pulse. See graphic representation of the scenes on the following page.

Research Diary Note: Somehow, the exploration into what it means to compose over time starts here. I play around with different time durations for fading and holding time, using one or both of them. It all feels wrong, not smooth enough, not balanced enough… The increments (steps) are still visible and it seems the flow stops when the colours “pause”/hold for two seconds. A difficult thing to do! Well, I don’t have to be frustrated today.

You “composed a scene”. Can I already talk about rhythm or melody?

The third scene was programmed to increase fluidity between the colours. To achieve this it was necessary to differentiate the time duration of the fading and holding times.

A fourth scene has been created by playing with irregular time durations for fading and holding times in order to create a first feeling of a melody.
EXPERIMENTS

The graphics below represent the four scenes, time-lines, from colour flow part 1. The colour order used in the illustration below does not correspond to colour order 1. In this illustration I have used clear, distinct colours to demonstrate the principles of the four different scenes. Thereby $H =$ represents holding time and $F =$ fading time.
The video shows all four scenes, played in order. Every scene fades to black to mark scene changes.
Two additional colour orders were created based on colour order 1 (below). The colours of colour order 2 were rearranged in order to create the smoothest possible colour transition from orange/apricot to red/purple and finally to blue. The third colour order was created to achieve a multi-coloured effect (German ‘bunt’). The colour order 2 tries to enhance the smooth, fluid transition from one colour to the next. Colour order 3 attempts the opposite in order to determine if this leads to the creation of a more rhythmic feeling, a more rhythmic scene progression. Both colour orders were played using the three different time-lines or scenes, two to four.
In the video you see colour order 2 playing scene three, followed by colour order 3 playing scene four.
Research Diary Note: Playing colour order 2 with scene three creates the best fluidity between the colours. The transition is so smooth, that it is hardly noticable. The smoother I wish for the transition to be, the closer the shade of the emerging colour should be to the one preceding it.

The feeling I get when playing colour order 3 with scene four creates a remote feeling of having achieved a first rhythmic or melodic lighting scene. Higher contrast between the colours and irregular fading and holding times impact and enhance the rhythmic feeling. Thus, the feeling of differences in speed within the same scene seems to influence the melodic sensation as well.

In colour flow_part 1, drawings have been used as a tool for reflection and simultaneously inspect visually what has been programmed. Later on, however, in the rhythm exercise chapter, drawings (which are then named notations) have been used as a composing tool. In that context, notations have been used to compose/think scenes before starting the coding process.
EXPERIMENTS

colour flow_part 2

Experimental Set-up:

- Laptop
- Microcontroller (DMX 512)
- Driver
- RGB LEDs: 3
- Woven structure
- RGB LED: 1
colour flow_part 2

Colour flow_part 2 is a first sketch, a first attempt at creating a composition consisting of three parts. The three parts are variations based on the three different colour orders and the four scenes (time-lines) created in colour flow_part 1.

In the following, descriptions of the experiments, the metaphor of instrument and composition will be used. Each textile structure (in this case a woven structure) is understood as an instrument on which various compositions, i.e. light sequences, can be played. A composition can consist of one or several voices, one or several sections activated independently in the textile structure. Thus, each voice can play its own melody or play in unison with other voices.

Part one: scene one is a repetition of colour order 2 playing the rhythmic structure of scene three, creating fluid, fine-graded changes of colour. All three sections of the textiles are lit up simultaneously, using three LEDs on the same side of the textile. As all three sections are playing in parallel, displaying identical colour orders, they appear to be a single, monochrome lighting surface (see e.g. next page, scene 1: step 3. LED four, placed on the opposite side of the middle section of the structure, is not in use and remains dark/silent = black line).

Part two: scene two uses a selection of colours based on those used in colour flow_part 1 accompanied by further randomly selected, contrasting colours such as red, yellow, blue, green, etc. The smooth colour flow is now broken up through contrasting “events”. The three sections of the structure only occasionally light up in unison, as each of the sections or voices now plays individually as well. Contrast and the feeling of movement are created by movement up and down the structure (see e.g. next page, scene 3: step 11). As soon as the fourth voice is activated, voices two and four both play their sequences on the middle section. This facilitates a multi-coloured effect in this section and also opens up opportunities for further directions of movement, e.g. from left to right and vice versa (see e.g. next page, scene 2: step 9). Whilst when only one side of the structure displays the colours, there is always a monochrome colour effect at one “frozen” moment in time.

Part three: scene three further elaborates on the variations in scene two, whereas voice four remains silent for the most part. Graphical representations of all three parts can be seen both in Poster 1 and on the next page and further visualizations of steps 3, 11 and 9 are found on pages 56f.
**EXPERIMENTS**

**colour flow_part 2**

- **scene 1:**
  - voice: 1
  - voice: 2
  - voice: 3
  - voice: 4

- **scene 2:**
  - voice: 1
  - voice: 2
  - voice: 3
  - voice: 4

- **scene 3:**
  - voice: 1
  - voice: 2
  - voice: 3
  - voice: 4

```
ligh off =
```
Scene 1: step 3

Scene 3: step 11

Direction of movement: up + down
Direction of movement: left + right
Scene 2: step 9
Research Diary Note: So far I have been pretending that the results of colour flow_part 1 and 2 met my expectations, i.e. that the process from programming the software to the light being displayed in the woven structure was straightforward and that the expected results were achieved immediately. By expected results I mean the woven structure displaying homogeneous, single colours according to the defined numerical values for red, green and blue (RGB) in the programming process. This was not the case, as I faced a problem with colour mixing of RGB-LEDs that is very common and which still is not resolved.

Instead of the structure displaying one homogeneous colour at the programmed moment in time, a multicoloured effect, example displayed in the photo below, occurred. As was mentioned in the introduction to colour flow, the additive colour mixing principle allows the RGB-LEDs to create a wide range of colours. Theoretically, the light of the fully lit red, green and blue LEDs creates white light and when light intensity of any of the three LEDs is varied, a range of colours appears (e.g. R: 100%, G: 100%, B: 0% = yellow). However, the fact that the three LEDs are set apart from one another spatially brings with it the complication that only a very small portion of the lit area display a 100% overlap of the emitted light and, thus, other portions of the lit area have other colours as the mix of colours of light is different there. Furthermore, “the lenses in most RGB LEDs don’t focus each color to the same spot” (University of Utah, N.D.), so additional measures have to be taken to enhance the colour mixing process (Neumann 2012, Newark/element14, N.D.). Diffuse scattering materials are recommended to enhance the colour mixing effect (Neumann 2012, Göbel, 2012, LBM, 2011).

So far, several experiments have been conducted to enhance the quality of the colour mixing process. Different diffusor materials have been placed be-
tween the RGB-LEDs and the optical fibre ends. Prototype adapters have been built to increase the space between the LEDs and the fibre ends, enhancing the mixing of the light by bouncing it through an extended cylinder (adapter) between the LED and the fibre end. A combination of both techniques has also been explored.

The engineering department at the company GTE Industrieelektronik GmbH, under the leadership of Christian Specker accompanied by two physicists, has explored different solutions. One solution was to install a diffusor at the focal point of the silicone lens of the LED in order to enhance mixing of the coloured lights and also to collect the light afterwards via a converging lens to increase the luminous efficacy. Two major disadvantages were discovered with this method. Firstly, the added diffusor materials (increased interference) absorbing too much of the needed light energy. The second disadvantage concerns the quality of the silicone lens, which is not manufactured in a high quality process. All commercial LED components have a high mechanical tolerance, which makes it impossible to add other precise optical equipment to them afterwards. Currently, Specker’s team has reached the conclusion that although this solution functions in a lab environment, i.e. in theory, it does not withstand technical issues relating to the conditions under which mass-production is carried out.

A second idea is to adapt a single optical fibre to a single LED chip of acceptable quality which would be possible to manufacture commercially. If this idea were to be realized, one would be able to buy three single LED chips, red, green and blue. After connecting each of the three fibres to one of the three LED chips, the fibres would then be connected to a single fibre. When the three monochromatic light beams pass this gate, we would have three different colours of light mix in a single fibre. This would have to be done for each optical fibre in the textile (3-to-1). This technique is known and used mostly for laser equipment used in research and development. It has not yet been subject to mass-production with many fibres, partly because it would be too costly. Specker and his team recommend continuing to explore diffusing materials, although the reduction of light intensity likely is an unavoidable side effect. What also increases the level of difficulty is that I am looking for a small scale solution and one that is suitable for use with a textile structure. Finding such a solution is an ongoing process.

The films introducing the RGB-LED and colour flow_part 1 show the light displayed with the use of an additional adapter as well as diffusor foil.
Although one side effect is decreased light intensity, this is currently the only way to show the “best” possible, homogeneous colour effect. To strengthen light intensity, the textile stripe was lit up from both ends (LEDs two and four, both equipped with adapter and diffusor foil and playing the same scene).

The film on colour flow_part 2 (view on page 62) shows part one of the sequence twice, followed by parts two and three. The first time part one is played, only LEDs one, two and four are playing. This is because LEDs two and four light up the same section of the structure, one from each end, and play identical sequences. Both LEDs are equipped with additional adapters and diffusor foil, whereas the stripe beside them (LED one) does not use any additional components. This is to demonstrate identical scenes played side by side, once using only the LEDs and once with the LEDs together with the adapter and the diffusor, showing multi-colour effects and the best possible colour mix side by side. Afterwards, all three parts are played in the order they were originally composed. Although all four LEDs are activated (as individual voices), only LEDs two and four are equipped with adapter and foil, as I did not have enough prototype adapters to equip all four RGB-LEDs at the same time.

How did I program fine-tuned sequences to have multi-coloured light appear in the woven structure? When I started working with colour flow_part 1, just after I was introduced to the software, I began exploring programming possibilities while I was still waiting for the LEDs I had ordered to arrive. The software has a three-dimensional preview window (“Visualize 3D application”) that displays a stage scenario (as this software was originally created to program stage lighting) in which the connected light fixtures are visible and the programmed lighting, in this case the colour changes of a LED fixture, is demonstrated in real time. Imagine my shock the first time I connected the textile and the LEDs to the system and a multi-coloured something appeared. From that moment, I have been on a journey to find out what went wrong. Did I misunderstand the programming processes? No, as it turns out I did not and solving the real problem has been much more challenging than correcting a simple programming mistake, at least in this case.

As I was finally able to program colour changes for my work, this happens – what a disappointment! I had been working towards this for years. People who had seen my first sketches were so excited about the results. I could not stop myself from feeling deeply disappointed as the multicolour effect did not allow any precision, neither in the design process nor for the outcome I aimed
to achieve. Instead of going into exploring design possibilities, the journey to resolve the issues connected to the RGB-LED colour mixing system started. However, more time was spent on exploring design possibilities relating to rhythm exercise, which uses monochrome white light.

A year after colour flow_part 1 was created, I sketched colour flow_part 2, taking into account that the colour mixing issue still had not been resolved. I did this in the form of a presentation in order to demonstrate the potential I see in the work with colours. As I am writing this, one year after the presentation, the search for a solution is still an ongoing process. I have not yet abandoned the dream of one day presenting a “perfect” colour work. More patience and funding is required as I need to involve external competence in order to conquer the challenge. However, I have not wasted my time in the meantime as we are about to see in rhythm exercise.
EXPERIMENTS

The video displays all three scenes. The first scene twice, directly followed by scenes two and three.
The video displays all three scenes in chronological order, installation view. (All four LEDs are equipped with a diffusor foil.)
colour flow_part 2.2

Experimental Set-up:

- Laptop
- Microcontroller [DMX 512 Driver
- RGB LEDs: 3
- Woven structure
- RGB LEDs: 3
Colour flow_part 2.2

Colour flow_part 2.2 is a further development from colour flow_part 2. Looking back on colour flow_part 2 in an exhibition and presentation situation, the three parts, three sequences of this composition appear unbalanced. Rather two distinct forms of expressions appear; scene one characterized through a fluid, fine-graded colour change in a very slow pace and scene two and three characterized through a more melodic interplay between a fine-graded colour range and contrasting colours appearing in ongoing varying tempi. It seems that the audience is challenged to have the patience for the slowness and hardly noticeable change in scene one even though that is something I wanted to propose. In the frame of a “fast” presentation with the purpose to demonstrate the potential of colour light emitting textiles I therefore have decided to create this new version of colour flow_part 2. Hence scene one will be changed and a fourth part will be added there all three sections of the fabric can be temporarily lit up from both sides.

Scene one has been replaced through colour order 3 (from colour flow_part 1) playing scene four, the most melodic light sequence from colour flow_part 1. The scene has been shortened from the original sixteen to twelve steps, in order to avoid the feeling of repetition. The changes of colour order and scene have been made in order to give the opening scene a more lively and melodic feeling, being similar to the following scenes. However, as in the original scene one for colour flow_part 2 all three sections of the textiles are lit up simultaneously. As all three sections are playing in parallel (using six LEDs, two LEDs per stripe, one at each side of the textile), displaying identical colour orders, they appear to be a single, monochrome lighting surface.

Scene two and three (identical as in colour flow_part 2) are characterized through a melodic interplay between a fine-graded colour range and contrasting colours appearing in ongoing varying tempi. Contrast and the feeling of movement are created by movement up and down the structure. As soon as the fourth voice is activated, voices two and four both play their sequences on the middle section. This facilitates a multi-coloured effect in this section and also opens up opportunities for further directions of movement, e.g. from left to right and vice versa.

The fourth scene is added, activating all three sections of the fabric temporarily from one or both sides, showing the highest complexity possible of
light “input” in this specific instrument. This scene is a further variation on scene three. Graphical representation of all four parts can be seen both on Poster 1 and page 68ff.

Research Diary Note: Having displayed and discussed colour flow in different presentation situations, the context in which the physical piece, the instrument, and its composition are “read in”, viewed in, has become something for consideration in the future. Colour flow_part 2 had been a consequence exploration out of colour flow_part 1 from a research perspective. The combination of colour- and time orders which achieved the strongest fluidity between the colours had been chosen from colour flow_part 1 for the opening scene of colour flow_part 2. The transition between the colours is so smooth, that it is hardly noticeable. Underlining most the aim for a more contemplative calming expression. The ongoing developing work towards increasing fluidity between the colours was based on observation of the change of daylight over the day. The change of light colour temperature, from cold light in morning and lunch time and warm light in the evenings and the appearance and dis-appearance of light by sunrise and sunset emerge so fluid and slow that you hardly consciously notice it. You observe the colour change in the fabric, and wonder what is happening? Is anything happening? Looking away for a moment and back again, suddenly you see the colour has in fact changed, very slow, but still noticeable. This has been reached in the original scene one from colour flow_part 2 as intended. In a “fast” presentation situation though, there the focus is to demonstrate the potential of colour display the slowness of colour change is a challenge. So therefore you can see colour flow_part 2.2 as an example for more “rapid presentation situations” displaying general possibilities of colour potential, whilst a further development of scene one from colour flow_part 2 would expose a specific area of expressional scopes/avenues.
The video displays all four scenes in chronological order, installation view. (All six LEDs are equipped with a diffusor foil.)
EXPERIMENTS

colour flow_part 2.2

black = light
any colour = a colour extended over several steps (including fading and holding times)
colour flow_part 2.2

Scene 1: step 3

Scene 3: step 11

LED 1    LED 2    LED 3

LED 4    LED 5    LED 4    LED 5

warp direction

direction of movement: up + down
direction of movement: left + right
rhythm exercise

Introduction

This series of experiments explores new ways of designing with time-based parameters to create dynamic light-emitting textile structures. The series of experiments is looking to create rhythmic light sequences and the design aim is to examine different ways of dividing time to facilitate the creation of different rhythms, speeds, dynamics and tensions in movement composition. Play and pause, i.e. activity in the form of movement and silence in the form of the absence of movement, and how these two states interrelate create the foundation for a specific feeling of rhythm, speed, dynamics, etc. These explorations are displayed in the form of braided artifacts. The braids are made of optical fibres, individually braided lengths lit by white LEDs and individually programmed to create moving patterns of light using a microcontroller and a digital interface.

A new lighting device system, which is a recent development in collaboration with UK based electronic specialists Circatron Ltd., allows coupling of the optical fibre ends (bundled into several independent strings) to the LEDs and a digital Mix (DMX) replay system controls the lighting sequence via various programming processes.

The lighting device system is a further developed version of the lighting device system Sarah Taylor used in Inner Light (Taylor, 2010).

Research Diary Note: the braid is based on thirteen lengths, each length is made of twenty optical fibers and connected to an individual LED. I am now able to light up individual lengths in the braided structure in any colour and at any moment in time. I am moving the light now one by one through the structure; firstly: string one lights up, secondly: string two lights up, thirdly: string three lights up etc., each of them for half a second. It is as if the light walks up a staircase, lighting up one step at a time. Two days later, the light is flowing in endless, continuous waves through the same braid. A range of expressions from being quite static (“step by step”) to fluidity has been achieved. Suddenly everything is possible, so what to do with it? What expression do I want to achieve? I have to start somewhere.

Currently this series of experiments consists of six parts investigating the most elemental building blocks in order to understand how to build and cre-
ate complex patterns, compositions evolving over time. The experiments are driven by the need to understand how to build rhythmic structures in order to be able to fully explore the aesthetic potential of time-based patterns.

In the following descriptions of the experiments the metaphor of instrument and composition will be used. Each braided structure is understood as an instrument on which diverse compositions, light sequences, can be played. A composition can consist of one or several voices, i.e. one or several strings activated independently in the braided structure. Thus, each voice can play its own melody or in unison with its other voices.

Why a change to a braiding technique? There are four reasons why I decided to work with braiding: it is a traditional technique, the way light is emitted and spread inside the structure, complex light patterns, and independency in the manufacturing process.

First: Research Diary Note: In the south of Spain I found Esparteria, an old traditional braiding handicraft in which braiding is done with Esparto grass. Over several trips to Andalusia I fell in love with the beautiful surfaces covering and protecting the windows of the old wine cellars from the heat of the sun, still allowing the smell of wine to evaporate the facades and linger in the narrow streets of EL Puerto de Santa Maria. They made me curious to find out more. I discovered that Esparto is used to create a wide range of textile products, ranging from curtains and carpets to baskets and wine bottle holders and that this single technique enables the creation of two-dimensional surfaces in several shapes (rectangular, round, oval), as well as various three-dimensional shapes. The tradition has nearly died out as it is passed on from hand to hand strictly inside families, why there is hardly any form of documentation to be found on the subject. I was fortunate enough to get hold of three pieces that were considered rubbish. These pieces triggered me to try out the technique - I so wanted to know how to crack the code. It took two weeks of intensive work to do it. Well, I did not learn the traditional way of braiding these structures with Esparto grass, but instead I was able to braid it with strings of other materials or optical fibres. See photos in Appendix 1: .

Second: using this technique, the textile structure is created by implementing the fibres from one direction. Weaving requires interlacing fibres from two directions, weft and warp. Braiding in this way, you start at the top and work your way down the whole length. Thus, the length and width of the structure is created at once. Incorporating optical fibres in the weft direction
of woven structures requires a quite high number of LEDs in order to light up a certain length of fabric. Braiding allows a lower number of LEDs to light up a certain length. The only disadvantage so far concerns an inability to create braids of sufficient width, as in their current format they are quite narrow. Despite that, it turns out the braided structures light up intensively.

Third: furthermore, using the structural interlacing of fibre strings in the braids achieved interesting and complex patterns of light. They are only accomplishable through this specific structure and they would not be possible to recreate in a woven structure (see the rhythm exercise experiments in the following pages). The decision was taken to work with a braid based on thirteen strings, even though braiding with more strings is possible. Thirteen strings, i.e. thirteen voices in a time-based composition is a complex enough challenge to start with.

Four: All too often I was not able to proceed with my work on woven structures as I did not have access to the required machinery or the right kind of material for the warp system. By braiding it myself using handicraft techniques makes me independent and allows me to proceed with my work at any time, unrestricted by access to machinery, material accessibility, or access to technicians.
rhythm exercise

Experimental Set-up:

- Laptop
- Microcontroller (Arduino)
- Driver
- LEDs: 13
- Braid: 13in1
Each LED has a dimming range of 0 - 255:
0 = light off, or light intensity = 0
255 = light full on, or light intensity = 255

The code used facilitates individual control of thirteen LEDs [thirteen DMX channels]. Thus, each LED can be activated independently and given its very own rhythm. When the light sequence of one LED has been run once, it automatically enters into an endless series of repetitions with an identical modus.
There are two ways in which the LEDs can be switched on and off:
– via holding time: The change in light intensity occurs in distinct steps.
Three values of light intensity, 0, 80, 255, are used to build a simple example phrase:

<table>
<thead>
<tr>
<th>Time duration:</th>
<th>1500, 1500, 1500, 1500, 1500, 1500, 1500, 1500 milliseconds.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light intensity levels:</td>
<td>0, 255, 0, 80, 255, 0, 255, 80, 0</td>
</tr>
</tbody>
</table>

In the composing process, the following notation is used to show this:

– via fading time: The change in light intensity occurs through a dimming/fading process with a scale range of 0 - 255.
The following scale ranges are used to create a simple phrase:

<table>
<thead>
<tr>
<th>Time duration:</th>
<th>1500, 1500, 1500, 1500, 1500, 1500, 1500, 1500 milliseconds.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light intensity level:</td>
<td>255</td>
</tr>
</tbody>
</table>

In the composing process, the following notation is used to show this:
There are two ways in which the LEDs can be switched on and off:

– via holding time: The change in light intensity occurs in distinct steps. Three values of light intensity, 0, 255, 255, are used to build a simple example phrase:

0, 255, 0, 80, 255, 0, 255, 80, 0

In the composing process, the following notation is used to show this:

1500, 1500, 1500, 1500, 1500, 1500, 1500, 1500, 1500

miliseconds.

– via fading time: The change in light intensity occurs through a dimming/fading process with a scale range of 0 - 255.

The following scale ranges are used to create a simple phrase:

0 → 255, 255 → 0, 0, 0 → 80, 80, 80 → 255, 255 → 0, 0

In the composing process the following notation is used to show this:
There are two ways in which the LEDs can be switched on and off:—
– or through a combination between holding and fading time:

In the composing process the following notation is used to show this:
There are two ways in which the LEDs can be switched on and off:– or through a combination between holding and fading time:

0 → 255, 255 → 0, 0, 80, 0, 80, 255, 255 → 0, 0

In the composing process the following notation is used to show this:
rhythm exercise_part 1

Experimental Set-up:

- Laptop
- Microcontroller (Arduino)
- Driver
- LEDs: 13
- Braid: 13in1_2 voices
LEDs: 2:
Each LED light one group of optical fibre strings.

2 light strings  =  2 voices
rhythm exercise_part 1

In the following, the six parts of rhythm exercise will be introduced. Each part is a series of experiments exploring several perspectives on how to compose rhythmic time-based structures. Part_1, the first part of the initial group of experiments, opens up rhythm exercise.

Each phrase, each individual rhythm is based on a ground beat of one second.

Every rhythm is based on two voices, two lighting “pulses” interacting with each other, partly parallel and partly in off-set rhythms.

The following signs have been used as a basic notation system to allow thinking and developing time-based rhythmic structures.

The height of a horizontal line represents the level of intensity of the light (pitch height in musical notation) and its length represents the time duration of the light at the indicated intensity (see example below).

The diagonal lines represent fading between different light intensity levels. The height at the beginning and end of the diagonal line define light intensity and the horizontal length time duration.

The vertical lines at the beginning and end of a sequence mark the beginning and end of each sequence or phrase. One or several voices inside one composition are connected via the vertical line at the beginning of the composition.

A single repetition of a sequence is marked at the end of the sequence using this sign:

A sequence that is repeated an infinite number of times has this sign at the end of the sequence:
rhythm exercise_part 1_1

The rhythm is based on a ground beat of one second.
The rhythm is based on two parallel voices, i.e. two lighting “pulses”.

Research Diary Note: just blinking, on - off, on - off ...
rhythm exercise_part 1_2

The rhythm is based on a ground beat of one second. The rhythm is based on voices, i.e. two lighting “pulses” interacting with each other, partly parallel and partly in off-set rhythms.

Research Diary Note: still very much blinking, although there starts a first shift.
rhythm exercise_part 1_3

The rhythm is based on a ground beat of one second.
The rhythm is based on two parallel voices, i.e. two lighting “pulses”.

Research Diary Note: something starts swinging, – even though it is an equal beat? Already rhythm?
rhythm exercise_part 1_4

The rhythm is based on a ground beat of one second. The rhythm is based on voices, i.e. two lighting “pulses” interacting with each other, partly parallel and partly in off-set rhythms.

Research Diary Note: it starts swinging, beginning of a 3D twist, movement inside the braid, when the two voices starts fading off-set.

A fast transition occurs from the end of one rhythm to the beginning of the repetition.
rhythm exercise_part 1_5

The rhythm is based on a ground beat of one second. The rhythm is based on voices, i.e. two lighting “pulses” interacting with each other, partly parallel and partly in off-set rhythms.

Research Diary Note: Therefore this rhythm was created. The decision was made to prolong the original ground rhythm in order to be able to see the twist more clearly.
rhythm exercise_part 1_6

The rhythm is based on a ground beat of one second.
The rhythm is based on two parallel voices, i.e. two lighting “pulses”.

Research Diary Note: There is immediately rhythm! why? it has accent, acceleration, dynamic...
rhythm exercise_part 1_7

The rhythm is based on a ground beat of one second. The rhythm is based on voices, i.e. two lighting “pulses” interacting with each other, partly parallel and partly in off-set rhythms.

Research Diary Note: this is a strict, consequent continuation of the previous rhythm, but gives a bumpy expression, the off-set cross-fading is too fast.
rhythm exercise_part 1_8

The rhythm is based on a ground beat of one second.
The rhythm is based on voices, i.e. two lighting “pulses” interacting with each other, partly parallel and partly in off-set rhythms.

Research Diary Note: this sequence is playing with stronger variations to the original rhythm in order to create a more smooth/organic, harmonious rhythm.

This rhythm and the following one explore variations and try to create a smooth, floating, three-dimensional twist (inside the braid) at the end of the rhythm. To create the “right” feeling in the relationship between speed and “visual three-dimensional overlapping-flow”...
rhythm exercise_part 1_9

The rhythm is based on a ground beat of one second. The rhythm is based on voices, i.e. two lighting “pulses” interacting with each other, partly parallel and partly in off-set rhythms.

See all nine rhythms in one overview in Poster 2.
rhythm exercise_part 2

Experimental Set-up:

- Microcontroller (Arduino)
- Driver
- LEDs: 13
- Braid: 13in1_13 voices
rhythm exercise_part 2

“step by step → wavelike”

In rhythm exercise_part_2 every phrase is based on thirteen voices. The aim is to switch every LED on and off, one after the other, in chronological order through the braided structure (1,2,3, …). See visualization below.
Research Diary Note: However, this is what occurred instead:
What really happened?

Although the thirteen strings of the braid were lined up in chronological order (1, 2, 3 …), the order in which each string was braided in the braiding process was not 1, 2, 3… In fact, the braiding process is divided between both hands: in the beginning, seven strings are held in the right hand and six in the left and the outer string of the right hand (string 13) is used to start braiding: two over, two under, two over and into the middle. Then, the left hand follows (string 1): two over, two under, two over and into the middle. The right hand continues (string 12) by doing two over, two under, two over and into the middle and then the left hand (string 2) does two over, two under, two over and into the middle, etc. (see drawing below). Thus, the textile structure and the time-based composition of lighting both influence the expression of movement, in this case the movement direction in the textile structure.
What really happened?  
*See graphical notation of time order and movement direction below:*

**Time order of the individual LEDs being switched on and off.**

**Time order of the individual strings inside the braided structure being switched on and off.**
Movement direction of light sequence inside braided structure.
In order to achieve the aim of this design experiment, i.e. to switch every string inside the braided structure on and off one after the other (from one side of the braid to the other), the time order has to be changed (below):

Time order of the LEDs being switched on and off. Movement direction of the light sequence in the braided structure.
One alternative possibility to achieve the aim is to re-connect the order of the strings to the LEDs, i.e. to adjust the physical set-up instead of altering the programming code (see Second set-up below):

### First Set-up
- Code
- Microcontroller
- Driver
- Cables: 13
- LEDs: 13
- Braid Strings: 13
- Movement inside braid

### Second Set-up
Third Set-up

<table>
<thead>
<tr>
<th>Code</th>
<th>First Set-up</th>
<th>Second Set-up</th>
<th>Third Set-up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cables: 13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEDs: 13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Braid Strings: 13</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Movement inside braid

Crosses mark the presence of the element.
The continuation of the sequence was developed using the third set-up, which was presented on the previous page. Phrases are coded in such a way that the “cross-over” movement, i.e. the movement in two directions, occurs inside the braided structure. By doing so, more exciting motion patterns are generated.

The final composition, or rhythmic structure, “step by step → wavelike” is based on twelve rhythmic phrases, linked seamless behind each other. Thereby the ground beat of 500 milliseconds maintains as the continuous metrum.

Phrase 1: every LED turns on and off, “step by step”-like, in a blinking manner. Thereby the time duration of the LED being on is 500 milliseconds (see drawing below).

Phrase 2: every LED is turned on, “step by step”-like, holds for 500 milliseconds, and then fades out over a period of 500 milliseconds (see drawing below).

Phrase 3: every LED is turned on by fading in over 500 milliseconds, holding 500 milliseconds, and fading out over a period 5000 milliseconds (see drawing below).

Phrase 4 – 12: the time periods for fading in, holding, and fading out are extended by 500 milliseconds until they all reach 2000 milliseconds (see drawing below and graphical notation of the complete composition in Poster 3).
Phrase 12
Video shows all twelve phrases of “step by step → wavelike” in order.
rhythm exercise_part 3

Experimental Set-up:

- Laptop
- Microcontroller (Arduino)
- Driver
- LEDs: 13
- Braid: 13in1_13 voices
Third Set-up:

- Code
- Microcontroller
- Driver
- Cables: 13
- LEDs: 13
- Braid Strings: 13

Movement
inside braid
rhythm exercise_part 3

Ambience 2011

Rhythm exercise_part 3 is based on 13 voices.
The composition is based on three longer sequences, which are played in order.

1. Sequence: “step by step → wavelike”:
[Composition “step by step → wavelike” (rhythm exercise-part 2)]

2. Sequence: “Verschränkung” [interlacing]:
Variation of the composition “step by step → wavelike” with the following order of the phrases:
Phrase 1/LEDs 1-6 + Phrase 12/LEDs 7-12
Phrase 2/LEDs 1-6 + Phrase 11/LEDs 7-12
Phrase 3/LEDs 1-6 + Phrase 10/LEDs 7-12
Phrase 4/LEDs 1-6 + Phrase 9/LEDs 7-12
Phrase 5/LEDs 1-6 + Phrase 8/LEDs 7-12
Phrase 6/LEDs 1-6 + Phrase 7/LEDs 7-12
3. Sequence: “mistaken”:
Variation of the composition from "step by step → wavelike". In the initial coding of the composition "step by step → wavelike" major mistakes were made, which in the end generated continual changes in the original phrase. For example, two voices became “independent” and played a cross-rhythm to the other voices. Moreover, one of them created a time-overlap, meaning that voice 12 is still playing sequence 3 when all other voices go back to play sequences 1 and 2 again. Hence, there will be an endless number of variations of the original phrase. See Poster 3.
Research Diary Note: when the braid is rolled up, the movement sequence of the light almost becomes a dance – ein Ringle Reigen …

Composition has been displayed at the Ambience 2011 conference exhibition.
rhythm exercise_part 4

Experimental Set-up:

- Laptop
- Microcontroller (Arduino)
- Driver
- LEDs: 13
- Braid: 13in1_13 voices
Third Set-up:

- Code
- Microcontroller
- Driver
- Cables: 13
- LEDs: 13
- Braid Strings: 13

Movement
inside braid
rhythm exercise_part 4
Lotterie_1-5

Rhythm exercise_part 4 is based on 13 voices. These five sequences explored further variations on “step by step → wavelike” [Composition rhythm exercise_part 2].

Lottery_1-3

“Step by step → wavelike” is based on twelve phrases played in order which have been divided into separate sections again. Each section has been further divided into two parts, LEDs 1-6 and LEDs 7-13, the two groups create opposing movement directions on the inside of the braided structure. The twenty-four mini phrases were then used to play “Lottery” in order to create new sequences. The numbers of the mini phrases were written down on pieces of paper, which were then shuffled and new, random orders of the phrases were drawn, creating new compositions using chance as co-composer.

Research Diary Note: oh, how do I create the transition between each mini phrase? How did I do it before?

A ground beat of 500 milliseconds has been the meter, measure of time, the interval between the start of each voice sequence. Voice/ LED 1 starts by playing its rhythm or phrase for 500 milliseconds, then voice/LED 2 begins playing its rhythm for another 500 milliseconds, etc. until voice/LED 6 plays its rhythm, followed by voices/LEDs 13-7. Directly after voice 7 has completed its sequence, the new phrase, starting with voice 1, begins to play. In each of the 12 sequences, all voices play in the same chronological order, first voices...
1-6 and then 13-7, all of them starting with a 500 millisecond interval (see-drawing left page). The thirteen voices are now playing in new orders and no longer repeat voice 1-13, voice 1-13, voice 1-13, etc. Instead, the following may occur: 13-7, 1-6, 1-6, 13-7, 13-7, 13-7, ..., 1-6, 1-6, 1-6, 13-7, ... . At this point, the question was how I was to create the transition between each mini phrase, i.e. between: 7-13 → 1-6, 1-6 → 1-6, 7-13 → 7-13?

The decision was made to play the transitions in the following way:

1-6 → 13-7:
As before, each voice starts playing 500 milliseconds after the previous voice has started playing (see below left).

13-7 → 1-6:
As before, voice 13 completes its phrase, like a full stop in a sentence, and then voice 1 starts playing (see above right).

1-6 → 1-6:Voices 1-6 are played with a 500 milliseconds interval. 500 milliseconds after voice 6 has started playing, voice 1 of the second sequence starts (see following page below left).
EXPERIMENTS

13-7 → 13-7:
Voice 7 completes its phrase and then voice 13 starts playing (see the notation below right. All notations of Lotterie 1-3 can be found on Poster 4).

1-6 → 1-6  13-7 → 13-7
rhythm exercise_part 4
Lottery_1-3

Research Diary Note: Suddenly, new patterns appear, new structural phrases. Verschränkungen (interlacing), yeah, Verschränkungen is the right word for this. See detail examples from Lottery_1 below.

How would this look like inside the braid?
rhythm exercise_part 4
Lottery_1
rhythm exercise_part 4
Lottery_2
rhythm exercise_part 4
Lottery_3
rhythm exercise_part 4

Lottery_4-5

From the original 12 phrases, five (1, 2, 5, 8, 11) were selected to create a variation on the Lottery game. Each phrase was used with its two separate parts (LEDs1-6 and LEDs 7-13). Each mini phrase was used three times. The procedure used to create the randomly ordered compositions were the same as for Lottery_1-3.

Thus, known phrases were rearranged through a play of chance, a play of chance with repeated phrases, creating patterns over time.

The transitions between the mini phrases were created in the same way as for Lottery_1-3 (all notations can be found in Poster 4).
rhythm exercise_part 4
Lottery_4
rhythm exercise_part 4
Lottery_5
rhythm exercise_part 4
Lottery_1-5

Research Diary Note: ups, what was this? Sudden movement at high speed, is this correct? or is this another coding mistake? No coding mistakes can be found. But maybe ... I am just underestimating the tempo, when I am looking on this drawing (see detail from Lottery_3 below).

As new structural patterns appear, Verschränkungen, I can no longer predict the movement of the light in the braid. The phrases are too complex. After viewing Lottery_1-5 several times, I begin to develop a slight familiarity with some of them (see detail from Lottery_5 below right).

This is odd, really strange – but interesting ...

This is just not working at all ...

Oh I like this ... so why?

... smooth fading in and out ... this one is fluid .... it feels like a repetition with a slight shift.

Three mini phrases together form a new rhythmic unit, this type of rhythmic structure I am naming Verschränkung for now. The same thing occurs by all the other Verschränkungen, several mini phrases, minimum two, create
new structural units (see example below).

Limiting the number of phrases used to play the Lottery game to five original sequences, Lottery_4-5 increases the perceived difference in speed between the different mini-phrases. Furthermore it opens up for the play with repetition of single figures/phrases/sequences. When one phrase is played twice in a loop, the repetition/repeat is clearly visible, a “moment of obvious repeat”.

However, repeating a phrase with several other phrases in-between does not necessarily bring the word repeat to my mind. Yet, phrase No. 1, step-by-step, seems to fall out of the picture a bit. It appears to be the most significant phrase, as although it has not been played for quite some time I still remember seeing it before. There I tend to say: “oh, this appeared before, it is repeated.”

There seems to be two ways to repeat a phrase: as a direct repetition and as a recurring element. Somehow these two forms of repetition are clearly distinguishable and create something different … another nuance of expression.
rhythm exercise_part 5

Experimental Set-up:

- Laptop
- Microcontroller (DMX 512)
- Driver
- LEDs: 13
- Braid: 13in1_11 voices
  [2 strings are off = white]
Third Set-up:

- Code
- Microcontroller
- Driver
- Cables: 13
- LEDs: 13
- Braid Strings: 13
  (2 strings are off = white)
- Movement
  inside braid
rhythm exercise_part 5

Erwacht Ihr Schläfer drinnen

Rhythm exercise_part 5 is based on 11 voices. The Arduino board has been replaced through the DMX 512 Replay Unit, and the braid is playing only with 11 voices (as canon is based on a eleven pitches).

This experiment is exploring the rhythmic structure of the old German canon Erwacht Ihr Schläfer drinnen (Awake you sleepers inside, melody by Giacomo G. Ferrari, 1763-1842). The canon is based on three parts and each part is repeated once before the melody moves on to the next part (see notes below).

In an attend to understand something about rhythmic structures in music, this simple melody was chosen, with the original aim of later playing the three canon voices on three braids.

First, it has been explored how to transfer the traditional note notation into a more graphical notation. Each note in the pitch range has been given a colour. The pitch range spans two octaves from C – F’ (every pitch height triggering one voice/LED). Thereby the pitches from the lower octave were represented in darker colours and from the higher octave by lighter colours, for example D = dark brown, D’ = light brown, F = dark green, F’ = light green (see illustration below right).

In the previous notation system, the length of a line represented a specific time duration. The notes below have been transferred into rectangles and the horizontal length of the rectangle represents the time duration of the note.

The height of a line represents the light intensity value and the height position of a square corresponds to the height position of the notation of an individual pitch. Together, colour and height position of a square represent a specific pitch and therewith a specific voice/LED inside the braid.
F' = LED 11
E' = LED 10
D' = LED 9
C' = LED 8
H = LED 7
A = LED 6
G = LED 5
F = LED 4
E = LED 3
D = LED 2
C = LED 1
rhythm exercise_part 5
Erwacht Ihr Schläfer drinnen

Trying out different forms of “graphical” notation:

Canon “Erwacht Ihr Schläfer drinnen”, three parts,
in coloured “graphical” notation:
Research Diary Note: speed, tempo is something very subjective and over the last days I tried three different speeds, too fast, too slow... right. But today right seems a bit slow again. I have to take a decision. The feeling of speed might always be dependent on my daily mood... ah, how did I decide too fast, too slow etc.? I was singing the canon over and over again while watching the sequence moving inside the braid. The right tempo as part of my childhood memory and my daily mood make the decision on the right speed a very subjective matter. Decision is made, I maintain the current speed for part two and three of the canon.

About notation, I received the comment, that I should only develop one form of notation. It should be as simple as possible and as open as possible, so that it will apply for a wide range of experiments. Would that work? Several forms have been tried out, as is shown above, but somehow forcing the notation for the canon into the “grid” of rhythm exercise_part 3 didn’t work out. Translating single notes into individual colours worked well as it was a better way for me to memorize it. The graphical pattern is more distinct and thus a lot easier to remember, making the transfer into coding much more straightforward. However, the other trials show in a way the same thing.

The biggest challenge was to find a form to translate double notes (two identical notes repeated), e.g. two F behind each other (see drawing below top), into graphical notation. How was to show, graphically, the repeated
notes while at the same time avoiding making them appear as a single, longer note (see drawing previous page bottom left, top green rectangle)? In case of inserting a space between these two squares, the time line would be automatically increased, if the strict counting meter was maintained. So, how do I distinguish those without changing the counting time/meter? The same question applies for the coding process.

When playing an instrument, the distinction between successive notes is created through different articulations. Variations in articulation define the transitions between a series of notes and, therewith, how the single note is played. For example they can be played as: legato = tied notes, nonlegato = not tied notes. Thereby a series of tied notes is often marked via a bow covering the range on top of them, and not tied notes are often played with short breathing mark between them. Meaning the notes get shortened from its strict counting meter. (Cf. Musik-Steiermark, N.D., Ziegenrücker, 1997) Articulation over-rules the counting meter. Different forms of articulation in playing an instrument are often marked through extra symbols as they indicate to the musician when and how the strict counting meter is “overruled”. Taking this into the graphical notation system and especially into coding there occurs a problem, it can only handle precise “meters”/time durations.

The graphical notation issue in this specific case was solved by shortening one of the repeated pitches. However, the same issue concerns another series of pitches where no direct repeat of a pitch occurs (see previous page bottom right).

I received the comment the squares have a logic towards weaving construction drawings, being a step closer to traditional symbols read by a textile designer. Well, yes, it does in some way, however for me it mainly reminded me to read notes and that helped towards an understanding of time based patterns. Fusing everything into one notation system did not work, however, although it may do so for someone else. I have a feeling that the different kinds of drawings I make stand for different things or different views on a similar thing, although I cannot put it into words at the moment.

For the very first time, a pause (= LED turned off) no longer creates a feeling of blinking, as it did in rhythm exercise_part 1. A pause becomes another rhythmic element. A voice inside the braid, being played and/or paused equally influences the composition of a rhythmic light sequence.

I received the question: Can you do this also in the negative form? Hm, I had not even thought about this. It had always been clear to me that the melody playing on the braid would be represented by strings lighting up. Every pitch played was to be displayed by a string “switched on”. Yes, of course, now a dark line is moving inside an illuminated strip, the same way a light line was moving inside darkness before (see next page). It is strange, the moving line doesn’t seem to appear so clear. Or?
EXPERIMENTS
rhythm exercise_part 6

Experimental Set-up:

Laptop

Microcontroller (Arduino)
Driver
LEDs: 13
Braids: 39 in 1_6 voices
rhythm exercise_part 6

“39in1_6 voices ... playing the wrong composition”

Rhythm exercise_part 6 is based on 6 voices.  
Three braids, each based on thirteen strings are grouped together. They are parallel aligned side by side at a distance of about two centimeters and each braid plays two voices. The physical object 39in1_6 voices is a further development of the braid 13in1_2 voices from rhythm exercise_part 1. It is about building either a “bigger instrument” or playing with three identical instruments. How can this object, consisting of three times two voices, which are clear distinct from one another, play a more complex composition?  

In order to try out this object in a fast way an existing code was played inside this piece. The final version from “step by step → wavelike” from rhythm exercise_part 3, was chosen, as it was the first completed sequences consisting of at least six voices (play below).
Research Diary Note: This gets really odd. Something totally different, seven voices are missing in this object, which creates brakes in the play, it feels too long, very static, boring … it is no longer possible to perceive the tempo of the composition gradually slowing down … it is very weird. I wonder if this code is correct. It is.

This clearly shows that the composition is not right for this object, this instrument. In this type of work new forms of expression are based on two main elements: physical object in form of a textile structure and a specific lighting composition. I am beginning to think more and more in terms of instrument (object) and composition because one can play several compositions on a single instrument, achieving different expressions. The same composition can be played on various instruments, regardless if this causes the generated expression to become meaningless, odd, weird, etc.

“… symmetric composition? ”

The most advanced rhythmic structure for any instrument with two voices in my experiments was rhythm nine from rhythm exercise_part 1 (see below). It has been used as a foundation to create a suitable rhythmic composition for 39in1_6 voices.

Rhythm nine consists of two distinct parts. Part 1 is based on a threefold repeat of a mini phrase played in parallel for both voices and Part 2 creates a floating, three-dimensional twist in the braid (created through an off-set interaction between the two voices). The aim of this experiment is to explore in which ways these two elements, repeat and 3D twist, can be played with six voices.

The following description demonstrates how the more complex composition has been built up out of these two mini phrases, they are symbolised through two triangles:
The completed composition consists out of six larger phrases, labelled Block A - F, which have been chronological developed. See below and on Poster 4.

A moment of silence, darkness, voice one and two start playing rhythm nine. They repeat the phrase and, simultaneously voice three and four play the same rhythm. The phrase is repeated once more. All six voices play it simultaneously. See Block A following page. The six voices are introduced by launching one pair at a time.

Watching rhythm nine play, I spend most of the time waiting for the mini phrase creating the 3D twist. In Block B, one pair, voices three and four, repeats rhythm nine three times. As the other pairs join in and play Part 2, one by one the voices highlight the 3D twist. Finally, all three pairs are reunited in the last twist (see Block B following page).

Accepted that Part 2, the 3D twist, is most interesting part of rhythm nine, in Block C it is repeated twice on its own in all pairs simultaneously. See following page and on Poster 4.

And now? What to do next? One idea that came up was to see what would happen if from here on the three Blocks were to be mirrored. To see if a thereby created symmetrical composition would be perceivable being played other time. Hence, Blocks D, E, and F were created as mirror images of Block A, B and C, respectively. Playing Blocks A-C backwards in revers order, so to speak (see following page and on Poster 4).

These symbols represent the appearance of the individual voice over time:

- voice 1+2
- voice 3+4
- voice 5+6

Whilst these symbols the presence of Part 1 + 2 in lapse of time:
EXPERIMENTS

Block A

Block B

Timeline
Research Diary Note: It appears, that I obviously never completed to code the whole mirrored sequence, after Block E I stopped. Looking at the sequence played inside the braid it all gets so endless, boring and static…

So why did this not work out at all?

In general, the mirrored effect is hardly visible at all when played over time, despite the fact that I am expecting it. After Blocks A - D have been played out, too much time has passed since the phrase of rhythm nine (Part 1 + 2) was played for the eye to remember it precisely. Therefore Block E appears to be almost the same as Block B and Block F almost the same as Block A. The repetition of patterns that appears to be the same over and over again begins to bore the eye after a while.

In this example, I noticed a major difference between my perception of the notation of the time-based pattern and the pattern itself, the actual rhythmic structure being played. Looking at the graphical notation (see Poster 4) a mirrored graphical image or illustration is clearly visible. The eye is able to discover the mirroring effect in the illustration as it is able to take in the entire image at the same time: it can zoom in on details and zoom out again to examine the overall composition of the image as a whole. Spending a certain amount of time grasping the overall expression, we seem to be able to memorize it quite well. “Do you remember this drawing we talked about last week?” A trained eye will have memorized the main characteristics and, in our case, the basic idea of the composition was to mirror symbols. However, our perception of time-based lighting patterns seems to lack precision. In this specific case, I cannot perceive the obvious pattern of the graphical notation in the time-based composition, despite the fact that I composed it myself.

Viewing the original rhythm nine on repeat, one longs for the twist to come back again. When playing this version on repeat it feels too long, even though it changes voices. Identical rhythm and speed repeated too often cause all tension and accentuation to be lost and the eye becomes bored.

And another comment on tempo: when watching this composition over and over again, the tempo seems to be changing from day to day and always to be wrong, just like before. Too fast, too slow… always the same, monotony creeps in.
The element in Part 1 where the lights drop from “full on” to “full off” (see below) is very tiring to the eye after a while. It resembles “blinking”.

EXPERIMENTS

255 = full on

0 = full of
Research Diary Note:

First Set-up

Second Set-up

Reviewing different ways of connecting electronic components and code to influence the movement directions in the braided structure: rhythm exercise_part 2 raised a need to rethink the set-up, as the movement in the braid didn’t turn out the way it was expected to. The set-ups illustrated above show the chronological progression of my work, whilst working with the experiments.

The fourth set-up did not require any rescrewing of the braided strings to the LEDs to create endless variations on a code that allows different movement directions in the braid. This creates the least risk for the optical fibre parts to be damaged, as they are very sensitive to bending, scratching etc., whilst working with different experiments.

Furthermore, this demands only a simple “click in + out” of the plugs (mounted on each cable end of the individual LEDs) to re-connect them to the driver board.

The LEDs are mounted horizontally on a bracket (which functions as a heat sink) allowing them to be numbered 1, 2, 3 – 13, either from left to right or from right to left (which has been done for all experiments). For the whole system to work, however, the LEDs are not defined/numbered until they are connected to a specific position on the driver board. It is the position that
gives the LED a specific number (channel) 1, 2, 3, etc. So, swapping the cables on the driver board, using the “click in + out” system, allowed easy renumbering of the LEDs and, consequently, altering of the time order in which the LEDs were activated despite playing the same code.

There are two moments/positions in the code where the activity on a specific LED is defined:

1) At the beginning of the code “Program constants” define that each LED (1-13) is allocated with a specific DMX channel number. For example: LED 1 = channel 1, LED 2 = channel 2, LED 3, etc.

The driver board has 13 LED connections (labeled LED 1-13), each of them has a specific DMX channel number. By defining in the code LED 1 = channel number x, each physical LED (connected to a specific position on the driver) receives its own number or position in the system. Setting the channel number in the code defines the number position of a LED on the coding level, as well as in the hardware components (driver, LED).

2) Further down in the code, in “LEDs sequence”, the individual timeline is defined, which controls the activation and pausing of LEDs, the time duration of both state, and the form of appearance, such as fading in or being switched
EXPERIMENTS

on in distinct steps.

As a result of this, one is able to create endless variations by changing either the channel connected to a specific LED in the code or the timelines of the individual LEDs in the code (which takes more effort).

Alternatively, what is probably the fastest way to alter a given composition/code is simply to swap the plugs of the LEDs in the driver board. The end result of changing the channel in the code and swapping the plugs on the board are the same. The difference is that one influences on the coding level = digital interface and the other the physical level = hardware components.

Of all this, what is still relevant when I change from the Arduino coding + Arduino microcontroller to another digital interface + microcontroller?

Which components/aspects maintain (even they might be controlled in another way) to compose light over time?

Definition of channel [a LED gets defined/addressed with a specific channel number]

![Diagram showing the components and variables involved in the experiment.](image)
Creation of timing/timeline for each LED

Cable connection between channel number/position on driver + LED number in code/software + physical LED → string → braid → movement.

Nevertheless in which way I have connected and manipulated the components of the set-up on the coding or physical level, it is important to try out and find the way which works best for you. Most important is to find a way that allows you to easily pre-predict, envision the movement inside the structure, whilst working on the coding level. However, I strongly recommend avoiding frequent re-screwing of the braided strings to the LEDs, as it is all too easy to damage the physical piece.
sound_light experiment

Introduction
Among all possible expressions, personal interest has led me to look into organic expressions. Over 200 sounds of water and wind have been recorded as a starting point for transferring rhythms and movements based on natural phenomena into lighting sequences. The intention has been to investigate how to re-awaken organic and captivating appearances that unfold over time. The idea to map temporal patterns found in nature and investigates how they can be applied in the design of dynamic light in order to create a composed experience with traces of nature as followed me from the beginning of my PhD research.

Starting the cooperation with Jan Carleklev, a Swedish composer and artist, in 2012 opened the possibility to start exploring a relationship between sound and light. An initial test using recorded sound to trigger the light of RGB-LEDs, displaying the light into a light emitting woven textile surface, failed completely. The sound information, even running through filters in order to reduce information, was so much that the visual output was total chaos, unreadable and not understandable for the eye. It didn’t make any sense. It was immediately obvious, starting to work with recorded sounds is a too high challenge in order to explore and investigate a basic understanding about possible relationships between sound and light. Therefore the decision was made to strip down sound and light to their most basic elementary components, in order to start an investigation. The use of pure digital created sine pitches and the basic light colours of the RGB-LEDs: red green and blue hence lay the starting point for the following experiment Sinus 90 + blue.

The woven structure is built up through the integration of PMMA optical fibres, which have been interlaced with paper yarn in the weft direction, and is 1x1m in size. The structure is divided in ten individual equal sized stripes/sections, each connected to an individual RGB-LED and independently programmable.

As in the previous projects the newly developed lighting device system, developed in collaboration with UK based electronic specialists Circatron Ltd., allows coupling of optical fibre ends to the LEDs and a digital Mix (DMX) replay system controls the lighting sequence via various programming processes, in this case the MAX MSP and Ableton Live (incl. Max for Live) softwares.
Early on in the project cooperation it was decided to work towards an exhibition installation, therefore two parts of the project will be described in the following: under Sinus 90 + blue the initial experiments, and under Sinus 64 + blue the further development into a composition for exhibition purposes. Already in the composing process we knew the project was accepted for the Shapeshifting conference exhibition in Auckland, New Zealand, April 2014. Hence a design research audience was in the back of our mind whilst working with this composition.
sound_light experiment

Experimental Set-up:

The softwares MAX MSP and Ableton: Live together with Max for Live have been used.
Sinus 90 + blue

In Sinus 90 + blue sound triggers and creates a dialog with light which is embedded inside a woven textile structure. In this initial experiment three different elements of sound trigger each one of the base light colours of the RGB-LEDs: red, green or blue. The dialog between single sine pitches and the three base colours of light explore elementary aspects in the relationship between sound and light.

Sound element one:
Was created by playing two to four individual sine waves (sine pitches) together. The individual sounds are slightly detuned in relation to each other, but all are close to the centre frequency 90 Hz. This approach is causing interference between the sine waves (The Physics class room, N.D., Infoplease, N.D.). The interference between the single sine pitches creates unique rhythmic sonic structures, laying a steady beat as a foundation for the sound-light composition. This sound element triggers blue pulsing light over the whole textile structure.

The base sinus pitch is frequency 90; it stays on this value all the time. Adding a second sinus pitch for example on 90,5 Hz, together they create an interference, a specific rhythm, a steady beat. By changing the second value the rhythm changes, as closer the values are to each other as slower the rhythm as bigger the distance is towards the next octave as faster the speed. When the second value reaches the double amount from the first the octave is created, the rhythm is so fast that it appears as one clear pitch again. The sonic rhythm triggers the blue LED, thereby changes in volume create changes in light intensity of the blue light. Appears a single sinus pitch, 90 Hz or the octave, the blue light is switched on, “standing” still, as soon as the addition of a second and third frequency creates an interference rhythm the blue light follows those rhythm speeds. Rhythms created due to two frequencies generating interference produce “periodic waves” which are perceived as simple rhythmic patterns (equally accentuated), whilst adding third and fourth frequencies generate “periodic waves” which are perceived as more complex rhythmical patterns (unequally accentuated), see examples on following pages. The textile surface is divided in ten horizontal stripes, each 10cm high and 1m wide. The fived stripe is triggered from the sonic rhythms in real-time, whilst stripe four and six follows with 100 milliseconds of delay, stripe three
Interference between two frequencies:
Simple rhythmic pattern = equal accentuated:
Top: Frequency 1: 64  Frequency 2: 65
Middle: Frequency 1: 64  Frequency 2: 64,4
Bottom: Frequency 1: 64  Frequency 2: 64,2
Interference between three frequencies:
Complex rhythmic pattern = unequally accentuation (strong and weak times):
Top: Frequency 1: 64 Frequency 2: 65 Frequency 3: 68
Middle: Frequency 1: 64 Frequency 2: 64.4 Frequency 3: 65
Bottom: Frequency 1: 64 Frequency 2: 64.2 Frequency 3: 65
and seven with 200 milliseconds delay, stripe two and eight with 300 milliseconds of delay, and stripe one and nine with 400 milliseconds delay. Stripe ten is not activated, in order to have the real-time moving stripe in the centre of the textile piece. See graphic on page 164. The time-based delay over the range of stripes creates not only a pulse inside one area of the textile, additional it creates a movement rhythm flow over the whole structure of the textile surface.
Sound element two:
was created through a sequence of increasing sine pitches starting at a frequency of 100 Hz and increasing to 440 Hz (playing a scale from lower to higher pitch) before starting over from 100 Hz again. This over and over increasing sound scale activates the red light, floating upwards and upwards the textile structure over and over again. The scale from 100 to 440 frequencies has been divided in ten intervals, ten ranges of pitches, triggering each one stripe of the textile. The lowest range triggers stripe one and the intervals gradually upwards the upwards following stripes. All stripes are activated in real-time to their sonic interval. When this sound_light element plays parallel to sound_light element one, the blue light, pink light is created; hence you see pink light floating upwards the fabric instead of red.
Movement directions for blue, red and green:

- **Real-time**: repeating upwards flow
- **Real-time + delays**: pulsing rhythm, over the whole surface
- **= off**: 400 milliseconds delay
- **= 100 milliseconds delay**: real-time, melody, one pitch at a time

**Sinus 90 + blue:**
### Movement directions for blue, red and green:

<table>
<thead>
<tr>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>400 milliseconds delay</td>
</tr>
<tr>
<td>9</td>
<td>300 milliseconds delay</td>
</tr>
<tr>
<td>8</td>
<td>200 milliseconds delay</td>
</tr>
<tr>
<td>7</td>
<td>100 milliseconds delay</td>
</tr>
<tr>
<td>6</td>
<td>Real-time</td>
</tr>
<tr>
<td>5</td>
<td>100 milliseconds delay</td>
</tr>
<tr>
<td>4</td>
<td>200 milliseconds delay</td>
</tr>
<tr>
<td>3</td>
<td>300 milliseconds delay</td>
</tr>
<tr>
<td>2</td>
<td>400 milliseconds delay</td>
</tr>
<tr>
<td>1</td>
<td>500 milliseconds delay</td>
</tr>
</tbody>
</table>

**Sinus 64 + blue:**

- Real-time: upwards + downwards flows
- Real-time: melody, one pitch at a time
- Real-time + delays: pulsing rhythm, over the whole surface
The third sound element:
is a melodic sequence of single sine pitches, covering a range of high and low pitches. They set off the green light, dancing and pulsing over the structure. Likewise here the range of pitches has been divided into ten intervals, each triggering one stripe in the textile. Lowest range triggers lowest stripe, highest range highest stripe, etc. When this sound_light element plays parallel to sound_light element one, the blue light, turquoise light is created; hence you see turquoise light dancing over the fabric instead of green.

These initial experiments have been given the working title Sinus 90 + blue, based on sound element one, establishing foundation rhythms built on frequency 90 (sinus (German/Swedish) = sine in English).
View sound-light element three: only green,
Research Diary Note: The third sound element is triggering the green light, though the light is activated in real-time the sonic and visual movement pattern don’t appear identical, not as a one to one translation, as intended. Somehow there is a slight shift in the visual pattern, partly matching synchronically to the acoustic pattern partly not. In fact individual pitches trigger individual stripes in the textile, but as a range (interval) of several pitches triggers the same stripe you partly perceive a gap between visual and sonic pattern. In the beginning this really irritated me, as I didn’t understand the whole programming process, by now I just have to accept this gap. Nevertheless it really shows how sensitive we are on the perception of synchronism between sonic and visual events. We would need a textile divided into the same amount of stripes as the amount of pitches used in a sequence in order to reach an identical visual and sonic pattern.

Right from the first experiments with the second sound light element the visual pattern appeared always slower than the sonic sequence, especially at the moment reaching the high point of the scale and starting from the beginning again. A constant feeling that the visual pattern is slightly off-sync to the acoustic one, always feeling “just slightly” delayed, felt really annoying and disturbing. And we had programmed the light to be activated in real-time to the sound, it was supposed to be in-sync. What was going wrong? In order to reach a visual gliding scale, the light colour moving from on stripe in the fabric to the next fading in and out had been applied to each section (as the use of pure holding time from section to section would have created a “going up the staircase feeling”, remember the experiments from colour flow). First thing we could identify then was, that when the sonic scale was starting from the beginning again, low pitch = lowest stripe in textile, the highest stripe in textile was still fading out, creating the obvious feeling of delay from the visual pattern in relation to the sonic one. As the initial wish had been to create precision between visual and acoustic pattern, a lot of programming trials have been made in order to solve the feeling of delay, especially working on the fading in and out times. Slight improvement at the breaking point from the high point back to the low point again was possible, but a general feeling of constant “slight” delay was not removable. In the end we took the decision that we had to live with the imperfection, as these were just basic experiments and carry on towards how to compose a more complex piece with...
these three sound_light elements.

However looking one more time back, as I am writing this, after analysing the gap in perception of the Green sequence, sound_light element three, it explains the “delay” perception in the red scale as well (being “on and off time” at the same time, this feeling there is something not precise here, but you cannot detect why).

Through the gliding, fine fading scale from one stripe to the next it was nearly impossible to detect, why it always is being perceived to be too slow, even knowing it has been programmed to trigger in real-time to the sound, as the visual movement appears seamless. Also here a range of sine pitches triggers the same stripe, meaning when the acoustic sequence is constantly increasing upwards the visual pattern reaches a section in the textile, stays a moment on this section – until the whole interval of sine pitches has been completed, and then moves forward to the next one. Even this might be a process of milliseconds we do perceive the feeling of off-sync between visual and acoustic event. In fact we cannot resolve this issue through further programming trials, we would need a textile divided into the same amount of stripes than the selected amount of pitches (pitch range) used in the sequence in order to reach an identical visual and sonic pattern.

Sinus 64 + blue

Research Diary Note: There has been an ongoing discussion over the whole work process between us on a central aspect of the matter of composition. Do we try to create a translation, from sound into light, or a dialog, between sound and light, towards an overall sound-light composition? Do we create “just” pure translations between sound and light, as with Red and Green sequences created so far, or do we try to find a way of creating/establishing a dialog between these two media in order to create an overall composition, sound and light being equal voices. How could that look like, be like? Pure translations, “the conversion of something from one form or medium into another” (Oxforddictionaries, N.D.-b), bear the risk to appear flat, too predictable after a while, maybe also something too much seen in other media before (translating sound/music into visual media). However in order to establish a visual-audible pattern for the audience, synchronisation between sound and light can make sense, to really see and understand what is going on between the two. Nevertheless to reach an elaborate composition it seems to be rele-
vant to explore how to escape the “pure” translation, in order to create a dial-
log between sound and light and vice versa. Therefore sound_light element
two and three will break out from their strict forms into something else more
and more by building an overall composition. Sound_light element one has
been never perceived as a translation, right from the beginning, shifting the
rhythm light patterns with delays over the whole textile surface had immedi-
ately created a different experience/feeling/expression. Sound and light are
clearly related, but having a conversation and are not mimicking each other.

Therefore in the continuation towards composing an exhibition piece
mainly sound_light elements two and three have been further developed.

Sound_light element one:
The base frequency has been lowered to 64 Hz. (This low frequency is only
perceivable with good speaker quality!) Creation of interference rhythmic se-
quences have been created by adding a second and third frequency, identical
process than in previous experiments has been used. The quality of sound,
using pure sine pitches remains the same. All ten stripes of the textile are
activated now; currently section six is moving in the real-time tempo, been
moved slightly above the middle of the overall surface (see graphic page
165). In order to utilise the full scale of the light emitting structure, the divi-
sion of the sections is asymmetrical now; stripe six is activated in real-time,
five and seven plays with 100 milliseconds delay, four and eight plays with
200 milliseconds delay, three and nine with 300 milliseconds, two and ten
with 400 milliseconds delay and one with 500 milliseconds delay.

Research Diary Note: In previous experiments the “real-time stripe” was in
the centre, therefore one stripe was out of action. Now the decision had to be
made to maintain a centred evolving symmetric light pattern or to increase
to full size of the surface and having an asymmetric light pattern. Only if you
know it and watch very carefully you can distinct the “real-time stripe” and
that it is above the centre of the fabric. The decision was made towards the
use of the full lighting potential of this surface, using all ten stripes.

The lowering of frequencies has been made, as we both preferred the ex-
pression of the deeper sonic rhythms, but this requires good speakers in order
to be able to hear them! It is possible to create the same pulses, rhythms using
90 Hz or 64 Hz (or any other frequency) as the base frequency. The timing
and accentuation and non-accentuation pattern of the rhythms can be identi-
cally, nether less it will still sound differently: lower/deeper (64 Hz) or higher (90Hz). Personal I favour to hear a low frequency range, instead of going to high up in the scale. I am very sensitive on the high frequencies, getting fast annoyed hearing them, and sound element two and three are going quite high up now any way.
Sound_light element two:
The frequency range has been increased from 50-1000 Hz and is playing with sequences of increasing and decreasing sine pitch scales.

So far all sound elements have been produced digitally via the MAX MSP software, now Jan introduced me to a physical tool, the Theremin, to generate sound element two. Since a longer time I had been searching for a more intuitive way of composing, respectively a more intuitive composing tool. As the number based programming, especially used in the rhythm exercise experiments, is so far away from any textile design ways of designing. I had been searching for a tool which would allow starting working with a more intuitive sketchy working process. The Theremin allows to be played with as improvisational tool, involving the player’s body as the interactive tool to generate sound. The generated sound is a scale of pure sine pitches.

“The theremin (…), originally known as the ætherphone/etherphone, thereminophone[2] or termenvox/ thereminvox is an early electronic musical instrument controlled without physical contact by the thereminist (performer). It is named after the westernized name of its Russian inventor, Léon Theremin, who patented the device in 1928. The instrument’s controlling section usually consists of two metal antennas which sense the relative position of the thereminist’s hands and control oscillators for frequency with one hand, and amplitude (volume) with the other. The electric signals from the theremin are amplified and sent to a loudspeaker.“ (Wikipedia, N.D.-b)
The Theremin is played by moving towards and away from it, either your hand or the whole body. As closer you come to the right antenna as higher the pitch, as more far away as deeper the pitch. It creates pure sine pitches in form of a “gliding scale” (in case you don`t use the left antenna, which controls the volume). We used the right antenna, moving towards and away, creating up and downwards gliding sound scales. The created sound is channelled to speakers as well as the computer, being able to further modify the sound via the Max for Live software. We played with the Theremin and recorded several sequences; thereby the sound was still triggering the red light inside the textile structure.

For more information on how to play the Theremin view video tutorials from Carolina Eick. (Eick, N.D.)
Research Diary Note: What kind of sound is this (created through the Theremin)? Single sine pitches? Previous created digital sine pitches and scales (via computer) and the pitch scale created via the Theremin sound different, even though both tools, digital and analogue (computer and Theremin in this case) create for an example a pitch on 90 Hz. We have been creating the same pitch scale range through the Theremin, but they do not sound alike, due to the fact that Theremin is colouring the sound (it cannot create a pure sine pitch). The through the Theremin created sound scales were so shrill to my ear, that I could not bear working with them, nor displaying them in an exhibition piece. The sound strongly reminded of fire or bomb alarm noise, being so awful that I had to close my ears. Therefore we decided to modify the sound towards something more pleasant. Of course we would have been able to go back to the original digital created sine pitch scales, but we liked the playful interaction, composing possibility through the use of the Theremin.

Therefore the tones of the pure sinus pitch scales were modified to a filtered white noise creating a richer wind like sound. This was the first sound we really liked immediately whilst playing (via the Max for Live software) to modify the original sound created through the Theremin, so we stacked to that.

(The sound from the Theremin is analogue; it has been transformed through the use of computer by using the software Max for Live, thereby the sound was passed through the sound effects Vocoder and then Reverb. Thus the sound quality has been coloured, enriched and wind like sound has been the result. (Wikipedia, N.D.-c, Wikipedia, N.D.-a))

This alteration of the sound raised the question: what colour matches what sound? In the initial experiments we had taken the decision from the beginning sound element one triggers blue, sound element two triggers red and sound element three the green LED. Whether a colour matches a sound or not was not questioned, the initial choices have been taken as a given fact. Whilst transforming the sound more and more, adding qualities on top of the pure sine pitches, this question appears to become more relevant. At first really outspoken by the creation of the “wind noise”, the wind doesn`t feel red. So what is it then? It would feel more blue, but blue is already assigned to sound element one and that feels like a perfect match. When sound element two sounded like an alarm signal the red was a perfect match, alarming noise = a colour used as warning signal. Whilst playing sound_light ele-
ment two and three (red and green) together the colour combination felt really flat and shallow, being too much a complimentary colour contrast (Komplementärkontrast). It didn’t work for us, especially after the sound element two had changed into the “wind sound”. As we had taken the decision to enrich the sound quality it felt the colour has “to do” the same. Since blue was occupied and green felt all right for the melodic sequence for sound-element three, the colour for the “wind sound” somehow had to base on red, as we still wanted to work with three distinct sound_light elements.

In order to enrich the pure monochrome RGB light colours: reed, green and blue at least a second colour has to be mixed in. So we decided to mix blue into the red, creating a scale from red to pink. As sound element two is increasing and decreasing its sound scale, the red ”increases” into pink and vice versa. See graphic next page. Summarised, sound_light element two is now characterised by increasing and decreasing “wind sound” scales, partly using the whole pitch scale spectrum and partly only sections of it, whilst triggering in real time a richer colour spectrum shifting and fading between red and pink.

(When sound_light element two is playing parallel with the Blue sequence the red LED is used alone again, mixing automatically a pink light colour with the underlying blue. Hence pink light is moving up and down the textile surface instead of a colour scale ranging between red-pink. This is a consequence of current programming conditions.)
Sound_light element two, colour spectrum:

Movement directions:
Sound-light element three:
is using the range of 50-735 Hz for a melodic sequence of single sine pitches, covering a range of high and low pitches. As previous the range of pitches has been divided into ten intervals, each triggering one stripe in the textile. Lowest range triggers lowest stripe, highest range highest stripe, etc. The pure sound of the single sine pitches has been slightly altered by enriching the sound quality through a minor amount of reverb. (Wikipedia, N.D.-a) The sound is nearly the same, though feels more full and rounded, like “melodic drops”.

Therefore the green colour has been enriched and altered as well, adding some blue to achieve a more subtle nuance of green. A minimal fading in and
700 millisecond fading out has been added, to each “drop of green”, in order to soften the appearance of the light colour (not a pure switching light “on-off” effect, creating a blinking, hard appearance) accordingly to the change of sound.

(When the Green is playing parallel with the Blue sequence the fading out has been shortened to 500 milliseconds in order to perceive it more distinct on top of the blue pulsing light. Additional the green LED is used alone than again, mixing automatically a turquoise light colour with the underlying blue. This is a consequence of current programming conditions.)

Nevertheless three distinct elements of sound-light still create an overall composition through, using a more prosperous sound and colour landscape. How do we start composing with these three sound-light elements now? Well, than I just let it go, handed over to Jan to come into his flow of playing and trying out to start building a composition. I stepped back into a more observing role (as I am not able to program in these software’s), giving feedback on what I see and hear, him taking that up … then it just come into a flow of doing: doing, viewing, reflecting, re-doing, viewing, reflecting, etc.
Total darkness – silence, out of its depth soars a gentle hushed vibration,
Increasing steadily consistently into a loud vibrato,
Eluding a vibrant blue out of the darkness
Pulsing, pulsing increasingly over the surface,
slowing down and down, fainting more and more into darkness again.

A moment of silence, woken by a lively dance of green,
A sweep of pinkish-red blows down the surface,
Green obliviously maintains its dance,
The next moment it’s gone,
   Whilst the wind continuous blowing, arouses into a storm,
   Loud, fast and furious,
   — and sweeps out again.

A breath of silent darkness,
And here it dances again, unfazed the green.
   Slowly slowly, faster and faster, a hounded dance,
   a hounded hunt
Thunderbolt, - red ends the hunt.

Excited blue pulses, pulses
   Slows down, slows down, exhales in shifting rhythms into darkness _
Whilst green underwhelmed takes up its dance again,
   Remaining,
   Swept out by a last breath of pinkish-red _ the wind.
Research Diary Note: It is the moment of transition, which seem to be crucial to reach an understanding of, as longer I am working in the context of time-based design, whereupon textile light design is an area of example. Transitions understood as a space of time, a moment of uncertainty, before a new phrase/pattern of the overall composition is established.

In his MA thesis Expecting the Unexpected Jan Carleklev explores “the lift”, a phenomena found in music, and how it could be applied on Experience Design. He describes the lift as follows: “The lift is a phenomena found in music, … The lift is an emotion/reaction that occurs when a pattern changes or an unpredicted pause interrupts the flow of music. Your expectations are disrupted. For a brief moment one hangs in the air without knowing what will come next. A moment of uncertainty.” (Carleklev, 2010, p. 3)

One possible form of the lift is a phase of transition in a composition of music or sound, which leads over from one part to another. Thereby transitions are not only a phenomenon of music, rather an occurrence that constantly happens in everyday life. “Transitions can be temporal, spatial and mental. Waiting for example is a temporal transition where you go from one state to another. More spatially oriented transitions are for example going through an entrance into a building. … The way a transition happens can take many forms.” (Carleklev, 2010, p. 5)

Exploring different forms of transitions in musical compositions led Carleklev to an illustration of transitions which can be applied to other forms of time-based design, for example Experience Design. (Cf. Carleklev, 2010, p. 5) See graphic on next page.
(Visually) I would rather describe them as follows:

Transition as **cross fade**: when gradually two independent phrases/patterns transit from one to the other. One ends, fades out, parallel whilst the next blends in.

Transition as **cut** *(break)*: sudden shift from one pattern to the other. One stops, next starts immediately without any break or pause in-between.

Transition as **pause** or **silence**: there is a pause, a shorter or longer moment of silence in-between two phrases/patterns.

Transition as **cadence**: within phrase/pattern one builds up a change, clues and signals, pointing towards a change, for example increasing or decreasing tempo and volume. The cadence is preparing for a change.
Zooming into the transition phase (Carleklev, 2010, p. 6):

In the context of our composition I would change the graphic to the following:
EXPERIMENTS

Being introduced to a pattern a, for example the blue sound_light element one opening the composition, you reach a comfort zone, after a while you expect the pattern to be and continue in a specific way. The tempo slows down, light intensity decreases into darkness, a change has been signalled, viz. preparation phase has been initiated. A moment of silence, change i.e. transition phase, a new pattern starts playing, for example the green melody. You adapt to a new pattern until it is familiar and a new comfort zone is reached. You pass the stages of comfort, preparation, change, adaption and comfort. Whereby transitions as cut (break) and pause/silence directly go from comfort zone into transition and then into the new pattern, no preparation is initiated.

Using different forms of transitions or a combination of those, it is possible to shift and change the dynamic feeling of a composition. Increase tension, release it, create drama or quiescence, assist/maintain a feeling of dahinplätschern/dahinströmen/rippling etc.

Looking back on our composition the different forms of transitions can be used as a base for analyse. We have been working with three distinct moments/phrases/patterns of sound-light; sound_light elements one, two and three. Each of these appears several times in shifting variations. See overview of complete composition with special markings for transitions on Poster 5.

The application of the four transitions on our composition is not straightforward. Combinations of transitions appear and you can view diverse sections of the composition under different perspectives. For example:
Timeline

Transition = pause/silence

Transition = cut or cadence??

Transition = cut or cadence??

Pattern/phrase 3

Pattern/phrase 2

Timeline

Transition = pause/silence

Transition = cut or cadence??

Transition = cut or cadence??

Pattern/phrase 3

Pattern/phrase 2

Upbeat/very short “sweep” = Transition = cadence

Short preparation/decrease = Transition = cadence
Especially when pattern 3 and pattern 2 play a longer time parallel, they appear rather like a new pattern, when a long transition phase. Hence you automatically view “just” the beginning of pattern 2 and the end of pattern 3 as a moment of transition.
DISCUSSION
Expressions – achieved

The research work in this thesis aimed to investigate and define the most elemental building blocks in order to understand how to build and create complex patterns, i.e. compositions evolving over time, placing the temporal frame, in which changes will appear, at the starting point of the design process. Three ways of creating movement, explored through colour flow, rhythm exercise and the sound_light experiment, have been investigated. In colour flow, a gradually changing colour scale creates continuous movement of light. Looking into the fluidity of fine gradient colour scale changes, as well as the more rhythmic feeling created by increasing the contrast of the colour variations. In rhythm exercise, different ways of activating light (switching on and off via holding and fading time) and how these can create different feelings for rhythms, tempo and perception of the passing of time was examined (through the emphasis on monochrome white light). In sound_light experiment (Sinus 90 + blue and Sinus 64 + blue) sound has been used to trigger coloured movement patterns. A basic relationship between sound and light has been explored; thereby a reduced and rather bolt colour range and more complex overlapping movement patterns have been created. Altogether a range of new textile expressions has been achieved from quite static (step-by-step, zick-zack) movements to movements of fluidity, to melodic rhythmic qualities and cooccurring movement patterns.

In colour flow three values, each one for red, green and blue have been mixed together to achieve a specific colour. It can be compared to premixing colours in a glass for example by aquarelle painting. The values of the three colours are mixed together synchronically at one moment in time. However in Sinus 90 + blue and Sinus 64 + blue the colours red, green and blue are rather treated in layers, like several individual colours layered on top of each other similar in aquarelle glaze-technique creating a new colour (see graphic on next page). Each colour is set independently partly appearing parallel in time and partly not. Each colour can move in its own speed, movement direction and kind of movement (floating, jumping, etc.). You design always red, green and blue separate and depending of their overlapping in time a further colour is created. For example: sound_light element three, the green, dancing and jumping fast, whilst sound_light element two, the red-pink scale, is sweeping and floating in its own speed over the surface.
Two different ways of colour mixing with RGB-LEDs have been explored:

**Colour flow:**
- Sinus 90 + blue/
- Sinus 64 + blue:

**Textile:**
- Final colour is pre-mixed.
- Layers on top of each other create final colour.

In the first way a specific mixed colour is the programming aim, whilst in the second you work with the three base colours and the overlapping of them creates a mixed colour “by coincident”. Thereby, after exploring this process for a while you can achieve conscious colour mixing here as well. It rather opens up for additional forms of movements, more thoughts on that in a moment.

As these two forms of colour mixing have been achieved due to different programming processes, they require a shift in design thinking. Going back to Easy Stand Alone software, colour flow has been programmed in; it is possible to re-think the designing process here too. Though how the software is set-up only more simple forms of overlapping movements can be created, as the three values for red, green and blue are always set at synchronic moment in time. Timelines cannot be totally independent created for each LED.

Considering the current colouring possibilities using RGB-LEDs, results maintain unsatisfactory. Although the multi-coloured effect (mainly discussed in colour flow) could be quite effective depending on what one is looking to achieve, opening up an area of new expressions requires more precision regarding colour output. Advertisements for RGB-LEDs claim they provide endless choices of colours, whereas the practical reality when they are used in connection with optical fibres is an entirely different matter. The colour re-
sults displayed in different structures and using different fittings (connecting optical fibres to LEDs) with different diameters are still too diverse, in order to really consciously design with them, even when you want to embrace the multi-coloured effect. I think that precision in the choice of colour and colour being displayed as chosen, is crucially important in order to achieve specific expressions, definite atmospheres. Especially if one is to realize concrete and site-specific applications in the future. Therefore, the improvement of the colour mixing of the RGB-LEDs remain one of the on-going research aims.

Looking at the composing of movement inside the structure, it became very apparent that the timing orders of the different voices/LEDs connected to specific sections in the structure and the order of the structural sections together created a specific movement direction in the structure. The section order has been used chronological so far, both in braiding and weaving (see graphics on next spread, left side), though non-chronological orders are easy thinkable and to achieve, which again would widen the range of expressions (see graphics on next spread, right side).

In these examples it is impossible to draw the non-chronological time/movement order. However, such a time-based pattern using activated light sections inside a textile structure (braided or woven) would be feasible. For the woven example, a multi-layered structure and the use of a jacquard loom or machine would be required.
DISCUSSION

Chronological section and time orders:

Timing order: voice/LED 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, etc.

Movement directions:

Timing order:  

Section order:  

Voice/LED 1  1  
Voice/LED 2  2  
Voice/LED 3  3  

→  

←
Non-chronological section and time orders:

Timing order: voice/LED 1, 2, 3, 8, 7, 4, 5, 9, 6, 10, 11, etc.
Section order: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, etc.
Looking back on the second way of colour mixing with RGB-LEDs, it opened up towards even more complex patterns of movement. In colour flow red, green and blue inside one section of the textile are always activated synchronous to each other, id est. one movement appears at a time inside one section. In Sinus 90 + blue/Sinus 64 + blue red, green and blue in one section of the textile can be independent, asynchrony activated from each other, i.e. several movements can appear at the same time in one section. For example: blue plays a base rhythmic pulse and red (chronological) upwards floats on top of the blue pulse or, the green is “dancing over the surface” on top of the blue pulse in non-chronological order.
Timeline

- pulsing blue
- green or red on top of blue
DISCUSSION

Time – Light

Warum ziehen gewisse Dinge im Zeitlupentempo an uns vorbei... 
warum scheint Zeit manchmal endlos langsam vor sich her zu 
schleichen, 
wie ein endlos gezogenes Gummiband...

+ manchmal ist sie im Nu vorbei, 
schon vorbei, 
bevor es richtig angefangen hat.

Why do certain things pass by in slow motion ... 
why sometimes seems time to sidle endlessly slowly, 
like an endless stretched out rubber band ..

+ sometimes it’s over in a blink, 
already over, 
before it has even started yet.

Time and light, light and time are intrinsically tied to each other. In TimeLight, 
Federico Favero defines, “... Light as Time provider signal“ (Favero, 2008, 
page 5), “The cycle of light and dark is the most compelling physical phe-
nomena that provide variation on earth. The presence and absence of light 
is the first feature of time, giving name to day and night. The presence of the 
sun and its continuous change of position produce variations on the natural 
and built environment. These series of perceived variations create physical 
connections between the light source, the surfaces in the space, and us; these 
associations are at the basis of our feeling of time.” (Favero, 2008, page 18) 
Furthermore he describes, that only through daylight variations (position of 
sun, variation of light colour, changes through clouds etc.) we are able to per-
ceive change and with it the passage of time.

This thesis has investigated how to expand a first understanding of time 
as a design material in textile design context in order to compose time-based 
patterns in and through the use of light. Can you really name time a new de-
sign material for textile expressions? Yes, in the case of the present research 
work giving light time durations, i.e. activating and turning it off via fading
and holding over a specific amount of time, the foundation for time-based patterns in light is formed. Changes in lighting through the use of different time durations and levels of light intensity create our perception of the passage of time: sometimes endlessly slow, sometimes over in a moment. In this sense, time becomes a design material as well as a “thing” in itself, a new moment of expression. In any form of lighting design light has to appear over time in order to be perceived. Furthermore, it has to be presented to us in variations in order to be noticed.

Rhythm - Time

“Maybe the only thing that hints a sense of time is rhythm; not the recurrent beats of the rhythm but the gap between two such beats, the grey gap between black beats: the Tender Interval. The regular throb itself merely brings back the miserable idea of measurement, but in between, something like true Time lurks.”

Elisabeth Deeds Ermarth (Lefebvre, 2004, p. xiv-xv)

Lefebvre stresses out the importance of using your own body as a point of reference whilst analysing rhythms (Lefebvre, 2004, p. 67). “We know that a rhythm is slow or lively only in relation to other rhythms (often our own: those of our walking, our breathing, our heart). This is the case even though each rhythm has its own and specific measure: speed, frequency, consistency. Spontaneously, each of us has our preferences, references, frequencies; each must appreciate rhythms by referring them to oneself, one’s heart or breathing, but also to one’s hours of work, of rest, of waking and of sleep.” (Lefebvre, 2004, p. 10) Riedelsheimer formulates it the following way: “Heart beat – the first sensation of a human is probably vibration, rhythm and pitch, long before the eye awakens. The own heart connects us with the world – it is our individual pulse generator (Taktgeber) … his rhythm is the most important measure of music. The relationship between pulse and music is versatile and multi-layered … our heart slows down and accelerates with the music we are listening to. The body seems to synchronise with the vibrations of its environment.” (Riedelsheimer, 2004, author’s translation)
The same applies by the creation of rhythm, through the process of creating rhythms myself the changing perception of tempo, tempo being a part of a rhythmic structure, struck me over and over again. Revisiting Research Diary Notes from rhythm exercise_part 5 for example: “speed, tempo is something very subjective and over the last days I tried three different speeds, too fast, too slow … right. But today right seems a bit slow again” (page 137). Or from rhythm exercise_part 6: “when watching this composition over and over again, the tempo seems to be changing from day to day and always to be wrong, just like before. Too fast, too slow…” (page 149). It refers back also to Lefebvre’s description of the clock time and the lived time. Even though different programmed rhythms and phrases are replayed, repeated identically with the precision of the perfect divided time (clock time), its perception varies based on our own individual bodily circumstances from day to day. And not only that, in the moment of origin of creation a rhythm a feeling for a certain tempo lays the base for its creation, even then being realised through a specific timing (clocked timing) via programming.

Zooming in once more into the concrete experiments and their contention with rhythm; thereby looking at the succession of a single voice, as well as the parallel appearances of several voices. Even though colour flow uses differentiated time (Lefebvre, 2004, p.78), varied time durations, and silences in form of darkness the created compositions are not characterised through a rhythmic time-based structure. Repetition, key element of forming a rhythm, has not been applied. Colour flow_part2.2 for examples is build up through four parts which are distinct, separated through a moment of silence, darkness, and then the whole composition is repeated. However repetition inside those four parts does not play a role, and silence does not form a part of a rhythmic structure. Colour flow is rather concerned with harmony, “relying on notes sounding at the same time” (Lefebvre, 2004, p. xi,) light colours being displayed parallel to each other (spatial dimension) and progressing in a rather synchronic manner (time progression).

Rhythm exercise goes very detailed into the exploration of differentiated time and their variations, as well as into the play with repetition of shorter and longer phrases. Rhythm exercise_part 1 explores short phrases which are endless identically repeated, and already a bit longer phrases deal with repetition of units within the phrase. (See more to pattern elements, units,
and composition on page 204 ff). In rhythm exercise_part 3, the overall composition is build up through three longer phrases; thereby these rather play with variations of pattern units, than with repetition. Rhythm exercise_part 4, specifically Lottery 4-5, and rhythm exercise_part 5 + 6 explicitly play with repetitions of different kinds. Nevertheless the created expressions maintain a linear rhythmic feel. The code is set-up in such way, that it plays with endless identical repetition over time, and it is et al. the identical repetition which create monotony and rather a linear feel of time progression.

In Sinus 64 + blue a range of different rhythmic qualities has been achieved, as well as span of diverse movement expressions. Sound_light element one, the blue, investigates rhythmic qualities in a wide range, prospering out of vibration into pulse and eventually into rhythm. It plays with variations of the rhythmic pattern, as well as overall shifts of tempo (change of duration) and light intensity – rising out of darkness into a loud vibrato and fainting out again... For me actually here starts something to breath and swing, a base for cyclic qualities arises. Sound_light element two, the red, would rather be described as big movement flows, then rhythm. One movement flow reaches over the whole length of the textile. Even though this sound_light element also deals with repetition and variations of the movement, there is no distinction in time duration, no accented and unaccented durations, which would lead to a rhythmic feeling. Sound_light element three, the green, rather explores being a melody than rhythm. Although a longer phrase is ongoing repeated, and varies in tempo and light intensity, the repeated phrase is built up through equal time durations, no accented and unaccented times, hence no feeling of rhythm is created. Nevertheless in all three sound_light elements an organic feel starts showing through, which not only originates in the richness of overlapping movement expressions, polyrhythmic quality, perhaps also because body movement has been used to create them.

Summarised composing rhythmic structures imply to work with: repetition and their variations of accented and unaccented times (Lefebvre: strong and weak times) and silences appearing with regularity and recurrence. Thereby creating “differentiated time, a qualified duration” (Lefebvre, 2004, p. 78). (See graphics on next spread, left side, as well as page 202f).

In cases of lighting design and this body of research work accented and unaccented times are created through change of light intensity and change of
duration, and silence through use of darkness. (See graphics on right side). (See also Research Diary Note: rhythm exercise_part1_6, p. 90, for a comment on accent and Research Diary Note: rhythm exercise_part 5, p. 138, for a comment on silence = pause).

General:

created through:

\[
\text{rhythm} \begin{cases} 
\text{accented + unaccented times} \\
\text{+ silence} \\
\end{cases} + \begin{cases} 
\text{repetitions} \\
\text{+ their variations} \\
\end{cases}
\]

applied as:
In this research work:

Material used to work with: Light + Darkness through: change of light intensity + change of duration create: accented + unaccented times + silence applied as: repetitions + their variations create: rhythm
repetition of equal elements (no accents):
no rhythm yet:
pulse, metronom, monoton, linear time, clock time: tickticktick...

accented times added:
no rhythm yet:
an accented area in a compostion

even adding more accented times randomly:
does not create a rhythm yet

a sequence of accented and unaccented times, identical repeated:
really rhythm yet? maintains monotonous

adding/increasing silence, pause = empty space:
increases feeling of rhythm

repeated phrase of accented and unaccented times + silence and its variations:
creates rhythm
Composition - Pattern

Research Diary Note [rhythm exercise_part 7]: “There is something with tension and balance... when you observe a painting, graphic work, or piece of textile design, while describing the overall expression you start talking about Bildkomposition, composition of the image/pattern. The way how certain elements of form and colour have been used and how their position, relation is to each other. Elements could be clustered creating a moment of density, concentration in a composition, therefore could create a focal point. Elements could be absolutely equally aligned over whole surface, no central area is created. Elements could increase towards a formation, a moving direction (organisation of elements towards) a focal area can be created. The overall composition has one or several directions towards ... a tension towards a formation of elements can be built up and released again, symmetry and asymmetry...”

In the case of time based patterns, change of tempo, repetition and variation of familiar phrases seem to create something like tension, monotone, balanced ...

Traditionally a textile design expression is build up through the composition of colour, form (2D and 3D), structure, touch/haptic and materiality. Usually a visual/pattern composition, inside or on top of the textile structure (created by weaving, knitting, printing, etc.), is build up through:
DISCUSSION

PATTERN ELEMENTS, single forms and lines: circle, square, triangle, ...
PATTERN UNITS, several pattern elements defining a group, or a group of pattern elements
PATTERN COMPOSITION, one form, or one pattern unit, or several pattern units create the overall pattern

A pattern element may or may not have a direction. For example, circles, squares, and equilateral triangles are symmetric shapes and do not have a direction. On the other hand, ovals, rectangles and all other types of triangles have a direction, e.g. horizontal, upright, etc. The way in which one or more pattern elements are arranged, positioned and repeated creates a “direction” in the pattern as well as an overall aesthetic/expression, an overall composition of the pattern. However, what happens if time and changing forms of expression are introduced into the textile design expression, e.g. in the form of constant change and moving artificial light?

The most elementary part, element or building block used to create a time-based pattern using light is switching the light on or off. There are only two forms of expressions the light can take on: switched on via holding or fading time or switched off via holding or fading time. A pattern unit, a phrase is created through an episode of either holding or fading times, or a combination of these. Already with these basic elements, a rhythmic structure of time and movement in the structure (using a minimum of two voices) can be created. One building block or one or several phrases create the overall composition. Thereby, the overall composition is formed by a series of unique or repeated phrases (either with or without one or several other interposing phrases).
elements = unit = composition
basic building block = phrase = composition
DISCUSSION

Composing - Notions

In order to be able to describe these new time-based expressions and to compose over time, new notions (definitions) and design variables, i.e. elements to design with, have to be defined in the context of time-based textiles.

I have been looking into music terminology and composing processes in order to make a first attempt to find a convergence between music terminology and light, i.e. composing music and composing light sequences (see below). Now, I wonder, if light intensity and colour are one and the same? Looking at rhythm exercise, i.e. use of monochrome light, the change of light intensity levels creates the compositions. Whilst in colour flow, however, a range of different colours form the composition. Technically speaking, light intensity levels and colour are the same when it comes to RGB-LEDs.

The higher the light intensity levels of the red, green and blue LEDs, the paler and lighter the colour of the light becomes; the lower the light intensity levels, the darker the colours. Still, it seems right to relate volume and light intensity level to each other and pitch to colour.

As the work progressed, it became more and more obvious that light, darkness, light intensity, colour and duration are the new design variables to play with in the creation of time-based patterns. Different kinds of building blocks and phrases create different tempi, rhythms, movements and flows of time; thereby, creating an overall composition.

Whilst the design variables (light, darkness, etc.) describe the WHAT you are working with, different forms of transitions describe the HOW you link these together in the process of composing, of creating a time-based design. Consideration of both of them is equally important. For example using four
Non-physical Variables:

<table>
<thead>
<tr>
<th>Light</th>
<th>needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darkness</td>
<td>in order</td>
</tr>
<tr>
<td>Light intensity</td>
<td>to create</td>
</tr>
<tr>
<td>Colour</td>
<td></td>
</tr>
<tr>
<td>Duration</td>
<td></td>
</tr>
</tbody>
</table>

Physical Variables:

textile structure

[colour, form, structure (weaving or braiding), touch/haptic, materiality]

Design Variables

Distinct light colours (red: R: 255 G: 0 B: 0, yellow R: 255, G: 255, B: 0, green R: 0 G: 255, B: 200, blue R: 0, G: 0, B: 255, dark blue R: 0, G: 0, B: 100) each of them with duration of 1 second, still a variation of expressions can appear depending on HOW they appear. Do they fade in or not, do they appear behind each other in time or parallel or a combination of these? In which way follow smaller or bigger phrases each other, in a larger composition via transition as a cross-fade, cut, pause or cadence? Using identical ingredients, design variables, can create a wide range of expressions, depending of the use of fading or holding times (zooming into micro level of design decisions), and the use of different forms of transitions (zooming out into the macro structure of the overall composition). Summing up the What you are designing and the How you work with it is equally important to reach an expression. They can completely change the dynamic feeling of a composition, design expression evolving over time, creating tension, or releasing it, creating drama or quiescence, maintaining a feeling of dahinplätschern/rippling etc.
DISCUSSION

Composing - Notation

In this research work, notations have been used in four different ways: as a reflection, composing, translation, and documentation tool. In colour flow, drawings, notations were used as a tool for reflection in-between the programming processes, whilst in rhythm exercise they became the main composing tool, steering the creative process of doing/drawing and thinking time-based sequences. In rhythm exercise_part 5, notations were used to translate rhythms from musical notation to another form of visual representation or notation, i.e. programming code, which were then displayed as lighting scenes. Regarding knowledge dissemination, notation was used to document and facilitate “handing over” parts of the insights I have had during my research practice.

In the process of composing time-based phrases, notation done by hand has been essential. As a counterweight to all the coding of endless rows of numbers, a feeling of hands on access felt a necessity in order to feel a last connection to a hands on practice based doing. As well as the visual representation of time-activity, event was required to grasp and develop an understanding of what it means to compose over time, as textile designers are trained to work with visual compositions in design processes. Programming codes were useless to me (not having a programing background), especially in the beginning as I was trying to envision the time-based events and movements in the textile structures. Currently notations are the most important design tool in order to create complex rhythmic structures in monochrome lighting. To make progress with the work on multi-coloured light, a new approach to the notation systems will probably be required; this is something that has to be looked into as the work grows over time. To sum up, notations are a part of new design processes whilst creating time-based patterns and can be used as a tool for different functions.

Composition - Instrument

During the research process, it became very clear that the time-based composition is not alone in defining the final expression. The textile structure displaying or playing the time-based composition is equally important: both of them equal influence the movement expression. Now, one could say that the
textile design/composition is based on two main elements: the instrument and the composition. Each specific instrument has its possibilities and limitations, wherewith it sets the frame for the temporal compositions. It defines the amount of possible voices inside one instrument, as well as the form the light is shaped to inside the structure, i.e. the instrument.

For example: a braiding structure which is based on thirteen strings has its maximum capacity to play with thirteen voices. Thereby a smaller amount of voices is possible, in case several voices are connected to one light source. The individual voices are shaped in wave-like lines throughout the whole length of the structure. The voices can be played in chronological or non-chronological order, this and the shape of the voice creates a specific movement form and character. (See also rhythm exercise and pages 189-195.)

Another example: a woven structure, horizontal rectangle, is divided in three horizontal sections. Each section can be played from its two sides, i.e. maximum of six voices is possible. Two opposite voices create a pair. Each pair is shaped in a stripe, throughout the whole width of the structure. The voices can be played in chronological or non-chronological order, this and the

Design process:

Instrument + Composition

Textile structure

braid weave

Notation

programming/coding

displayed in structure

New Expressions
shape of the voice creates a specific movement form and character. (See also colour flow and pages 189 - 195.)

Only when a specific composition is played on a particular instrument a certain expression is created. Several expressions can be created through/on one instrument when different compositions are played on it.

(Research Diary Note: whenever I played a composition in another instrument for which it was not composed for from the beginning, it felt odd. It just always felt wrong. Being able to fast test an existing composition inside a newly created instrument didn’t help much. Each instrument requests its own composition, in order to show its most potential and beauty.)

Expressions - future

Inside one textile instrument a wide range of expressions can be achieved by displaying varying time-based compositions (even though each instrument has its potential and limitations, as discussed in previous parts). Among all possible expressions, personal interest has led me to look into organic expressions. Especially the knowledge about the daylight and its main characteristics and influence on human wellbeing has laid the starting point to search out for rhythmic time-based qualities found in nature, starting with the 24h day rhythm and the 12months rhythm of the sun path.

This work has not been about designing another form of “blinking” LED, which has dressed itself into textile appearances. The explorations provided through this thesis do allow a wide range of expressions in the future. Nevertheless the present work has strived for creating physical instruments where light becomes a textile piece in itself and vice versa, where light and textile structure melt into each other and become indivisible and time-based compositions start hinting towards qualities found in nature. Throughout the work my evaluating comments on the experiments (something starts swinging, fluidity between colours, rhythm created …) found in the Research Diary Notes conclude how the achieved results got close to these searched expressions. Especially the beginning of colour flow started out to explore the smooth fluidity of light colour changes found in the 24h cycle of daylight. The striving for incorporating and transforming rhythms and movements found in nature into lighting sequences met its challenges on the way. For example displaying colour flow’s smooth fluid colour transitions, characterised by
very slow pace, to first audiences, I realised that the audience is challenged to have the patience for these. The experiments opened up towards a more general potential of the use of coloured light inside textile structures, introducing varying tempi and contrasting colour ranges. Lack of programming skills, needing to learn programming from the beginning, led to basic general time-based explorations (colour flow and rhythm exercise). Whilst in the cooperation with Jan Carleklev in sound_light experiment higher complexity of time-based patterns has been achieved, those point towards the possibility being able to start transforming rhythms found in nature into lighting sequences in the future.

Investigating most elemental building blocks, in order to understand how to build and create complex patterns, i.e. compositions evolving over time especially in the area of light emitting textiles, achieved more general forms of expressions and are the main contribution of this thesis. Nevertheless, the work has been accompanied by the search for a specific area of expression. The role of a designer is connected to taking responsibility and awareness for what kind of new expressions we release into the world and their influence on the environments in which they are placed in. Therefore in the future, I will continue my work by exploring nature as a source of inspiration, both for the temporal, as well as for the structural, physical part of the textile design. In order to investigate: how to re-awaken organic and captivating appearances that unfold over time. With this kind of cross-modality in my work I will bring together tactility (in the form of textile surfaces) and light, whereby the experience of those sensations – tactility, light and time - will stand at the centre. I will map temporal patterns found in nature and investigate how they can be applied in the design of dynamic light in order to create a composed experience with traces of nature.

This work can be also seen in the context of new ways of sustainable design approaches, like biophilic design (Kellert, 2005), visible green (Hosey, 2012) and the use of aspects of fractal geometry in man-mad objects (Harris, 2012). Kellert, Hosey and Harris point towards new design approaches, based on the belief that “Life is more than its “resources”, and sustainable design must mean more than just the efficient use of those resources.” (Hosey, 2012, p. 18) In order to reach long-time sustainability the authors conclude that form, shape, imagery, growth principles, organizing principles etc. of nature should be implemented in future man-mad objects and buildings. (Kellert, 2005,
Hosey, 2012, Harris, 2012) Especially Hosley and Harris point to a main “underlying order [in nature] – the structure known as a fractal”. (Hosey, 2012, p. 87) Its main characteristic is self-similarity or alternating repetition: “In most natural systems, repetition occurs in an alternating composition rather than as simple repetition. The initial repeating units alternate with a subsequent set of repeating elements.” (Harris, 2012, p. 65) (Aspects of creating rhythm and its variations have been explored on primary level in rhythm exercise and sound_light experiment.)

Rhythms found in nature are familiar and at the same time undergo constant variations. Wherever we are we recognize the waves of the sea or a river as waves and at the same time every wave is unique, a shifting variation of the former. The work will explore how one is able to design or compose a balance between the known and the unknown, the familiar and the ongoing variations of the familiar, embedding moments of chance and surprise. Thereby recorded sounds of nature (water, wind, etc.), as well as the study of fractal structures in nature can lay a starting point for a new research journey.

Although we today are becoming increasingly detached from the presence of nature, we are still deeply related to it through our long, interwoven evolution and the biological rhythms of our bodies, such as heartbeats, breathing or the way we age. (Cf. theory of biophilia (Wilson, 1984, Kellert, 2005, Harris, 2012, Hosey, 2012). Future work aims to link our awareness back to those rhythms and doing that, I will be closing the circle which has been started by my previous works woven light - powered by sun energy, Light Shell and Light and Shadow play - the sun an aesthetic trigger for urban textiles, in which the rhythm of daylight was central to the design process, the expressions and the design concepts.
CODA
Concluding the research work conducted so far has resulted in a series of objects that display a range of time-based light patterns/compositions inside textile structures. Thereby, demonstrating a variety of new expressional possibilities in the field of textile light design.

Coming back to my initial research question: What does it mean, if time and change – constant movement – becomes part of the textile design expression? Through the design processes a first platform and understanding about time as a design material has been developed, which allows composing time-based patterns in light design. New design variables (light, darkness, light intensity, light colour and duration), notions (tempo, rhythm, time and movement) and tools (notations, programming, etc.) have been defined and established.

The use of new design variables (light, darkness, light intensity, light colour, and duration) immediately requires new ways of working and, therewith, opens up towards new ways of design thinking whilst working with temporal forms of design and composition, especially by the use of light emitting materials and light sources. The most important tool to the creation of complex rhythmic light patterns in monochrome lighting from the design point of view was hand written notations done in order to pre-vision time-events, i.e. movements of light inside textile structures. Whereas programming (via Sunlight Easy Stand Alone software, Arduino coding and Ableton: Live together with Max for Live) became the most important tool for technical realisation into physical matter. Furthermore, the use of new design variables lead to new forms of expressions that add new expressional qualities to the textile designer’s palette, like tempo, rhythm, time and movement.

The new expressions will hopefully lead to discussions on and envisioning of future textiles. Through my research work I wish to “expand notions of what it means to read a piece of work” (Koskinen, 2008, p.19(31)). Exposing new textile expressions in public spaces provides opportunities to open up an general preconception of what a textile is supposed to be, to show, to express, etc., therefore expands notions of what it means to read a piece of textile work. Displaying the objects in public spaces allows reaching a professional audience as well as a general one and challenges both likewise in the thinking and perception of textile expressions. Thereby public spaces such as galleries, show rooms, museums, etc., are some of the traditional platforms for the dissemination of art and design work (Koskinen, 2008, p. 17-19, (31)) and have
been approached as publication platform throughout the entire PhD. Art, design practice and research create new human experiences. The displayed objects perform new expressions and therefore create new experiences, new insights, understandings and knowledge about the world of textiles. Adding the time perspective of the work makes it necessary for the viewer to expose himself or herself to the work for a certain period of time. Only in discourse with others can research results reach potential outside the researcher’s capacity into a future.

I would like to end this thesis by pointing to my coming work, which aims to explore more complex compositions in coloured light. It will have the specific aim to explore rhythms over time which can be found in nature (like daylight rhythm, rhythms of water and wind). And therewith raises the following questions:

How to map temporal patterns which can be found in nature (e.g. daylight rhythm, rhythms of water and wind)? How can they be applied and transformed to the design of dynamic coloured light?

How to design and compose with the balance between the known and unknown, the familiar and the on-going variations of the familiar, embedding moments of chance and surprise?

How to develop more complex compositions of coloured light? And thereby: how to evolve design thinking and processes, in order to achieve this?
A final Note
Coming from a practice-based discipline, Textile Design and Craft, and executing research through and for this practice, I still wonder how to give justice to its full scope of achievement in the frame of disseminating a thesis work, as both the created expressions, as well the process of making reach beyond linguistic matter.

The language through which a textile designer communicates is through the use of textile materials, textile creations. As my research grows out of this practice, I want to emphasize the physical outcome of my work in the form of textile objects. Practical explorations are integral to the research as the investigations generate physical objects. The processes of making, developing a physical object and its final form are both inseparable inscribed inside the object as such. The created new forms of expressions are the main contribution in this body of work; therefore the physical objects are the central focus in this research. The textile objects developed through the research have been ongoing disseminated through exhibitions and documented via film to suit the format of the thesis.

Traditionally textile designers are trained to work with colour, form, structure, material aesthetic, tactility etc. This knowledge and these skills don`t derive from theory studies alone, they are achieved through practical training and practice-based explorations, through which the designer over time builds a range of skills, knowledge and competence. Three series of experiments have been conducted and recorded in this thesis exploring the visual effects of moving light as a continuous time-based element in textile expressions. The applied process of research through making has been described by Albers the following way: “In visual perception a color is almost never seen as it really is – as it physically is. … In order to use color effectively it is necessary to recognize that color deceives continually.” (Albers, 2006, p.1) Therefore, the study of colour theory is less effective than studying colours through experiences in order to gain skills on working with colours, or to “develop ... - by trial and error – an eye for color. This means, specifically, seeing color action as well as feeling color relatedness.” (Albers, 2006, p.1) Hogan describes for another practice-based discipline: “that we learn basketmaking by doing and recorded knowledge becomes immeasurably more valuable when it leads us back to basketmaking as practiced, living tradition. It is precisely because of so much craftsperson`s knowledge is tacit that nuances of making can rarely be fully recorded”(Butcher, 2008, p. 7). (Cf. Biggs, 2004, p.6-7, Polanyi, 1985) Both authors address with these statements that we embody
more knowledge and skills as we can put in words. The examples relate to disciplines in which practice-based learning dominates and where communication and knowledge acquisition go beyond linguistic matters. The field of textile design research lies for me directly there and with this the presented research work. It remains a challenge to document the process of making and accompanying thoughts, likewise the achieved expressions. The braiding structures for example, which have been used for rhythm exercise, have been documented via drawings and description of the principle of braiding process. Nevertheless, until you start your own process of making, until you hold bundles of fibres in your own hands and train them through repetitive doing you find out, that the hands have to find their rhythm and stay in it in order to create an even braided structure. That there is a certain tension to keep between the already braided part and loose fibres hold in your hands, that you continuously have to move your body backwards in order to maintain this tension. That it is good to always start with the same hand, after having had a break, and applying a rubber band around each bundle of fibres (creating a specific weight) with a certain distance to the already braided section, in order to achieve evenly braided surface, etc. Drawn time lines and films give a hint towards time-based thinking, but the real dimension of what it means to envision and create time-based compositions maintain even more beyond verbalisation.

I have handed over achieved expressions and knowledge through physical artefacts and accompanying text, graphic material and film as key aspects and an initial guide on the road towards future time-based textiles. Implementing the gained knowledge and skills into new forms of teaching would widen and deepen the scope of this thesis. It would comprise creating a framework where people are able to acquire new skills by practical means. Turning my research into teaching in a wider sense would imply developing and equipping a physical and temporal space with tools, materials and technical equipment. Presenting new design dimensions and demonstrating new technical skills, providing guidance and time for individual explorations to a group of people in order for them to have the opportunity to gain new skills. This would help them create their own understanding of what it means to design with time, movement and rhythm. It will be then, that I will be able to hand over knowledge from hand to hand again.
ACKNOWLEDGEMENTS
First of all I would like to thank my supervisor Clemens Thornquist for fantastic writing support, engagement and sharing his time and thoughts with me.

I would like to thank my supervisor Sara Robertson for fantastic writing support, inspiring discussion on textiles and generously providing her house and creative thoughts every time I stayed in Selkirk.

I would like to thank my previous supervisors Margareta Zetterblom and Lars Hallnäs for their expertise and contributions.

Special thanks to Sarah Taylor for inspiring discussions and sharing the same spirit about textiles and light. Furthermore generous support enabling access to labs at Heriot Watt University and University of Brighton, as well as the contacts to Circatron Ltd. and Richard Horley Lighting, without them the current research work would not exist.

Special thanks to Ann Hardie and Prof Robert Christie from Heriot Watt University and Will Nash, Claire E. Hoskin and Simon Driver from Brighton University.

Richard Horley from Richard Horley Lighting for a personal software introduction.

Marie Ledendal, PhD Student at Heriot Watt University for splendid project cooperation and times full of intensity, laughter and English tea.

Jan Carleklev, designer and composer, for splendid project cooperation, opening my horizons towards music composition and sharing thoughts on time as design material.

Hanna Lindholm, Fredrik Wennersten, Roger Högb erg for all the patience and enormous support in the hand + industrial weaving labs.

Magnus Bratt for fantastic support in 3D thinking, 3D printing, laser - cutting and etching.

Javier Ferreira Gonzalez and Dan Riley supporting me with base codes.

Emanuel Gunnarsson for the patience of teaching me soldering.

Henrik Bengtsson for all the fantastic photo documentaion and 3D animation of my work and being a great discussion partner on aesthetics over the last years.

Katja Bülow and The Royal Danish Academy of Fine Arts, School of Architecture for access to the Daylight Laboratory.
Eva Blomqvist and the Textile Museum of Borås for all their expertise and generous providing exhibition space for a solo exhibition.

Hilde Hauan Johnsen for providing me with reference material on her work, optical fibre-sound installations in cooperation with Maia Urstad, 2007-2012.

Emma Richardson and the New Zealand Film Archive Ngā Kaitiaki O Ngā Taonga Whitiāhua for providing access to the film reconstruction All Souls Carnival (1957) Courtesy of the Len Lye Foundation from material preserved and made available by the New Zealand Film Archive Ngā Kaitiaki O Ngā Taonga Whitiāhua. Courtesy of the Museum of Modern Art. Digital version by Park Road Post Production and Weta Digital Lt.

Zane Berzina, Delia Dumitrescu, Astrid Krogh, Marjan Kooroshnia, Barbara Layne & SubTela, Ana Pineyro, Rachel Wingfield & Loop.pH and Linda Worbin for providing photos of their work.

Christian Specker and GTE-Industrieelektronik GmbH for investigating in the matter of RGB-LED-colour mixing.

Lisa, Anne-Britt, Stefanie and Marjan for keeping my spirits up with fikas, dinners and playtime`s with Johan :-)

Nils Christian Jansen for fantastic support in 3D thinking and 3D construction work for all the exhibition frames.

Last but not least all of my family and most of all my Mum and Sergio, without your love and support this thesis would not exist.

Funding support:
Altrud + Otto Jansen, Estrid Erikson Stiftelsen, Smart Textiles Initiative, The Swedish School of Textiles, University of Borås.
LED: A light-emitting diode (a semiconductor diode which glows when a voltage is applied) (Oxforddictionaries, N.D.d)

Frequency: “The number of vibrations per second of a musical pitch, usually measured in Hertz (Hz). (OnMusicDictionary, N.D.b)”

Hertz: “The unit in which the frequency of a note is measured. One hertz is one cycle per second. (OnMusicDictionary, N.D.c)”

Octave: “interval between two tones seven diatonic pitches apart; the lower note vibrates half as fast as the upper and sounds an octave lower (iMusicDictionary, N.D.a)”

Pitch: “The specific quality of a sound that makes it a recognizable tone. Pitch defines the location of a tone in relation to others, thus giving it a sense of being high or low. (OnMusicDictionary, N.D.d)”

“highness or lowness of a tone, depending on the frequency (rate of vibration) (iMusicDictionary, N.D.b)”

RGB-LED: Each light emitting diode that each contain three LEDs, one red, green and blue which through additive colour mixing allow displaying a wide range of custom colours.

Scale: “a series of tones or pitches in ascending or descending order scale tones are often assigned numbers (1-8) or syllables (do-re-mi-fa-sol-la-ti-do) (iMusicDictionary, N.D.c)”

Sine Wave: “Sine wave = any oscillation, such as a sound wave or alternating current, whose waveform is that of a sine curve. (Dictionary.com, N.D.)”

“Sine waves are not some abstract signal created in a lab. They’re the primary building block of all sounds we hear. Analogies would be a single color of light or a pure chemical element from the periodic table. All the colors we perceive are combinations of individual wavelengths of light. And everything we experience in the physical world is made up of elements from the periodic table. And, in much the same way, music is just a collection of sine waves. A perfect sine wave is a single pure tone and has no distortion of its own. It’s the most pure component of sound. (NwAvGuy, N.D.)”
REFERENCES


CARLEKLEV, J. 2010. Expecting the unexpected. MA in experience design MA thesis, Konstfack, University College of Arts, Carft and Design


REFERENCES

Zürich: Diogenes Verlag AG.


FORNAY, C.E. 2005-2006. Personal communication between Fornay (Product Development Director at PowerFilm, Inc.) and Jansen, subject: thin film solar cells, 2005-2006. [mail + sponsoring of thin film solar cells].


GÖBEL, A. 2012. Personal communication between Göbel (Industriesbüro Göbel) and Jansen, subject: Lichtmischung bei RGB LEDs, 31.08.2012. [mail].


University of Borås, Textile Research Centre.


HENNIG, K. 2008. Personal communication between Hennig and Jansen, subject: light, March-June 2008. [tutorials + mail contact].


REFERENCES


LBM. 2011. Personal communication between LBM and Barbara Jansen, subject: RGB colour mixing, 23.08.2011. [mail].


REFERENCES


NORDFELDT IVERSEN, L. 2006. Personal communication between Nordfeldt Iversen and Jansen, subject: exam work “SKÆRMen”, October 2006. [interview by mail].


All photos and graphic material from Barbara Jansen, except the following:


Page: 252-255: Photos: by Heike Overberg, School of Arts and Design Berlin Weißensee, 2006

Page: 258f: Photos: by Heike Overberg, School of Arts and Design Berlin Weißensee, 2006

Pages: 262-265: Animation stils: by Henrik Bengtsson, Imaginara, 2014

Page: 270: Photo: by Jan Berg

Page: 273: Photo right side: by Jan Berg

Page: 275: Photo right side: by Jan Berg


Page: 300: Photos top row: by Delia Dumitrescu


Page: 302: Photo top row: by Linda Worbin

Page: 302: Photos middle row: by Jan Berg, textile by Delia Dumitrescu

FIGURES & VIDEOS


[Project funded by CETEMMMSA Technology Centre and La Incubadora del FAD (Barcelona)]

Page: 304: Photo middle row, right: by Linda Worbin

Page: 304: Photo bottom row, left: by Astrid Krogh, available at: https://www.dropbox.com/sh/ep8fr03n51ocujc/AABVfunsUf5y-mlt8t27KPa#lh:null-37_BUILDINGWITHTEXTILES_Horizon.jpg


All videos: director Barbara Jansen, film and editing Filip Asphäll, University of Borås, 2012-2015.


Optical Fibres

“What are optical fibres?
The term optical fibres or fiber optics can be described as being long lenses.
“A cylinder or rod of transparent material forming a core and surrounded by
an external cladding with slightly different material. Light, when entering
the fiber, rebounds on the outer cladding towards the core. This way the light
advances through the fiber in bounds or steps, until it exits at the other end.
… The term “fiber optics” applies really to a branch of light physics dealing
with the properties of certain materials which display a phenomenon called
“total internal reflection”, and not to an object.” (Cortés, 1999, p. 9)

Optical fibres are mainly made from glass, PMMA (Polymethyl Metha Acrylate) or polycarbonate. Optical fibres (both glass and PMMA fibres) are produced
for telecommunication as well as lighting purposes. Telecommunication fibres radiate single frequencies, however lighting fibres the full visible spectrum. Generally optical fibres can be either used as solid core bare optical monofibres – a single blanc fibre, or as a bundle of fibres in a cladding, so
called clad fibres.

What to choose: glass or PMMA fibres? In general, glass fibres are more
used in telecommunication purposes and the trend goes towards PMMA fibres in lighting applications (Cortés, 1999, p. 15). Comparison of some main criteria’s, see overview next page.

PMMA optical fibres are produced as bare optical monofibres, clad fibres
and sidelight guides. Originally optical fibres are supposed to transmit light
from one end of the fibre to the other with as less loss of light as possible and
therefore are also called endlight fibres.

As more optical fibres have been used in lighting applications the wish
for a side light emitting fibre grew. Today’s solutions for that are so called sidelight guides. Simple sidelight guides are based on a bundle of bare optical fibres twisted together and inserted in a transparent tube. Producers constantly work on improvement; like the Microbraid Sidelight Guides from Advanced Fibre Optics which are based on a bundle of woven optical fibres in
a transparent tube (Advanced Fiber Optics, N.D.).

Most relevant for a textile application are end- and sidelight guides as they transmit the light open visibly, meanwhile, clad fibres cover the light internally in an opaque cladding (which can be flame retardant treated). (Jansen, 2008a)
Comparison between glass and PMMA optical fibres:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>GLASS:</td>
<td>Exceedingly brittle, easily shatters</td>
<td>Dangerous to handle, harmful</td>
<td>High temperature resistant</td>
<td>Flame retardant</td>
<td>After 3-4m</td>
<td>Long distant until 30m, by 1550nm wavelength</td>
<td>High</td>
</tr>
<tr>
<td>PMMA:</td>
<td>Good mechanical properties</td>
<td>Easy to handle, no body harm</td>
<td>Max. 70°C</td>
<td>Not flame retardant</td>
<td>After 8m</td>
<td>20-45m distant (depending on the use of one or two light projectors), by full visible light spectrum</td>
<td>Lower</td>
</tr>
</tbody>
</table>

Side effect: increased diameter, costs and longer production time. [Cf. Cortés 2008, pers. comm., 25. March]
Daylight rhythms

The following text and graphic material is supposed to be read as an introductory pre-study to the PhD research, laying out a foundation for the investigations into time-based patterns in textile design. It introduces three independent larger projects whose light design core centre around daylight rhythms. Woven light – powered by sun energy (MA thesis, 2006), Light Shell (MA thesis, 2008), and Light and Shadow play – the sun as an aesthetic trigger for urban textiles (PhD cooperated project, 2009-2011) will be shortly introduced with their aims, design concepts, design processes and visualisations of possible concept applications.

The projects will be summarised in their physical development, textile construction, as well as their conceptual ideas utilising and integrating daylight into textile design.

woven light – powered by sun energy

The School of Arts and Design Berlin Weißensee

Introduction
The experiences of one year light in extremes (living in Scandinavia) and its fundamental importance to human beings formed new questions towards my understanding of textile design and the standpoint I want to take as a textile designer in the future: “What if a surface near a window could capture the light of long summer nights … and what if larger light surfaces were available to people in winter …?”

Where do I see the future of my work as a textile designer going? Do I see textile design primarily as a decorative field of creative work, or can textiles take on a much more functional role in the future?

Out of these questions the diploma thesis woven light – powered by sun energy arose. In this work the basic idea to build up a textile surface with two different sides which each have individual functions has been developed. One of the sides is equipped with solar technology for energy generation and the other side has the function of a light source.

It is a fascinating idea to develop light out of light. However the work emerged not only out of this fascination. Rather, it is understood as
research in a new, defining field where different disciplines meet; textile technology and design, solar technology and micro-electronics. And it arose under belief that one of the present and future tasks of a designer is to be engaged with the utilisation of renewable energy sources.

Design concepts

The following two design concepts, Sandwich and Duo, represent the final design work of this project illustrated through the practical design experiments. The design concepts are understood as concept proposals. They summarize background research in solar technology, light emitting textile surfaces, light and human wellbeing and experimental design investigations. (Cf. Power Film Solar, N.D., Fornay, 2005-2006, Quaschning, 2005-2006, Stark, 2005-2006, SolarServer, N.D., FlexSolarCells, N.D., LBM, N.D.-b, Luminex, N.D., Richter + Partner, 2011)

Sandwich: the integration of solar technology and light emitting surface inside one textile structure, each technology covering one side of the structure. The surface incorporating solar technology placed in window facades towards the sun, and the light emitting surface positioned room inwards.

Duo: the two functional sides are separated into two independent textile surfaces, nevertheless creating one system of energy generation – and light emission.

Currently this is the more realistic concept, based on present technical constrains. At the moment no small enough form of energy storage is available, being able to be integrated into a textile surface. Furthermore the production of solar technology and light emitting woven structure belong to completely different industries. Besides that the energy generating surface needs to be always displayed in the south facade of a building, whilst a customer might want to use a light emitting surface in another cardinal direction of the building.
Energy generating surface
Light emitting surface

Sandwich

Energy generating surface
Energy storage
Light emitting surface

Duo
Design Experiments
The thesis explored three main areas of practical investigations: solar powered Light Textile, Light dots and Light Textiles. Hand woven prototypes have been developed: both energy-generating and light-emitting.

Development of Light Textile - solar powered:
A functional prototype based on the integration of six thin film solar cells and interwoven PMMA optical fibres (lit up via LEDs) in a two-ply fabric was developed in collaboration with Mathias Stark, a student of Renewable Energy Sources at HTW Berlin. Due to study conditions (technical and financial constraints); the prototype is a rather coarse fabric. However, it provides visual proof that the idea need not necessarily remain a vision for the distant future. See photos page 252 f.

Development of Light dots - solar-powered:
Small solar-powered textile surfaces incorporating light dots were developed in collaboration with the Thüringen-Vogtland Institute of Textile Research (TITV). There speciality is to create fine, electronic conducting textiles. Here thin film solar cells have been connected to the conductive fabric, powering incorporated LEDs, to create light dots. See photos page 254 f.

Development of Light Textiles:
All light textiles are based on the integration of PMMA optical fibres and on double sided designs. One side is light dominating (optical fibres) the other side is combined with an additional material. This second material can have characteristics from soft and fleecy, smooth and shiny, transparent to opaque, white or coloured. The different materials and material colours affect and alter the light quality and intensity, hence the light aesthetics. The combination with a second material creates a particular visual and haptic material aesthetic, not only influencing the light quality at night, but generating a specific feeling in day time too. Both day and night time expression of the surfaces had to be equally interesting.

Three groups of experiments have been created: white, gold/copper and yellow/green.
White: using only white materials to see the pure material impact on the light intensity and quality (use of white LED lamp to light up the samples).

Gold/copper (synthetic metal yarns): using the glossiness of the metal effect as a reflection layer to strengthen the light effect. The colours of the yarns influence the light effect, especially visible using a white light source, copper and gold slightly coloured the light reddish and yellowish.

Yellow/green: use of yellow and green materials, as well as relief elements like crochet knots, and silk petals. The 3D elements create shadow effects in the light surface and colour the light (use of white LED lamp to light up the samples). See photos page 256 ff.

(Jansen, 2007b, Jansen, 2008b, Jansen, 2009d)
Light Textile - solar-powered:
Top: solar powered two-ply fabric, collaboration with Mathias Stark, HTW Berlin
Bottom: Variations to integrate solar cell in textile structure
Light Textile - solar-powered:
Top: solar powered two-ply fabric, collaboration with Mathias Stark, HTW Berlin
Bottom: Variations to integrate solar cell in textile structure
Light dots - solar-powered:
Collaboration with the Thüringen-Vogtland Institute of Textile Research
Light Textiles: in white, gold/copper, and yellow/green
View into the exam exhibition:
Design Applications
The integration of solar technology into textile surfaces would facilitate increased flexibility and mobility of energy generating surfaces and with that enlarge the amount of application areas. The development of new type of surfaces being able to exploit renewable energy sources is an environmentally friendly answer to humanity’s ever-growing energy needs.

Why should sunlight always be shut out? Why not capture it and make use of it at the same time? I believe this offers a great deal of potential for designers in the future. It is a field in which innovations can be designed to benefit mankind in an environmentally friendly way.

Imagine all these sun protecting textile surfaces (roller blinds, lamella curtains, panel curtains, awnings, sun sails, etc.) we use in the architecture of today, especially in the huge glass facades, being able to generate energy. (At the time of this thesis no solar technology applied on textile surfaces had been found, the thin film solar cells were the most flexible and thin solar technology found at the time. I suggested that in the future the solar technology should be printed or laminated directly onto textile surfaces. Whilst starting to work on Light and Shadow play in 2009, first engineering research into printable solar technology on textile surfaces had been found. See page 286 ff.)

The function and use of large-scale light surfaces is consistent with human beings’ existential need for light. The work towards a woven light design which offers a big light surface that is even all over and it’s shining as strong as possible, therefore maintained the aim for future structural development. Finally the surfaces could be used as a big movable light screen in a space either private or public. Being placed in glass facades, windows, etc., or creating temporary and flexible light rooms. See visualization of lighting screens in a 3D animated environment on page 260 ff.

Working on concepts of lighting for an everyday environment – creating big window screens for public buildings et cetera – raised questions about industrial production possibilities. Is it possible to weave PMMA optical fibres on industrial machines? My MA studies at The Swedish School of Textiles (2006-2008) explored that question, utilizing the industrial weaving machines at the University College. Most successful hand woven structures from the Diploma thesis, creating even all over lighting surface through the integration of PMMA optical fibres, where further explored on the machinery. (See
page 268 ff  

The woven structures used in my PhD research work, are a selection out of these explorations and have been produced on industrial weaving machines. (Cf. Jansen, 2007b, Jansen, 2008b, Jansen, 2009d)
Play animation film, scenes only with light screens.
Industrial weaving:

MA Studies, 2006-2007, The Swedish School of Textiles, University of Borås:
Testing PMMA optical fibres (0,5mm, 0,75mm) in the warp system of a shaft machine (Dornier). Steel and copper used as weft materials, recolouring the light colour (white LED lamp).
Industrial weaving:
MA Studies, 2006-2007, The Swedish School of Textiles, University of Borås:
Testing PMMA optical fibres (0.25mm) in weft system of shaft machine (Dornier),
cooperation with company FOV, Borås.
Industrial weaving:

MA Studies, 2006-2007, The Swedish School of Textiles, University of Borås:
Experimenting with relief structures, Jaquard machine.
Industrial weaving:

MA Studies, 2006-2007, The Swedish School of Textiles, University of Borås:
Experimenting with organic patterns; sketching via photogram techniques
to printing to jacquard weaving.
Industrial weaving:

MA Studies, 2006-2007, The Swedish School of Textiles, University of Borås:
Experimenting with organic patterns, jaquard weaving.
Light Shell

The Swedish School of Textiles, University College of Borås

Introduction
Light Shell is an investigation into self-lighting textile shells – textile spaces. A Light Shell aims to enrich its future architectural environment through lighting and being a sensual stimulation of everyday life which can be experienced through vision, touch and being able to move inside and around. It is an investigation into the relation between light emitting textile surfaces, the human body and space.

The words Light and Shell describe the core values of this project. They combine today’s society’s need for light and space to adjourn to.

The current project aims to develop a design concept which describes in an experimental way how a Light Shell could feel like. It aims to find an aesthetic expression how light – space/architecture and textiles could interact in the future by supporting the body in a positive way. A design concept is understood as a statement, a proposal which opens up for discussions and questions about future design values. The project is based on a research and experimental approach and is not aiming at product design

Design Concepts
The following design concepts represent the final design work of this project. They are understood as concept proposals for a Light Shell.


A Light Shell functions as an aesthetic, poetic shield for the body. It creates an internal space in an architectural frame where people can withdraw for a
while. A Light Shell is supposed to surround the body with an embosoming gesture to give the feeling of safety and wellbeing. Being surrounded by a dynamically changing light supports a person with a regenerating and relaxing element. It is important that the developed shape-space is usable in an everyday environment, either private or public space, as the need for light concerns everyone always. The size of a shell is supposed to house a variety of body sizes and figures.
Design Concept 1

is a lying oval shaped space which embosoms one person’s body with lighting. The shape has been developed with the focus on a lying body position, a space to be used for a personal moment of time-out, comforting and stimulating the body through light, touch and embossing shape.

Light design: lighting covers the top and side walls of the inner shape, smooth even all over light surface, dynamic change of lighting regarding daylight at day and artificial lighting at night. Light source: Parans Solar Panel (Parans, N.D.) in combination with a new hybrid system including LED lighting.

(For the thesis the uses of a white LED lamp and film projected into the fibres have been used in order to display dynamic lighting inside the Shell.)
Design Concept 2

is a round cupola shaped space which embosoms one to two bodies with lighting. The shape has been developed with the focus on a lying and sitting body position, a space to be used for a personal moment of time-out, comforting and stimulating the body through light, touch and embossing shape.

Light design: lighting covers the top and side walls of the inner shape, smooth even all over light surface, dynamic change of lighting regarding daylight at day and artificial lighting at night. Light source: Parans Solar Panel in combination with a new hybrid system including LED lighting.

(For the thesis the uses of a white LED lamp and film projected into the fibres have been used in order to display dynamic lighting inside the Shell.)
Design Process
The work can be described as a continuous flow between building up on existing knowledge and exploring completely new fields of tasks. It can be described as a continuous change between analysis, intuitive sketching and experimenting and observations. Thereby theoretical research and previous design tools have been used to set an outline/starting point for the design parameters in this project. See examples of the design process below.

3D knitting has been explored in a continuous exchange between hand knitting and hand flat-knitting machines.

Interviews have been used to gain some ideas about people’s relation to spa-
It is a very personal perception how small or how big a space should be to feel confident inside. Analysis of the interviews showed that people would like to: relax, lie – sleep, lie – sit, or work by travelling in a light-emitting textile space.

Body and 3D shapes: explorations and observation of the relation between body - space - shapes.
Body and asymmetric shapes: sketching with asymmetric shapes and different body positions.

Sketching for Design Concept 1
Development of knitting prototypes on industrial flat-knitting-machine,
Design Concepts 1 + 2
Light and Shadow Play
- the sun as an aesthetic trigger for urban textiles

PhD project cooperation with Marie Ledendal, PhD student at Heriot Watt University, UK, 2009-2011

Introduction
This project is cooperation between Marie Ledendal and me joining our both PhD research work areas. Marie is having a focus on exploring how to reach a visual aesthetic expression of reversible dynamic patterns; combining solar technology and electronic technology with chromic materials.

Whereas I am exploring how design parameters such as time, movement and rhythm relates to textile design, amongst others having a focus on integration of unpredictable design elements/variables, like the sun, which generates a constant changing flow of design expressions.

Having travelled several times to the South of Spain experiencing and photo documenting all kinds of variations of sun sails (see Appendix 1, page 312ff) plus my long time interest in double functions of textiles: sun screening =/+ energy harvesting (see woven light – powered by sun energy) found a dialog partner in Marie. Although the set-out material and technology choices for this project match Marie’s PhD research in the core, and not mine, the sun and its rhythms as centre for design concept developments has been following my work since quite some time.

The project investigates how the sun can be utilized to enhance aesthetics through textile surfaces in urban environments. The project explores the interplay of textiles as a sun-screening element within the outdoor public architectural space.

What happens when we use the sun’s heat and light to trigger a light and shadow play through a textile surface?

What happens when designing with an unpredictable parameter – the sun – in relation to the predictability of the textile design processes?

The emphasis of this project has been to develop design dimensions/solutions to be able to create pattern compositions for a continuously changing pattern. No longer is the designed pattern purely on the textile surface, a second pattern is created. The textile surface and the sun form a constantly moving light- and shadow pattern in the 3D space.
Design Concept
With this project we put forward the concept of dynamic, energy generating sun sails which incorporate printed solar technology. In this way we can create areas of shadow and generate energy at the same time. We also use thermochromic dye (heat sensitive dye) for a playful colour change in the sails. The sun’s changing light will create a dynamic light and shadow interplay. Thus its variation in heat will trigger colour changes. Thereby the aim is to enhance aesthetic experiences within the urban environment.

Design Context
Textiles are widely used as sun shading elements in urban environments, be it in old historical environments, like in the south of Spain, or in modern architecture. (Cf. (Krüger, 2009)”

“Why should sunlight always be shut out? (Jansen, 2007b)” Why not capture both light and heat and make use of it in design. We believe that the integration of solar technology in textile structures offers a great deal of potential for designers in the future. “Increased flexibility and mobility to generate energy are elements which speak for the integration of solar technology into textile surfaces. Developing new surfaces for energy generation through renewable energy sources is an environmentally friendly answer to humanity’s ever-growing energy need. (Jansen, 2007b)” The current development within solar technology points towards possibilities for printed solar cells onto textile structures. (Krebs, 2005, Wilson, 2012)

We have taken this as a base to develop a conceptual application for the future. This project has been based on a real street scenario; however it has been investigated on abstract scale model.

Design Scenario
LAT.:37,23, LONG.: -5,58. South of Spain. Seville. Calle Sierpes. It is summer and heat is trapped in the city. Hot, dusty air makes it, at times, nearly impossible to breathe and the sun is burning down on the ground. Horses, Feriar. Flamenco. Wide avenues and narrow streets. The river. Abanicos, the typical traditional fans, waving in the hands for a flow of air. Light - a lot
of bright light. Laughter. People buzzing around. Shopping malls. The heart of Andalucía. The Calle Sierpes is covered with sun sails. What a relief. No burning sun on your head anymore creating a play of light- and shadows on the flow of people in the street. Life is pulsing in and out of the boutiques in one of the most popular shopping streets of the city.
Design Scenario:

Seville: LAT.:37,23, LONG.: -5,58

The starting point of the project has been to use Seville as a scenario to base our observations and explorations in.

A mood board has been created to define the atmosphere in the selected environment. Words and visuals described the mood; happiness, ‘A sunny day’, alive, ‘lived in’, housing environment, traces of living, fragility, rhythm, movement, pulse, etc.
Based on the mood board, basic forms have been selected. Over 200 sails with forms/shapes/patterns have been created using laser cutting technology. A simplified 3D model of a street section has been built, in which the sun sails have been displayed.

A visit to the daylight laboratory. The laboratory at The Royal Danish Academy of Fine Arts, School of Architecture in Copenhagen has been used to investigate the sun sails in the 3D model under an artificial sun. The artificial sun
creates light and shadow patterns in a street environment during a 24hours sun path simulation. The main focus has been to observe the changes of the light and shadow patterns in the street environment, created using various sun sail patterns.

Thereupon more complex pattern compositions have been developed. The compositions were defined by experimenting with pattern elements strewn randomly onto the backgrounds, and then were ordered more consciously.
The final pattern compositions were thereafter converted into computer laser cutting files.

At the second visit to the daylight laboratory at the Royal Danish Academy of Fine Arts, School of Architecture in Copenhagen more complex pattern compositions were tested two pattern compositions have been prepared for animation films.

Above right: still from animation film, showing one of the final design compositions in the street scenario.
Research Results
The research results have been formulated in form of text, graphic material, animation films and a 3D architectural scale model including sun sails.

Through experiments and observations we have develop new design notions (like movement, tempo, rhythm and time), and variables (like light, shadow, colour, duration, and direction (movement direction and pattern direction)), required whilst working with this type of scenario. In order to describe and define these new design notions and variable for time-based expressions, static (non-changing) design variables of traditional textile design compositions/patterns had to be described first, to assist defining

Movement Direction
of the light + shadow patterns in this street scenario

A  A  A
B  B  B

STREET
NORTH - SOUTH

EAST WALL
WEST WALL

A
The sun`s heat will trigger colour changes.
B
Two colour stages appear: base temperature = base color = A,
activation temperature = changed color = B.
words from the known design process towards new processes. Therefore we have defined a traditional visual/pattern composition, inside or on top of the textile structure (created by weaving, knitting, printing, etc) through pattern elements, pattern units and pattern composition (see detailed discussion under Discussion: Composition).

Working with these types of scenarios the designer can no longer just develop a pattern composition on a 2D surface. The scenario shows that the challenge of the designer is to visualize the coexistence of a three dimensional pattern in space. What will this look like? To what extent can the design be predicted? Or will it be completely unpredictable? In
fact two movement cycles of the light and shadow pattern in the street are predictable, they can be studied for example in a daylight lab. The 24hour cycle of the day will always display the light and shadow pattern in the morning on top of the West wall, moving downwards the wall to the floor, crossing the street towards the East wall, and finally moving upwards the East wall. In the 12month cycle of the year you can see that the light and shadow pattern at noon will be directly centred under the sun sail in June and moving more and more towards north as lower the sun stands in the rest of the year (in this specific Latitude and Longitude, see graphics previous pages). Nevertheless these yearly repetitive cycles the current weather conditions are not predictable. Will it be hot enough to trigger the colour change of the thermochromic print for example, maintains estimation on reviewing the weather forecast of previous years. The two animation films show two different sets of sun sail patterns, displaying a 24hour cycle in June. Thereby one “day” is hot enough to trigger the colour change and the other isn’t.

Research Diary Note:
In the beginning of the project it was still an open aspect, if we would focus on creating patterns of different “greyscales” of shadow, or creating light patterns inside a shadow area. (See right side, top row.)

The former we envisioned that areas of printed solar technology would create the darkest shadow (as printed areas totally black out the light), areas of only the sail material create the palest shadows, and the areas of printed thermochromic pigment would change their shadow appearance depending on the day reaching high enough temperature to trigger colour changes. Envisioning that the thermochromic printed areas whilst heated would turn transparent, thereby influencing the shadow intensity as well. (See right side, bottom row.)

First printing tests from thermochromic pigments on semi-transparent fabric caused a big surprise. The fabric was heated up, the colour turned “transparent”, only the colour of the textile maintained, as expected, but the casted shadows didn’t show any difference between heated and non-heated state of the pigments. Did we look wrong? What was going on? Repeating the test in the daylight laboratory showed the same, the colour disappears in heated state, but the shadow stays identically in heated and non-heated state. Measurements of the light transmittance values of magenta coloured
thermochromic dye printed on transparent acetate film were carried out using the spectrophotometer. The tests confirmed that thermochromic dye does not become ‘translucent’ but rather ‘colourless’. This is due to that the molecules in the dye is still there (and so are binders and other additives) nevertheless, if the pigments are in heated or non-heated state. The dye cannot turn translucent, even though the colour visibly disappears in heated state, becoming ‘colourless’, the shadow cast by a thermochromic printed area maintains the same. This discovery marked a big impact on our design decisions. Before thinking the emphasis would be on colour design, different colour areas would create different shadow forms and these change over time. Now the cut outs in the sails create light patterns instead and the thermochromic printed area functions more as a background colour into which form is “cut out”.

Working in scale model or/and full scale? Working in paper or textile? Due to restricted time and funding frame for this project it was early on decided to work with scale models and the visits to the daylight laboratory allowed us to study sails and their light and shadow patterns in the model in the latitude and longitude of Seville. Initially trials of scale sails in paper and different woven textiles showed really fast, to use the textile in a scale model is no help,
always an irritating gape between those two. The textile structures casted clearly visible shadows of the textile structure into the model, being far too big in relation to what much likely would happen in real scale. Therefore the decission was made to work only with paper mockups, both for the sun sails, as well as for the 3D model.

Summary
In all three projects are the design concepts embedded in the daylight – day and night – rhythm. In woven light – powered by sun energy light is utilized from light. The suns energy is harvested and stored in order to be able to prolong the day into the night through artificial lighting inside textile structures. In Light Shell the suns light is displayed directly into the textile surface, textile Shell, and the day prolonged into the night by displaying artificial dynamic changing light inside the Light Shells. In Light and Shadow Play the sun triggers the light and shadow patterns inside a street environment and its heat activates colour changes inside the sun sails.

The first two project concepts center in the day and night rhythm using both natural and artificial light, embracing the cyclic repetitive repetition pattern of the daylight rhythm, constantly shifting and variating over the day and year. Thereby linking the artificial lighting to natural rhythm, daylight rhythm, was crucial part of the design concept development.

The third project concept, interlude of sun sails, is embedded purely into the daylight rhythm. Thereby on one hand dealing with traditional textile design processes, designing a pattern in the sails, and on the other hand opening up into new design process into time-based design, creating ongoing moving light and shadow patterns. Especially the observations of the moving patterns lied first foundations into the definitions of new design notions and design variables dealing with time-based textile light design. See graphic to the right and Chapter: Discussion, page 209.
Non-physical Variables:  

| Notions: |  |
|----------|  |
| Light - sun | Tempo | create |
| Shadow | Rhythm | overall |
| Colour changes | Time |  |
| Duration [24h cycle, 12month cycle] | Movement | expression |

+ 

Physical Variables:  

textile structure:  

colour: thermochromic ink  
form:  
- laser cut forms (creating forms of light)  
- printed solar technology (creating forms of shadow)  
- printed thermochromic ink (creating forms of shadow and colour)  
structure: weave
Different forms of Light expression: *dotted, pixel like:*

*Drops of light,*
by Delia Dumitrescu, 2013
LEDs, knitted structure

*White Display and Touchpad, and Blue code,*
by Barbara Layne and SubTela, N.D. and 2008
LEDs, woven structures

*E-Static Shadows,*
by Zane Berzina and team, 2009
LEDs, woven structure
Different forms of Light expression: *linear*:

*Spår* [traces],
by Anna Persson and Linda Worbin, 2010
electroluminescent wire, woven structure

*Moon lighter*,
by Delia Dumitrescu, 2013,
electroluminescent wire, knitted structure

*Spiratomic Space*,
by Rachel Wingfield and Loop.pH, 2010,
electroluminescent wire, lace making
Different forms of Light expression: even light surface:

*Series: Designing glow-in-the-dark pattern on textiles*,
by Marjan Kooroshnia, 2014, 
glow-in-the-dark pigment, printed textiles

*Luminous Textiles*,
by Ana Pineyro, 2008,
electroluminescent ribbons and leather, woven structure

*Dimma* (foggy),
Anna Persson and Linda Worbin, 2010,
electroluminescent film, tufted structure

*Horizon*,
by Astrid Krogh, 2013,
optical fibres, woven structure

*IKAT II*,
by Astrid Krogh, 2011,
optical fibres, woven structure
Esparteria

Vineyard Terry’s, EL Puerto de Santa Maria, Andaluzia, Spain, July 2009
Esparteria
CalleValdés/San Bartolomé, EL Puerto de Santa Maria, Andaluzia, Spain, July 2009
Esparteria

Esparteria (workspace and sales) from Jose Luis Fernandez, Pilas, Andaluzia, Spain, July 2009
Sun sails
South of Spain

Top: Cadiz, Plaza de San Juan de Dios, July 2007
Bottom: Seville, Plaza Nueva and Plaza de San Francisco, July 2007
Sun sails
South of Spain

Top: Seville, Calle Sierpes, July 2007
Bottom: Seville, Centro Andaluz de Arte Contemporáne, July 2009
Sun sails
South of Spain
Top: Grazalema, July 2007
Bottom: Granada, old town, July 2007
Sun sails
South of Spain

Madrid, streets around Plaza Puerta del Sol July 2007