EXTERNAL FORCE

exploring changeable expressions
in woven structures
when activated by wind and light

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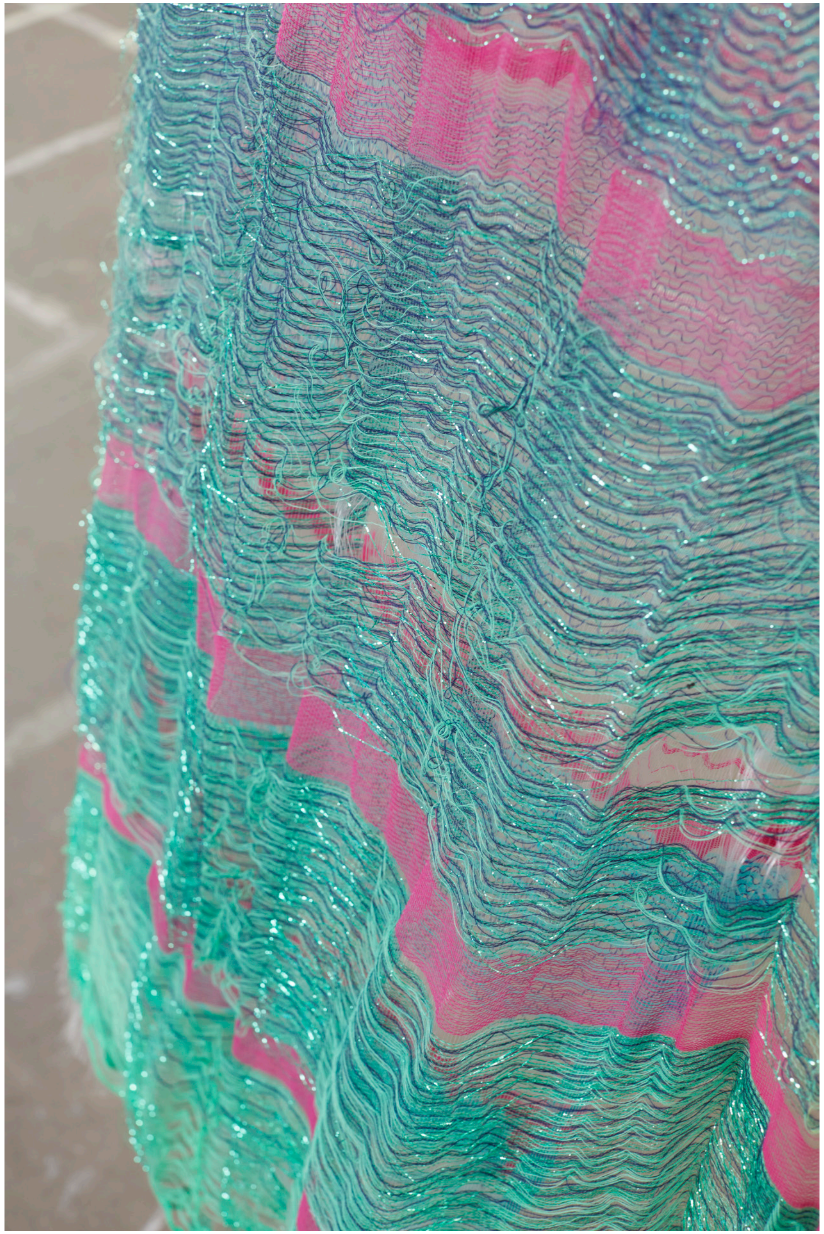
1.1 REPRESENTATIVE IMAGES OF THE WORK

SOLAR WIND

STRATOSPHERIC CLOUD

NORTHERN LIGHTS



1.2 ABSTRACT

This work places itself in the field of textile design, weaving and exploring the design of changeable expressions in textiles. The intention of this work is to design three textiles that interact with the environment in outdoor spaces to achieve changeable expressions. Weaving is chosen as a technique because of the possibility to achieve different qualities in the same piece of fabric. The material, structure and density in the weave determine the interaction between the textile and the external factors, such as wind and light. The parameters make the various parts of the textile react in different ways, for example, the looser the threads are attached in the weave, the more they move in the wind. The interaction between the surroundings and the material causes the textile to change expression in terms of color, pattern, and transparency. The textiles provide an interactive element to an outside space, where it can be used as either a decorative piece or with a functional purpose as room dividers. The project opens up to utilize the textile responsiveness to external forces in design, to create dynamic textiles which change in apparence.

1.3 KEYWORDS

Textile design,

wind,

light,

weaving,

structure,

changeability,

movement,

textiles for outdoor applications.

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2.1 INTRODUCTION TO THE FIELD

Textiles and movement

Movement is an important quality of textiles. How a material moves and behaves is an important factor when choosing a material both for fashion and interior applications. A heavy velvet curtain moves and drapes differently than a stiff panel curtain, and the choice of material is importat for how the user wants the product to appear and interact. The velvet curtain provides a softer and heavier apperance, while the panel is lighter and stiffer, and, moves more swiftly.

The importance of this interaction suggests that the moving expression of such applications should have greater consideration in the design development. Even though movement has a great relevance for the expression of a design, Bågander (2021) describes that the static expression is often the primary motive of design. Her research challenges that by using the interaction of the wearer and the garment in the design development, rather than treating the interaction as a by-product. Applied to interior textiles, the behaviour and movement of the textile in, for example, curtains, could be utilized aswell in the design development. Interactions, such as a wind gust from opening a window could be used as a design feature to the textile.

Changeability in textiles

The moving expression of a textile could be defined as a changeable or temporal expression. The changeable or temporal aspect is considered to have sustainable value. Talman (2019) describes that a material with changeable qualites can have a longer lifecycle, but also engage the user to value it more because of the temporary expressions. Research within changeability in textile design shows how a textile can achieve multiple expressions in e.g. colors and patterns. In the collection Shifty Weaves (fig. 1), the textiles change apparence depending on which angle you view them from. It creates an intriguing experience where the viewer can move around and get multiple expressions from one material (Jungkvist 2019). Changeable expressions can be found in nature, for example where seasonal changes can cause color change in leaves and trees. The use of changeabilityin design can therefore be a way to experience or simulate a natural environment in man made spaces.

Natural forces in design

Today, the natural force of light is often integrated in the development of architecture, textile and design. The Al Bahar Towers in Abu Dhabi (fig. 2) demonstrate this with its separate facade of folding panels, that responds to sun to regulate the temperature and climate inside, while it also provides a design feature to the building (Arch Daily 2012). Hörteborn (2019) means that even the wind has a potential in the field of architecture, and by incorporating it in the design expression, it could make our spaces more interactive and beautiful.

Figure 1: Pattern Shift from the collection Shifty Weaves (Jungkvist 2019)

Figure 2: The Al Bahar Towers in Abu Dhabi (Arch Daily 2012)

2.2 STATE OF THE ART

Textiles and wind

In the area of textiles, there are several recent works that utilize the interaction with wind in the design development to create changeable expressions. The wind is an important factor in Echelmans work (Echelman n.d). The large scale sculptures are made of net-like structures that move effortlessly in the wind (fig. 3). When in motion, the layers of the hollow structures interact with each other and create new shapes and patterns that makes the sculptures ever changing (Echelman n.d.)

In the workshop Architecture from textiles in motion (Hörteborn, Zboinska, Dumitrescu, Williams, Felbrich, 2019), both digital and physical simulations of textiles interacting with wind were made. The knitted textiles (fig. 4) were exposed to heat, that caused the shrinking yarn in the textile to shrink and created a three dimensional pattern on the surface (Hörteborn, et. al 2019). The different structures in the textile, such as the stiffer, shrunken parts and the flexible, unshrunk parts interacted in different ways with the wind.

Even though the works differentiate from each other, both in aim and outcome, they suggest that structure is important in the behaviour of the textile interacting with wind. The net-like structure in Echelmans sculptures (fig. 3) allow the layers to interact with each other, contributing to the changeable expression when interacting with wind. The three dimensional surface in the knitted material (fig. 4) creates form and allows the various parts of the textile to react differently to the wind.

Figure 3: Earthtime 1.78 by Echelman (Seidler, Ellia, Weber & Roncevic 2021)

Figure 4: The knitted material from Architecture from textiles in motion (Hörteborn et. al 2021)

Natural forces and art

In the area of installations, there are several recent works where the properties of the material cause changeable expressions due to the assemblent and placement of them. Moriyamas (2016) installation Mirage in the forrest (fig. 5) explores material interaction with wind, light and the surroundings. The thin holographic films are attached to a frame in which they can move and change direction (fig.5). When changing direction the light breaks in a different way, making the piece appear in different colors. The reflective material and the placement of it, gives the piece a changeable expression.

Shotz's work (2016) is about material interacting with light. She often works with reflective, compact materials, such as glass and metal. In Scattering screen (fig. 6), glass beads scatter the light and the surroundings into thousands of pixels. The phenomenom of light scattered like pixels is made visible through the material she uses, the shape they are in and the placement of them (Openshaw 2015).

Both works suggest that placement and light has great influence on the possibility of achieving changeable expressions in a material. The expression of the material is heavily influenced by the placement of them, and would be completly different if they were placed in another environment.

Figure 5: Mirage in the Forest by Moriyama (Kioku, Matsumura, Moriyama 2016)

Figure 6: Scattering Screen by Shotz (Ironside, McGilvray, 2016)

2.3 MOTIVE & IDEA DISCUSSION

In this degree work, the idea is to explore changeable expressions in the textile when it is interacting with wind and light. Echelman (n.d.), Moriyama (n.d) and Shotz's (n.d.) works are examples of this, as the expression of their work is heavily influenced by these factors. The hollow, transparent, or reflective material combined with their structure achieves changeable expressions in color, pattern, or transparency.

Hörteborn et al (2019) work suggests that different structures, such as loose or dense, affect the interaction between an external force and a material. In addition to this, different material qualities, such as transparency and opaqueness would aswell affect the apperance of the material interacting with an external force. Combining various materials, structures and densities achieves different expressions of the textile when interacting with light and wind, and this project aims to explore that.

The textile technique weaving offers many possibilities to achieve different qualities in one piece of fabric. The same material can behave differently depending on which structure it is woven in and in what density the weft and warp are interlaced. A satin weave structure can produce a fine and light fabric if it is woven with thin threads and a sparse structure, but if the density of the weft is higher, the result can instead be a stiff and heavy fabric. This project aims to explore these possibilities, focusing on material, structure and density.

Echelman (n.d.), Moriyama (2016) and Shotz's (n.d) work are site specific installations, where the placement of the works has informed the development of the pieces. In contrast, this project aims to explore various placements, to observe how different conditions of wind and light affect the textiles. Hörteborn et. al. (2019) explores the potential of wind to generate form in a knitted material. This project will instead explore weaving to create the changeable expressions in the textile, here with both wind and light.

2.4 AIM

The aim of this work is to explore changeable expressions in the textile,

when activated by wind and light,

through materials, structures and densities in the weave.

3.1 DESIGN METHOD

research – pre-study – experimental sketching with different material qualities

material exploration in the jacquard looms – translating the experimental sketches into the loom

experimenting with materials, structures and densities in the looms

– outside experiments – color – development of collection

In this project, the chosen design method was applied research. The work was practice-based, where the samples and sketches were the basis of further development (Muratovski 2015). A branching strategy was used, where some of the methods were done simultaniously (Jones 1992).

RESEARCH Literature and visual references were collected to establish the area of the project and identify the gap.

PRE-STUDY The pre-study consisted of material experiments in the jacquard looms where different structures and materials were used, aswell as sketching with ready made fabrics where stiff and drapable qualities were used to reseach how the qualities were affected by the movement of the airflow.

EXPERIMENTAL SKETCHING The sketches were developed into three tracks that were chosen based on their difference in movement to each other. Later in the process these were discarded as the findings in the material exploration were considered more interesting in relation to the aim of the project.

MATERIAL EXPLORATION The material exploration was made of two parts where one consisted of translating the experimental sketches into the loom, and the other consisted of experimenting with materials, structures and densities in the loom. This resulted in a large sample library, where the collection was developed from the knowledge gained by trying ideas out.

OUTSIDE EXPERIMENTS The samples and sketches were brought outside where they were placed in different light and wind conditions. The interaction between the textiles and the surroundings were analyzed and used to develop the pieces.

COLOR Keywords were decided and a moodboard was made for the visual expression of the collection. The colors for each piece were chosen based on what materials would support the changeable expressions in the piece, and how the colors worked with each of the changeable expressions. For example, in Stratospheric Cloud, the turqouise was enhancing the changeable expression, as opposed to the yellow that was first considered for this piece. Digital sketches were made of the placement of the colors, and samples with the materials were made in an ARM-loom.

DEVELOPMENT OF COLLECTION The samples were analysed and further developed to the final pieces. Final changes were made to connect the textiles together as a collection, but also because of materials and colors worked in each piece with the changeable expressions.

3.2 PRE-STUDY

A pre-study was done to gain deeper knowledge within the chosen technique, weaving. The aim of the pre-study was:

Explore how different weave structures and materials can interact with airflow in a textile design context.

The prestudy started with a material exploration in the weaving lab. The monofilament warp was chosen because of how the material interacts beautifully with light. The exploration was focusing on trying out materials, structures and densities of different qualities. Materials with different behaviour were used, such as steel, shrinking, and, regular polyester and cotton yarn. The stiff materials, such as the steel and shrinking yarn were woven in plain weave structures that interweave more freqently and produces a more stable, and stiff material. The polyester yarn was used in looser structures, such as crepe and satin weaves. When woven in the monofilament warp with a low density, it generated a loose material. These samples were then hung up and airflow was introduced with a fan, to see how they interacted with wind.

It proved difficult to draw any conclusions from these experiments, as it was unclear how the material, structure, and, density affected the interaction. In fig. 7, the yellow stripes were woven in plain weave, and the white and purple parts were divided in two layers in a crepe weave with low density. The intention was to cause the loose threads to move, but instead the whole entity was in motion. If the textile was in a larger scale, the effect of the whole piece moving could be avoided, and perhaps, the interaction between the different materials could become clearer.

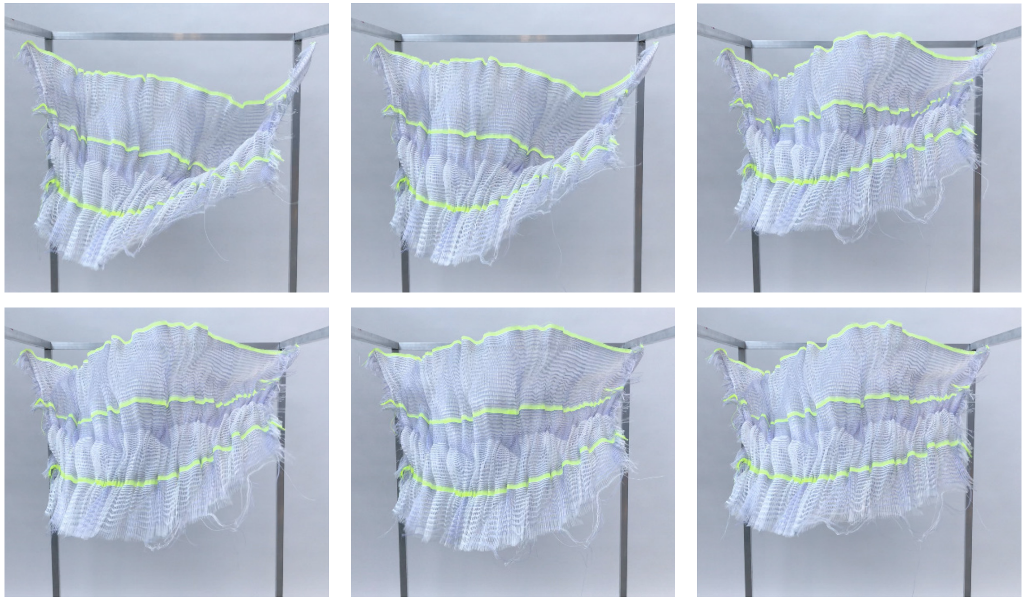

Figure 7: Sample for *the floats*. Made in the monofilament warp, with a plain weave binding and linen floats that move when airflow is introduced.

Therefore, ready made fabrics were used to sketch with to explore how different qualities could interact with airflow. The scale that was decided was 2 m long, and 1,5 m wide, as that scale would be big enough to not make the whole textile move with the airflow. Viscose, organza, linen and monofilament fabric were sewn together in different proportions. Later, the viscose and monofilament were chosen to continue to work with, as the interaction of the viscose had a more defined expression than the organza and linen. The monofilament was very stiff, and was contrasting to the others, so this was also chosen.

Three different tracks were developed, and these were chosen based on their difference in movement to each other. Two of the tracks were made with ready made fabrics and one was woven in the machine. It was woven because the movement was about floating threads, and it was more efficient to weave, than to sketch with ready made fabrics to try out the idea. The first track, *the stripes* (fig. 8), was made with the monofilament material in stripes. With little airflow, it made the viscose move, and the monofilament not, and the movement could be described as interrupted. The second track, *the squares* (fig. 9), was made with monofilament in squares, and because the monofilament was stiff and move heavy, it caused them to jump when airflow was introduced. The third track, *the floats* (fig. 10), was decided to make in the monofilament warp, with floats in a geometrical shape, and the other parts woven with a stiff structure in contrast to the moving floats.

Figure 8: The 1:1 sketch *the stripes*

Figure 9: The 1:1 sketch *the squares*

Figure 10: *The floats*

3.3 DEGREE PROJECT

The degree project started with continuing to develop the 1:1 sketches. In parallel, a material exploration was made in the jacquard looms in the weaving lab. The material exploration consisted of developing *the floats*, translating the sketches *the stripes* and *the squares* into the loom, and, exploring materials, structures and densities. The woven samples and 1:1 sketches were hung up, to see how they interacted with airflow. The interaction was analysed, to see how the different materials, structures and densities contributed to changeable expressions in the samples and sketches, and that led the development forward.

When having woven samples for all the tracks: *the stripes*, *the squares* and *the floats* - they were taken out to different contexts, to see how they interacted with the natural wind, aswell as different light conditions. The interaction with the outside factors influenced the development of each piece. A color scheme was made through a moodboard, and the placement of the colors was decided through what materials worked in each piece for the changeable expressions, aswell as how they worked together as a collection.

3.3.1 EXPERIMENTAL SKETCHES

Starting the degree project, the 1:1 sketches were further developed by rearranging the stiff material symmetrical in both sketches, and in *the squares*, the amount of the stiff material was increased (fig. 11). Previously, the monofilament squares had been sewn randomly, and now they were instead placed symmetrically on the surface. The main aim with this experiment was to suspend both sketches in similar positions, to see how the different arrangements of the materials affected the movement in comparison to each other. It was concluded that the interaction in *the stripes* generated a form, rather than the materials moving differently. This was thought to depend on that the sketch was suspended in the corners, and that it had too little free movement in the material. In *the squares*, the interaction generated a textural surface, with the squares folding and shaping the textile in the wind.

Figure 11: The 1:1 sketches, *The stripes and the floats*, where suspended in various positions to experiment how they interacted with different parts attached and the wind coming from various directions.

To allow more movement in *the stripes*, it was decided to attach it only in the stiff monofilament, to allow the drapable viscose to hang freely. This caused a pulsating movement in the material (fig. 12).

A more dense monofilament was sewn in to see if it affected the movement in a different way (fig. 13). When sewn into *the stripes*, it caused soft folds in the material. This was considered interesting to develop further as the wind caused the soft folds to bend and drape the viscose (fig. 13).

For the squares, It was decided to try different scales of squares in the stiff monofilament and see how that would affect the surface and movement (fig. 14). It was concluded that the largest size, (20 x 20 cm), affected the surface the most. The smaller ones (10 x 10 & 5 x 5) were small enough to follow the continuous movement in the material. It was therefore decided to use only the largest squares and work more with the spacing in between them.

Another sketch was made, where the spacing in between the squares was increased exponentionally (fig. 15). The larger the space between the monofilament squares, the more the viscose moved.

Figure 12: *The stripes* is attached only in the stiff monofilament. The fan is placed next to it, on the right side. When it blows, it causes the a wavy motion through the textile.

Figure 13: *The stripes* is suspended in the ends of the width. Because the frame was shorter than the width, the material was pulled together. The higher density in the stiff monofilament caused soft folds in the piece.

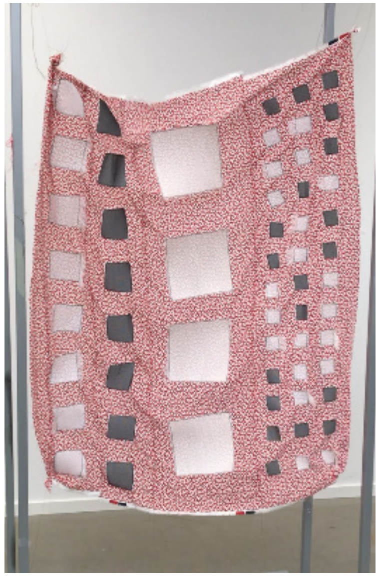

Figure 14: *The squares* with different sizes of stiff monofilament.

Figure 15: The space in between the stiff monofilament was increased exponantially.

3.3.2 THE MATERIAL & STRUCTURE

The material and structure are of great importance when working with movement in a textile material. Various fibers and yarn qualities react differently to wind and movements, and in the weave itself, the density and weave structures affect on how the material behaves. Apart from affecting how the fabric behaves, the weave structures also determine the visual expression of the textile. So while experimenting with the 1:1 sewn sketches, several experiments were made in the loom of how the 1:1 sewn sketches could be woven, aswell as what kind of visual expression they would have. Plain weave structures have the ability to create stiff and stable structures, whereas satin structures are based on floating threads with less binding points that allows the threads to move more (Alderman 2004). These two categories were explored in this project as they generate contrasting material qualities that were considered interesting in terms of creating different movements.

To translate the full scale sketches to the loom, a material exploration was made. The materials used in the sketches where weighted, and compared with the warps on the looms in the weaving lab. Two looms were tried out, one with 91 ends / cm, and another with 26,4 ends / cm. The lightest warp was chosen with 26,4 ends per cm, and it had a black and white warp. Because the visual expression that was aimed for was light, the black warp was woven out as floats along with the piece, and then cut off.

Because of the high thread count in the loom with 91 ends / cm, satin bindings were calculated based on how long the floats would be (fig. 16-17). Satins in 40, 30 and 22 shafts were woven with densities ranging from 60 to 15 picks per cm. The structures with higher densities resulted in a tighter and more rigid fabric, but the structures with less picks resulted in a very loose structure, almost falling apart. Another test was made with 5 and 10 shaft satin, and here the results were more promising. With a lower repeat in a weave, the threads have more binding points and less weft density is required to keep them in place. Less threads in the structure equals a lighter fabric, that has more ability to move.

Plain weave structures where woven for the stiff materials (fig. 17). Because monofilament is stiffer than regular yarn and creates more tension on the warp when moving up and down in the loom, the structures were scaled up. Plain weave structure were scaled up to go under and over 8, 16 and 32, as variations of panama, to ease the tension on the warp.

Figure 16: Sample made in bonas, with 91 ends / cm. Polyester multifilament as weft. 22 shaft satin with a density of 30 picks / cm.

Figure 17: Sample made in staubli, with 13,2 ends / cm. Blue monofilament in plain weave structures, with different densities.

There were several ideas of what the visual expression for the collection could be. Satin structures were used for a the drapable quality, which was a large part of the textiles. With satin structures, it is possible to create many shades of one color without changing the structure, or adding extra yarns into the weft. Gradients communicate something that changes, which was fitting with the idea of textiles with changeable expressions. One sample with gradient were chosen as a final sample for *the stripes* (fig. 22). This sample had both the lightweight quality in satin structures with the stiff parts with monofilament woven in as stripes.

Floats were going to be used for one of the tracks, but were also tried out for the other two tracks. It was important what material the floats were woven with, as the material used interacts differently in the wind. Polyester multifilament (fig. 21) easily becomes static, and tends to lay against the surface instead of moving in the wind. While a thicker yarn, such as a plied polyester yarn (fig. 20) can make the textile heavy and not move as much.

The squares were difficult to recreate in the loom, so other alternatives were considererd. One sample (fig. 18) made with shrinking yarn as floats, was only shrunken in the top. The gradation of density was interesting in relation to wind - as the bottom of the textile would move more than the top. This sample was chosen to develop instead of *the squares*. When developing this idea further (fig. 19), every other thread was woven as a float in another color to create a color contrast between woven parts and the floats..

Figure 18: Sample made in staubli, with 13,2 ends / cm. Polyester multifilament in the weft, and form funky as floats.

Figure 19: Sample made in staubli, with 13,2 ends / cm. Polyester multifilament is used in the weft, with light cotton as floats. This sample was chosen as a final for the squares.

Figure 20: Sample made in staubli, with 13,2 endes / cm Polyester multifilament as weft and polyester yarn as floats.

Figure 21: Sample made in bonas, with 91 ends / cm. Polyester multifilament as weft. 22 shaft satin with floats on every other weft in blocks.

Figure 22: Sample made in staubli, with 13,2 ends / cm. Light cotton in the weft, and white monofilament in plain weave structures.This sample was chosen as a final for *the stripes.*

The third track was *the floats*. This piece was chosen to weave in the monofilament warp. At first, a stiff base were thought to be interesting as a contrast to the moving floats. Later it was instead chosen weave a slinky material as the base to incorporate movement in the whole piece. Floats were woven in geometrical shapes (fig. 23) and in rows (fig. 24). The sample with the rows were chosen to develop further, and to incorporate smaller floats aswell in the parts between the rows.

It was decided to use shrinking yarn in the woven parts between the rows of floats. This would shrink the textile and make the floats pop up from the surface. When weaving this, a too tight weave was chosen for the shrinking yarn, so the effect did not occur (fig. 25). Otherwise, it gave an interesting texture and color effect in the weave.

One sample was woven with a much looser structure and lower density (fig. 26). Alternating rows were used, so that when one weft was weaving one row, it was floating in the next. Lurex and cotton were used in the floats, as they was light and could move a lot with airflow. The lurex also shimmered when in motion. Multifilament was used in panama structure, where it created a softer surface, and held the structure together.

Figure 23: Sample made in monofilament warp. Polyester yarn in weft.

Figure 24: Sample made in monofilament warp. Polyester yarn in weft. The floats are shorter and cut.

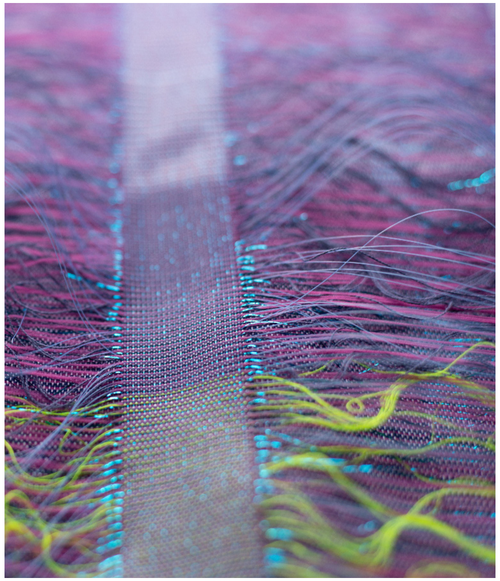

Figure 25: Sample made in monofilament warp. Polyester multifilament, monofilament, lurex and synthetic neon yarn in weft.

Figure 26: Sample made in monofilament warp. Polyester multifilament, polyester yarn and lurex in weft. This was chosen to be the final sample for the floats.

3.3.3 OUTDOOR EXPERIMENTS

The pieces were meant for outdoor use, where they could interact freely with the environment. When having satisfying samples for all the pieces they were brought outside to different environments. The environments were chosen based on their wind and sun conditions. First, a hill at an island in the archipelago was chosen because of its strong winds.

The floats was placed laying flat on a stony surface (fig. 27). In this context, the light structure draped beautifully against the stony surface. The strong sun and the wind catched the floats which made the lurex sparkle and move a lot. Because the textile was placed at the stone, the transparent aspect of the material got lost, and the colors appeared saturated in this environment.

It proved difficult to attach *the stripes* to the surroundings (fig. 28). When performing the experiments indoors, the material was suspended in both ends, and contracted so that the soft folds appeared. It was not possible to attach the material in this way outside, so the soft folds did not appear. The stiff monofilament did not affect the movement in any way. The hard wind made the material move up and down, in a pendling movement. It was decided to go to a place with a softer breeze, with more possibilites to suspend the material.

Next, a forrest environment was chosen to experiment with conditions with less sun and wind. There was a path where occasional breezes of wind blew through, and *the stripes* was hung there. The soft folds could not be achieved here either, and there was no difference in movement and expression between the stiff monofilament and the drapable satin.

Figure 27: *The floats* placed on a stone.

Figure 28: *The stripes* suspended between a couple of trees.

The floats was also placed in the forrest (fig. 29). Here, the material appeared in a different way than on the sunny stone. With the shadow of the trees and the light shinging through, the texture of the material appeared more sheer.

The floats was placed again in another forrest environment (fig. 30). This place had stronger wind conditions. The sample was cut shorter, appoximately 1,5 m in length so that it was able to hung vetically. It was woven as a double weave, without the two layers interlaced. The two layers were separated and hung independetly. This made the whole textile lighter, and move more. The surface of the textile appeared differently, depending on from which side it was viewed. From the front, the piece appeared more opaque and the lurex showed up, making it sparkle as it moved through the wind. From the back, the piece appeared more transparent.

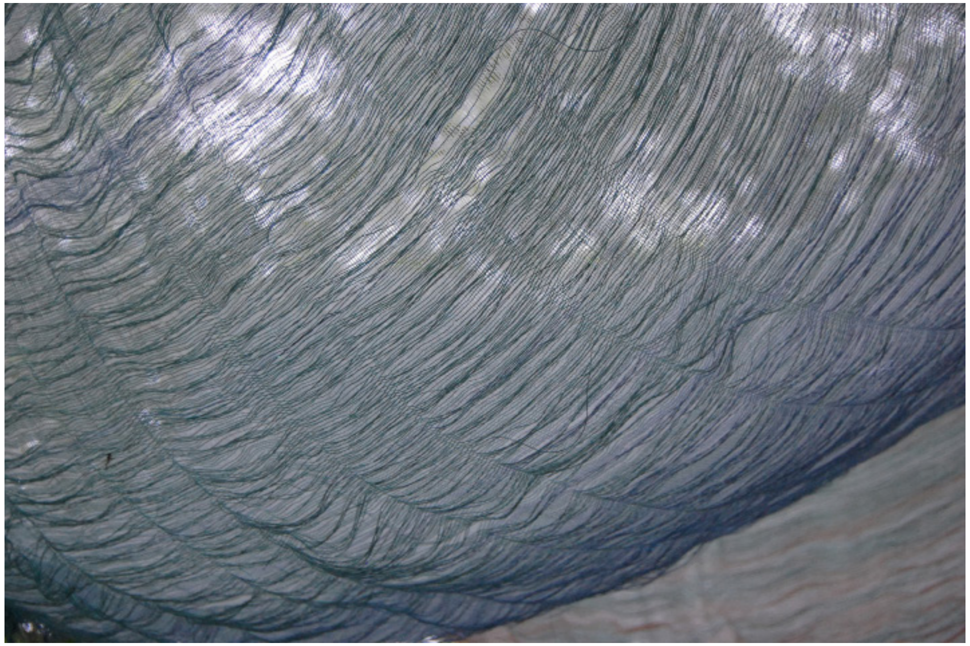

Figure 29: Details of *the floats*.

Figure 30: *The floats* from the front.

The squares was also hung in a forrest, in a glade with powerful wind and sun (fig. 31). When the wind blew, the textile was pendling back and forth. When blowing back, the light catched the pink and made it more saturated, and when blowing forth, the yellow floats where only visible on the surface.

When weaving this sample in the loom, the floats had laid flat on the surface, and when taking it out, they bundled up in groups on the surface and became less dominating in the expression. It was therefore a surprising effect that they transformed the surface yellow in some angles.

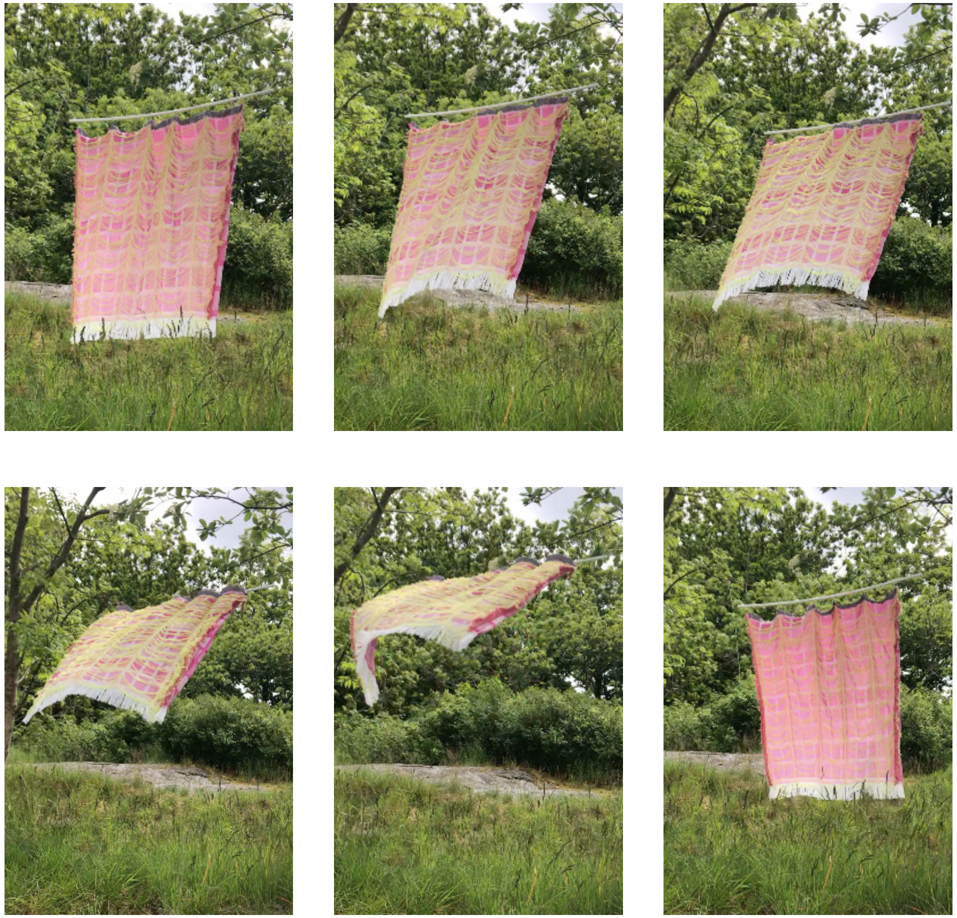

Figure 31: *The squares*. Screenshots from recording.

3.3.4 DEVELOPMENT OF THE COLLECTION

Taking the samples out in nature brought insights into how the pieces interacted with the surroundings. Instead of basing the collection around the stiff and drapable materials' interaction in the wind, the samples instead suggested that it would be about the changeable expressions in the textiles when they interacted with the outside forces. To distinguish the sketches from the final pieces in the collection, they are here mentioned with the names that they got in the end of the process. *The stripes* became Solar wind, *the squares* became Stratospheric cloud, and, *the floats* became Northern lights.

The squares and *the floats* both transformed in the different settings. *The squares* changed in color when it moved in the wind. *The floats* changed in transparency depending on light conditions and how it was placed. However, *the stripes* did not achieve this, and it was realized that it no longer fitted into the collection. One previously made sample was chosen to develop further to replace *the stripes* (fig. 32). It had an interesting effect when turning it, as the different angles revealed different aspects of the surface. When looking at it from the front, the floats blended in with the woven parts. When turning it to the side, the shrinking yarn took over, and the surface turned blue, while the geometrical shapes popped out.

The effect appeared when turning the piece in certain angles. For the piece to be able to turn, it would have to be smaller in size. A smaller piece was concluded to be a nice contrast to the other pieces in the collection, which were larger in scale. The movement in this piece would also be different than the other two, since their effect appeared when the textile fluttered in the wind, but in this, it appeared when turning it.

Figure 32:: Sample woven in staubli, with 13,2 ends / cm. Yellow multifilament and lurex in satin weave. Blue funky form as floats that is only shrunken in top.

Solar Wind

A sketch (fig. 33) was made in the ARM loom with monofilament warp, with both satin and plain weave bindings. The shrinking yarn was woven as floats in rows. It was concluded that the plain weave was a better choice for the piece, because when weaving it in the monofilament warp, it appeared as more transparent in certain angles. Paper sketches (fig. 34) were made to decide the size of the piece, the rows and the amount of floats. 80 cm was estimated a good length for the textile to be big enough to turn around (fig. 36).

As the warp was transparent, and the weft colors mixed, it was decided to do a gradient with thicker parts. A more subtle gradient would not be as visible because of the mixture of colors. For example, the gradient was not as visible when seeing it from close (fig. 35) but more visible from far (fig. 36).

Figure 33: Sketch made in ARM-loom.

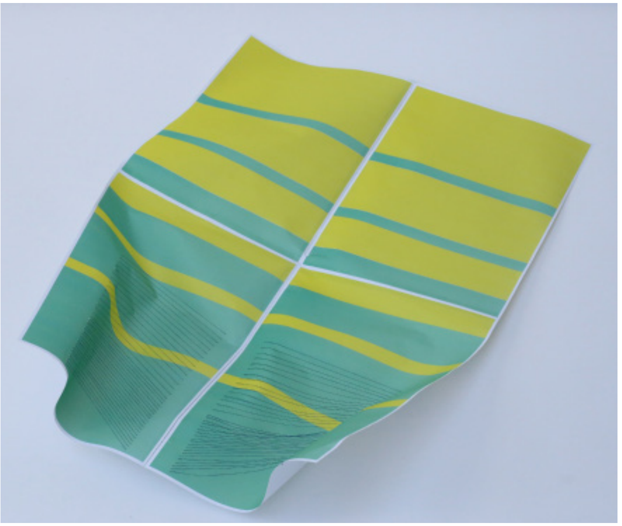

Figure 34: Sketch of scale and floats.

Figure 35: Details from the side. The blue funky form becomes more articulated when viewed from the side.

Figure 36: Back. Here, the thicker gradient becomes more visible.

The denisity was increased, to make the piece more compact. The yellow yarn was later changed to white, because the yellow color brought a warmer tone, that was not used otherwise in the collection. The piece was made longer, approximately 200 cm, to match the other pieces in length (fig. 37).

The longer piece made it possible to experience the blue floats become more apparent when seen from under or over (fig. 38) but also when seeing it from the side (fig. 39), without having to place the piece in a very high or low position.

Figure 37: Solar Wind woven in full length, in white and turqouise.

Figure 38: Details Solar Wind.

Figure 39: Series with Solar Wind in motion. When the textile is turning, the blue shrinking yarn becomes more apparent on the surface.

Stratospheric Cloud

When further developing Stratospheric Cloud, it was decided to make the piece big in scale, to fit more densities to get a slow fading effect until disappearing to the fringes in the bottom. Instead of using every other thread as a float, every third was used instead. They were woven down at half the length as previously, and this made them not bundle up on the surface as they had been in the sample for *the squares*.

From the top to the bottom, in each density, the satin weave slowly transitioned from floating from the front, to the back (fig. 42). When woven, it became clear that the color combination was not fitting with the other pieces, as the color interaction between the pink and lime yellow gave an orange result (fig. 40). When looking at the material closely from the side, the lime yellow became more prominent, but the orange was still very highlighted in the combination (fig. 41).

Figure 40: Stratospheric Cloud with pink and lime green. The color interaction makes an orange effect when seeing it from far.

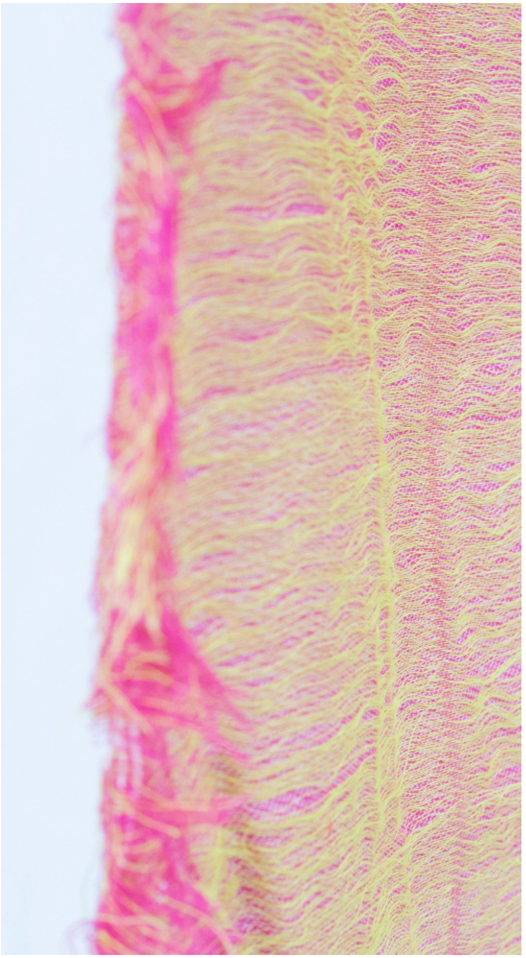

Figure 41: Details. When looking closer from the side, more of the yellow green is shown.

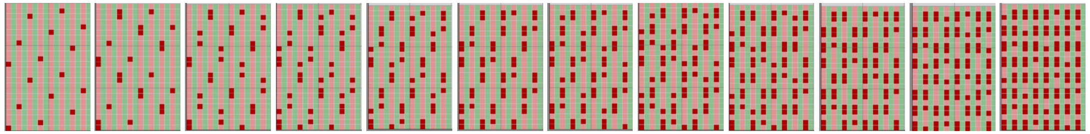

Figure 42: Weave bindings used in piece from top (left) to bottom (right). The red dots show the warp slowly transitioning from the back to the front. The green lines show the black warp woven out on the backside. The gaps on every third weft shows the float.

Another piece was woven, where the lime yellow was changed to the turquoise. This color was a better match, because it did not influence the pink as much. The turquoise was instead articulated when the textile was moving (fig. 45) or when seeing from the side (fig.44), and it gave a very nice effect.

The final piece was woven with 36 densities changing each density with 3 picks created a visible border in the textile. 36 pick /cm was used in the top, and was lowered with one 1 pick / cm every 5 cm, until reaching 1 pick / cm in the bottom. This generated a seamless gradation (fig. 43).

Figure 43: Stratospheric Cloud in pink and turquise. Here, the turquise is not visible from far.

Figure 44: The turquise is instead revealed when seeing it close, from the side.

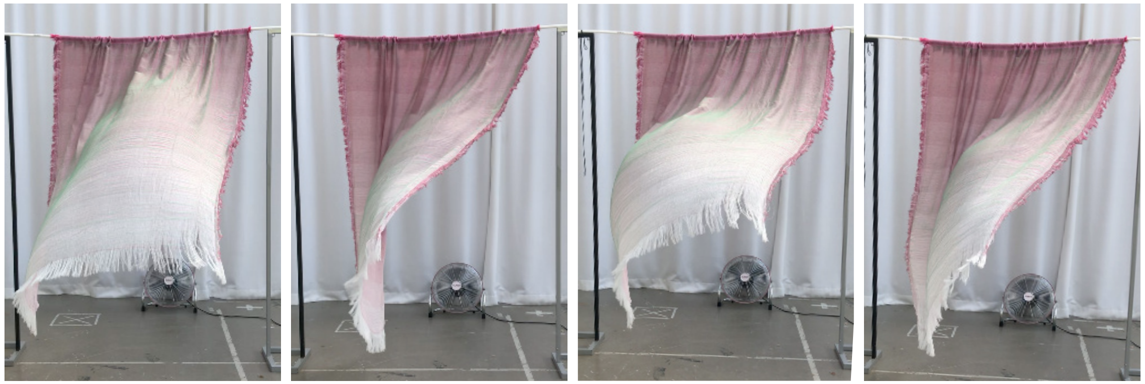

Figure 45: When the textile is in motion, it shifts in color

Northern Lights

When developing Northern Lights, it was concluded that the colors were one of the few things to be changed. In the previous sample, each part was made with 1 yarn floating in rows, 1 lurex floating in the next row and 1 multifilament or other yarn in rep weave. So when changing colors, matching yarns had to be found for all the qualities. A sketch was made in an ARM loom where the different qualities where tried out (fig. 47). At first, the idea was to use all the colors as a gradient, to connect the collection together, but because no matching lurex was found for the lime green, this color was excluded from the scheme.

One sample was woven, with a gradient from blue to turquoise to pink (fig. 46). It was realized that the placement of the color did not work, as the turquise cotton were much lighter than the pink, so the gradient did not make sense. Some digital sketches were made where the pink was used as stripes, between the gradient of the turquoise and blue (fig. 49-50). This was a much more balanced composition - as the warm pink broke off the cold blue and turquoise.

If the material would be woven as a tube and separated, then the two layers would interact with each other when the textile moved in the wind. This was simulated thorugh a sketch (fig. 50). The warm pink contrasts against the colder turquoise and blue, and because of the transparent material, it would shine through the layers. A more subtle gradient was created, to accentuate the pink stripes (fig. 48).

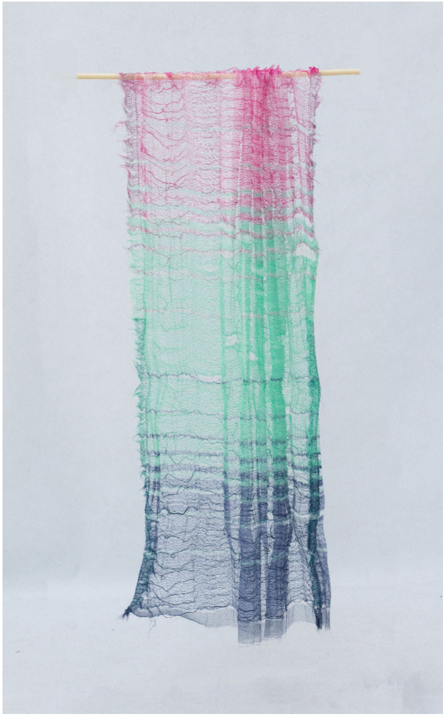

Figure 46: Sample with gradient from pink to turqouise to blue.

Figure 47: Sketch made in ARM-loom.

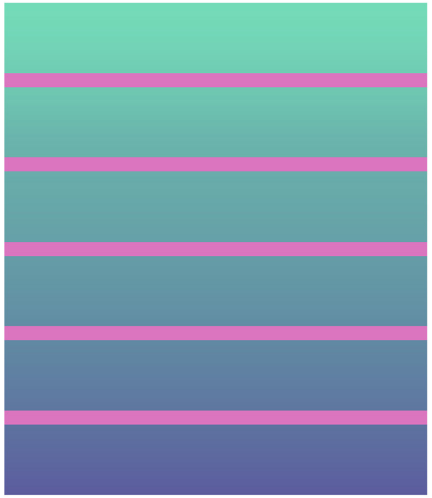

Figure 48: The more subtle gradient

Figure 49: The pink stripes aligned.

Figure 50: The pink stripes in motion.

The final piece was woven with 14 picks / cm (fig. 51). The top layer was woven with lurex and cotton in floats and polyester multifilament in rep weave. Every fourth weft was woven in the back layer in polyester multifilament in rep weave. When in motion, the thin layers of the weave interact with each other, changing the pattern of the textile (fig. 53). Each layer shine through the other layer, and because the layers are woven differently, it enhances the effect of the pattern changing the textile (fig. 52).

Figure 51: Full scale Northern Lights

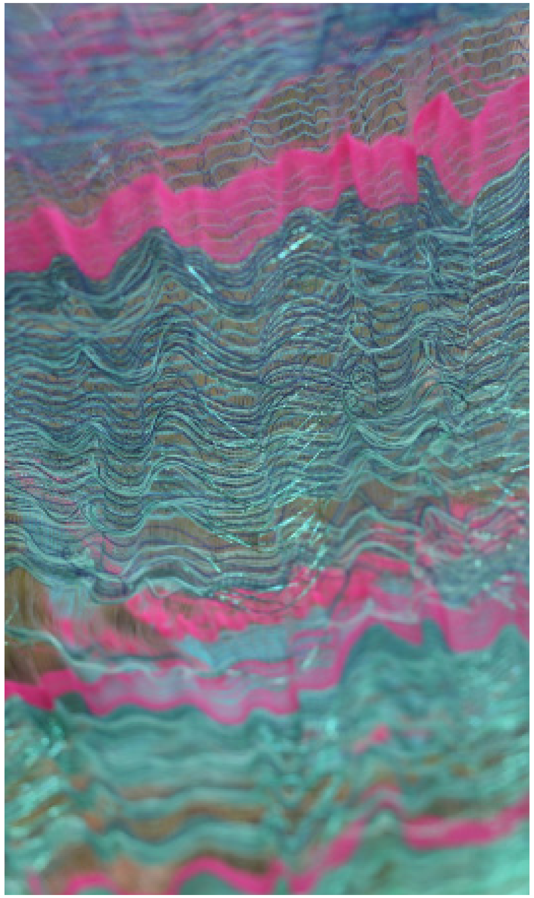

Figure 52: Details Northern Lights. In the top, the back layer is filtered through the front layer.

Figure 53: When the textile is in motion, the pink stripes moves and filter the textures from each side.

3.3.5 COLORS

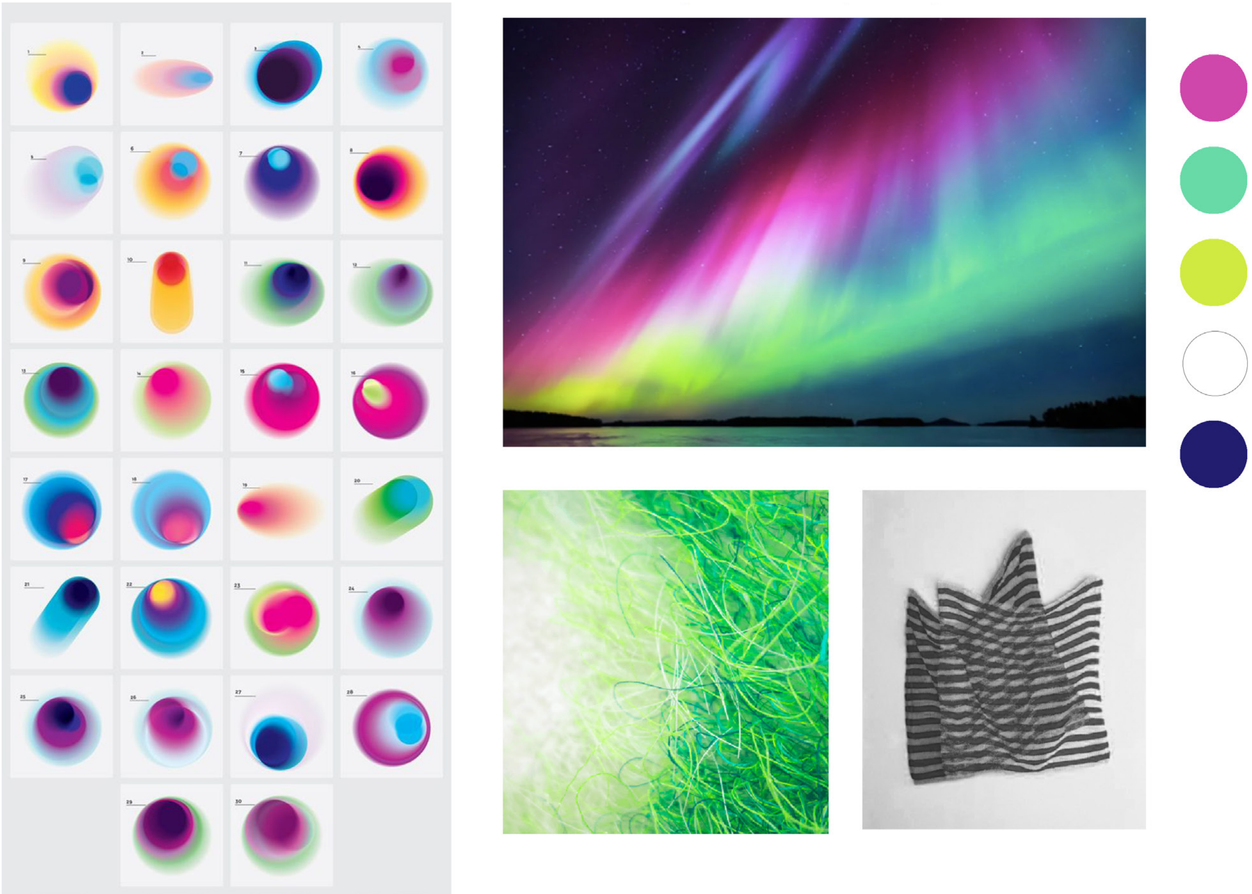

Figure 54: Moodboard for the colors

The colors and visual expression for the collection was in mind during the whole process, although the definitive decisions were taken in the end when the pieces were finalized. The idea for the visual expression was to connect it to nature. Gradations were chosen as a general theme, as it communicates something that changes. An imagery of northern lights communicated both the gradation and the connection to nature, and was chosen to base the color scheme on (fig. 54).

Figure 55: The blue funky form created a contrast against the lighter colors.

Figure 56: The turqouise revealed when seeing it close from the side.

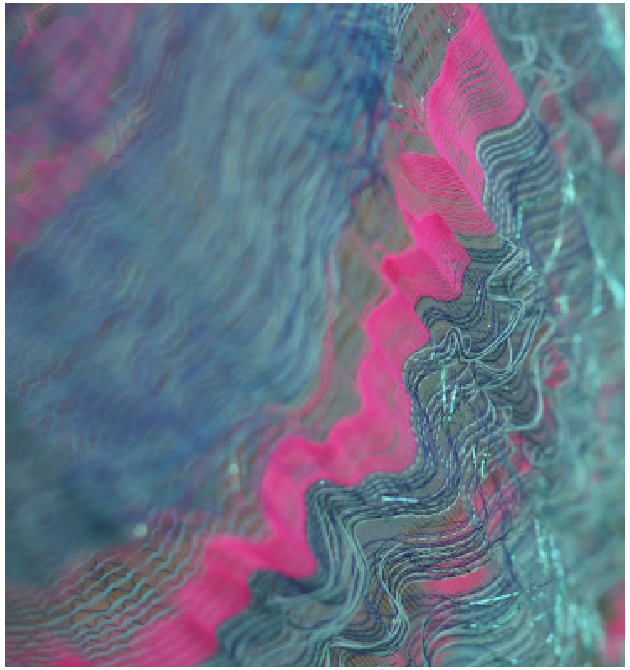

Figure 57: The two layers interacting with each other.

It was important to find the right qualities of yarns in the colors decided, as the quality of yarn affect how the textile behaves. For Solar Wind, it was important to find a shrinking yarn in a color that would contrast against the other colors, because otherwise it would not create the changeable expression when the textile was viewed from different angles (fig. 55). The only available yarn suitable for this was blue funky form, so this color had to be used in Solar Wind. The turquoise and white was used, for the woven parts, as these contrasted to the blue funky form, and made the changeable expression stronger.

Stratospheric Cloud worked well with pink in the woven parts. The yellow color that was first experimented with did not work, as it created an orange effect when mixed with the pink. The turquoise worked well instead, as the pink hid the light turquoise when seeing it from far, and revealed it when the textile was draping in the wind, or seeing it close (fig. 56).

The blue, turquoise and pink were chosen for Northern Lights, as matching colors could be found in multifilament, cotton, and, lurex. The multifilament was important to use in the rep weave, as the yarn is stretchy, and contracted the weft some, which made the floats longer, and therefore they could move more in the wind. Because the backside was woven more loose, it gave space for the blue multifilament to shape in a wave. When seeing the backside though the front, it contributed to the effect of the pattern in the textile changing expression (fig. 57). The cotton and lurex were important to use for the floats, as they were light enough to move with the wind. Lurex yarns were found for all the colors, however the green sparkled more than the blue. The green was therefore chosen to use in the bottom part of the textile where it moved more and contributed to the textile glittring in when in movement.

4.1 RESULT

The result is three woven textiles that are woven on industrial jaquard looms (fig. 58). They explore different changeable expressions when interacting with wind and light. The pieces explore different structures, materials and densities, but they all have vertical rows with weft floats. The structures, materials and densities contribute to the changeable expressions in different ways.

Figure 58: The final pieces.

4.1.1 SOLAR WIND

Solar Wind is woven with vertical rows of floats with shrinking yarn. When turning, different aspects of the surfaces are revealed. In some angles, the piece appear more opaque, and from other it appears more transparent. When seeing the piece from under or over, the shrinking yarn becomes more apparent (fig. 59-60). The weave structures used are panama and floats. The piece is 60 x 200 cm. The warp is monofilament, and the weft is light cotton, viscose and funky form. The piece is woven on a staubli jacquard loom, with 26.4 ends / cm. The weft is 25 picks / cm.

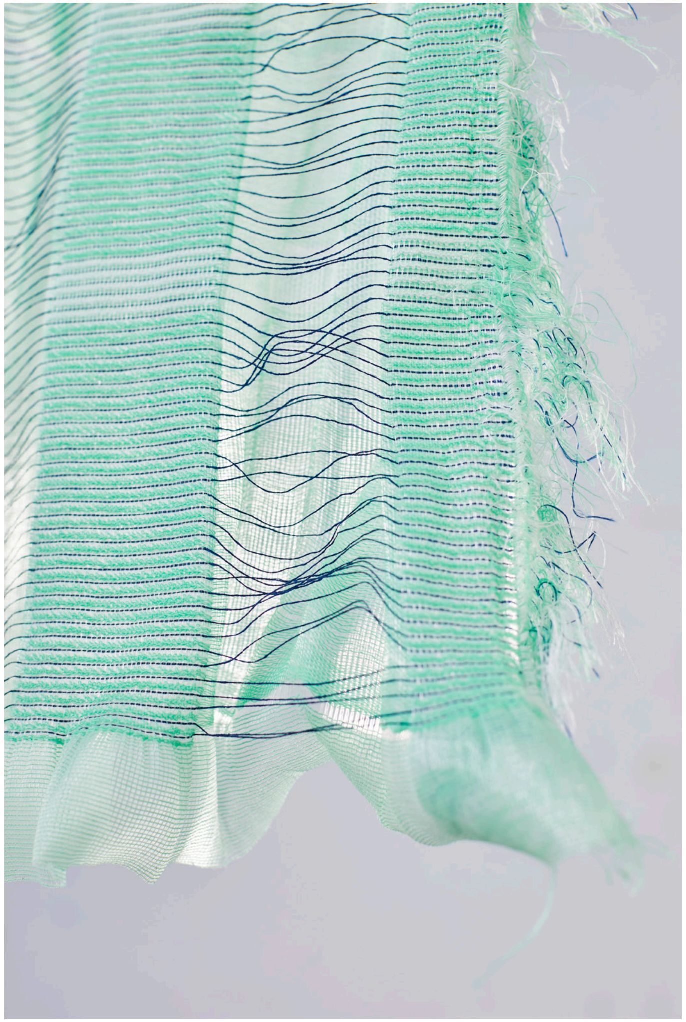

Figure 59: Solar Wind seen from below.

Figure 60: Solar Wind seen from above.

4.1.2 STRATOSPHERIC CLOUD

Stratospheric Cloud is build on a gradation of density, that decreases from 36 to 1 pick / cm with 1 pick each 5 cm. The satin structures help accentuante the gradation, as it makes the surface gradually go from pink weft floats to white warp floats. When in motion or viewed from the side, the surface shifts in turquoise, because of the floats that lay on top of the surface in vertical rows (fig. 61). When still, the surface appears light pink (fig. 60). The piece is 150 x 200 cm. The warp is white polyester, and the weft is light cotton. The piece is woven on a staubli jacquard loom, originally with 26,4 ends / cm, but since the warp was black and white, the black is woven out and cut away, resulting in a warp with 13,2 ends / cm.

Figure 61: The surface appears as pink.

Figure 62: The surface shift in color.

4.1.3 NORTHERN LIGHTS

Northern Lights is a double weave with alternating vertical rows of weft floats on the front, with panama holding the weave together (fig. 62). The two sides are woven separately but woven together in the top edge. When in motion, the pattern of the weave and colors of the two layers interact with each other, changing expression of the pattern (fig. 65). The lurex and floats on the front vibrates in the wind (fig. 63), while the back provides a more smooth surface. The piece is 130 x 150 cm. The warp is monofilament, and the weft is light cotton, polyester multifilament and lurex. The piece is woven on a staubli jacquard loom, with 26.4 ends / cm. The weft is 14 picks / cm.

Figure 63:
Full scale image of Northern Lights.

Figure 64:
The floats vibrates when in motion.

Figure 65:
The backside with the polyester multifilament formed as a wave shape.

Figure 66:
The two layers interacting with each other.

4.2 PRESENTATION

The intended way of experiencing the textiles are outside in nature where they can interact freely with the environment. A possible application area is festivals, where people gather to experience culture, music and art in a more open setting. There, they could displayed as the single pieces, or be multiplied and function as space dividers or as set designs.

The changeable expressions in each of the textiles are visible from certain angles and with different light conditions. The textiles should therefore be exhibited in different environments that enhance these qualities. The different types of environments and the different expressions of the pieces would aswell fit different types of gatherings or events.

Solar Wind is best viewed when it is placed in an open, sunny environment, so that it can freely interact with the wind and light. Preferably it should be hung in a frame or a branch from a tree, quite high, so that it is possible to view it slightly from under. The viewer should be invited to move around it and view it from different angles, both from far and close, as the surface is experienced differently depending on the angle and distance. Since Solar Wind is best experienced in a sunny environment, an event during daytime that would allow participants to view the piece from different distances would be preferably for this piece.

The shift in color that occurs when Stratospheric Cloud is interacting with wind, can be seen both from close and far. When seen from far, the color of the floats blend into the textile, and becomes visible when it is moving and draping in the wind. It should be hung in a frame, or from a line that is suspended high so that the textile can interact freely with the wind. Stratospheric Cloud could fit a large range of events because of its neutral expression. It could aswell be used in multiple and displayed as a curtain wall.

Northern Lights is best viewed in a place with shifting light conditions, as the shadow makes the weave appear more sheer and the light makes the lurex occasionally sparkle. It is best experienced from close, where the wind makes the layers move and interact with each other. The viewer should therefore be invited to move around the piece and view it close, as the small interactions between the different layers is a part of the changeable expression and experience. Because of the light interacive materials in the piece, the lurex and monofilament, and the visual expression of the piece, this piece could also fit evening events, where an artificial light would be recquired.

Figure 67:
Solar Wind placed on a beach.

Figure 68:
Stratospheric Cloud placed in spot with sand dunes.

Figure 69:
Northern Lights placed in forrest

4.3 DISCUSSION

This project aimed to use natural forces, such as wind and light, in the design process and develop the textiles from how they interacted with these parameters. The focus in the beginning was to create different movements in the textiles when interacting with wind. This was experimented by using contrasting materials and weave structures that enhanced these qualities. Later when the textiles where brought outside to different contexts, the focus shifted to creating changeable expressions in the textiles when they interacted with wind and light in different environments. Different structures, materials and densities in the weave were experimented with, and these caused the textiles to achive a shift of color, transparency and pattern.

The focus in the project shifted because of the impact that the surroundings had on the textiles when they were taken outside, and because the experiments with the different material qualities did not achieve any substantially change in how the textile behaved. As opposed to the knitted materials from Hörteborn e. al. (2019) (fig. 4), where the different material properties were affecting the movement in a very clear way through the three dimensional surface. The use of a stiff and drapable materials did not affect the movement as distinctly, and this might depend on that they were only used in the weft. If stiff material was inserted in both warp and weft, it might would affect the movement in a more defined way. It was not possible to change the warp in the jacquard looms, but these machines offered other possibilities, such as to combine different structures, that were interesting to explore in this project though.

The changeable expressions were achieved from the structures, materials and densities in the weave. In Moriyamas (2016) (fig. 5) and Shotz's (2016) (fig. 6) work, the inherent properties in the material and the scale of it created changeable expressions. The reflective properties that were used in Moriyama and Shotz work were applied in both Northern Lights and Solar Wind. Clear monofilament was used in the warp, and made the textiles transparent from some angles, and reflective in others, similar to both Moriyama and Shotz. In Moriyamas and Shotz's work, the scale of the reflective material determined the materials responsiveness to light, whereas in this project, the density of the weave determined how much the material reflected light and created a transparent material.

Lurex was primarily used in the bottom part of Northern Lights, where it had more more possibility to move. It was used as floats that could vibrate and sparkle with the wind and light. This aswell contributed to the changeable expression of the textile. Similarly to the structure of Moriyamas work (fig. 5), where the plastic films were able to move and change direction.

The changeability in Echelmans (fig. 3) work comes from the movement and the hollow structures, where the layers of the textile interact with each other. This can be seen in Northern Lights, where the transparent monofilament allows the layers to interact with each other and change the apparence of the piece.

The changeable expression where one color is more visible from certain angles, reminds of the changeable expression in Moriyamas work (fig. 5). The color of the films change when they change direction, making them more transparent, green, pink or white. Similar to this, the color of the floats in Solar Wind and Stratospheric Cloud becomes more apparent from certain angles, when the textile is moving. In Moriyamas work it is caused by the inherent properties in the material, whereas in Solar Wind and Stratospheric Cloud, it is caused by the weave structures.

The fragility of the pieces suggests a temporary usage of the textiles, as they might break with harsh winds and unforseen interactions. To install the pieces in a permanent setting to explore how a constant infuence by nature would impact the textiles, would be interesting as a development in the project. It would aswell be interesting in regards to the changeable expressions, as the outdoor experiments were performed during one type of season. With the change of season, the conditions of light, rain and wind change, and with this, the experience of the textiles would be differently.

The changeable expressions in the pieces suggests there is great potential with including natural phenomenons in the textile design area, and that there is more to explore. With the textile materials responsiveness to forces, the inclusion of these in the design of textiles could make our spaces more dynamic, in constant change.The project opens up to more possibilities to research changeable expressions specifically in weaving, but also more generally in textile design. Since the textile material is responsive to forces such as light, wind, rain, it could be utilized as a feature in the design, both for indoor and outdoor textiles. Other textile techniques such as print, knit or sewing offer other possibilities that would generate another kind of exploration. The parameters structure, density and material, would still be relevant, but they could also introduce other, such as form.

With the vast options that each of the parameters offer, one project could not cover all these. There are endless of possibilities and combinations, and when you change one of them - the others are affected aswell. The many samples made in this project were necessary to understand how the different aspects of the woven textile affected the interactions of wind and light. These samples are shown in the appendix, and hopefully they could generate ideas and knowledge about behaviour and movement that can be created in a woven textile.

4.4 CONCLUSION

This project has explored the potential of changeable expressions in woven textiles when activated by wind and light. The structure, material and density in the woven textile determines the interaction both of wind and light. These three parameters were appropriate to explore in the jacquard looms, where there are more possibilites to experiment without being as restricted to repeat heights and threadings, as in other types of looms. All the material explorations and the final pieces where woven on jacquard looms, with various warp materials and thread counts.

Floating threads is a structure that offers a lot of potential in creating changeable expressions and was used in all of the pieces. The float can blend in the textile, and become visible in certain angles, that can be seen in both Solar Wind and Stratospheric Cloud. The floats used in Northern Lights offer another kind of changeable expression. When woven with lurex, they create a sparkling effect when the floats move with the wind.

Plain weave and satin structures were used in creating the textiles. Plain weave, specifically panama weave, was used in both the pieces created in the monofilament warp with very different results. When used in Solar Wind, the high density created a stiff and compact material. When used in Northern Lights, with low density, it instead created a very loose material that allowed a lot of movement when interacting with the wind. The conclusion of this is that if the density is low enough, such as in Northern Lights, the weave structure does not affect the behaviour of the textile significally. This conclusion can also be drawn from Stratospheric Cloud, where the whole piece consists of the same satin structure, but the bottom part moves more than the top because of its lower density.

Many different materials were used in the collection. The polyester multifilament that was used in the woven parts in Northern Lights behaved differently depending on if it was combined with other materials and densities. This material had the potential to generate both a stiff and a soft material, depending on what density was used. When used in the monofilament warp with a lower density, one of the polyester multifilament yarns formed a wavy shape when woven with. This created an interesting effect that affected the expression, as the wavy shape was contrasting to the other yarns.

The material, structure and density are all relevant when exploring textile behaviour, movement and changeability in a woven material. Even though density is highlighted as one of the most influential parameters, the others are equally as important. If one is looking for movement in a textile material, which parameter that should be experimented with depends on what kind of textile one is developing. In this project, the focus was on creating experimental textiles for spatial purposes, but if one was developing textiles for body where another kind of usage should be considered, other parameters might be more interesting to research in the design development. There are aswell other textile techniques, for example laser cutting and sewing, that could provide other aspects that could be interesting in the research for changeable expressions in textiles.

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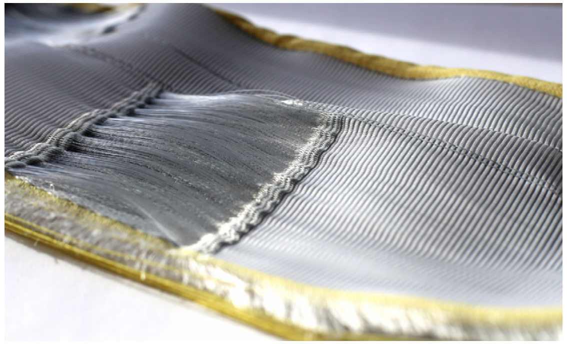
5.2 TABLE OF FIGURES

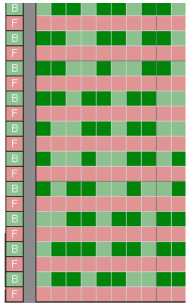
6. APPENDIX

This appendix consists of materials made in three looms in the weaving lab in The Swedish School of Textiles. This appendix does not cover all the samples that were made in this project, but a few selected that were thought to be interesting and relevant relating to changeable expressions in textile materials as well as for the one who is interested in weaving.

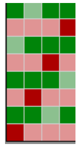
First, samples made in Bonas is presented. The warp in this loom was white polyester with 91 ends / cm. Next, comes two Staubli, both with 26.4 ends / cm. First, samples made in the black and white polyester is presented, and last, the samples made in the monofilament is presented.

6.1 WHITE POLYESTER

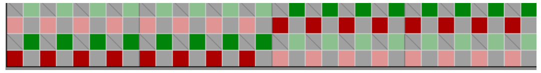




10 shaft satin is woven under the monofilament floats

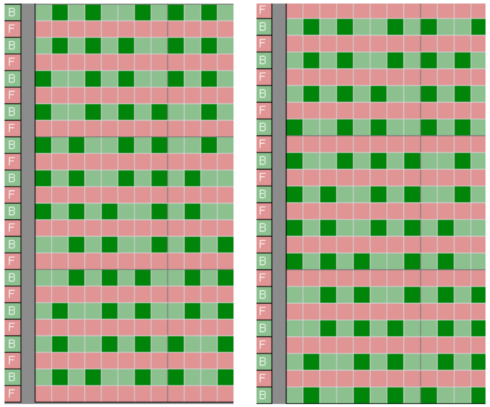


A tigther twill is used in the border between the floats and the plain weave, to make sure they do move too much



16/2 plain weave is used to weave the monofilament with a high density to get it really stiff.

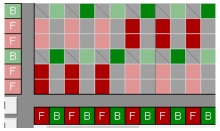
Polyester multifilament and monofilament in the weft. The density is 40 p / cm. Unfortunately was this structure very complicated for the machine to weave, and it only managed to weave 15 cm during several hours, due to its sensitivity to the tension of the weft threads. Since the bottom layer was very thin, and only attached in some points, it would be interesting to try out how it would respond to airflow if it was possible to get a larger piece.



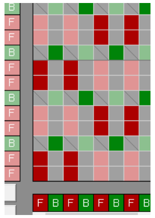
The weave structure interlaces the same amout of threads in both structures. The weft shifts, so that in left, the first weft is floating on top, and in right, the same thread is weaving under it.

Polyester multifilament in weave and floats. The density is 30 p / cm. The polyester multifilament has an interesting porous texture, and because it is syntetic, it is static and draws towards the weave. Perhaps it would be less static if it were used combined with only natural materials.

6.2 BLACK & WHITE POLYESTER

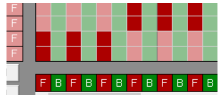


3 / 1 plain weave

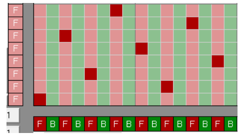


2 / 1 plain weave

Monofilament in weft. 45 p / cm. A third of the wefts (green) are woven on the back layer, which makes the actual density 30 p / cm. 3 / 1 plain weave generates a tighter material.

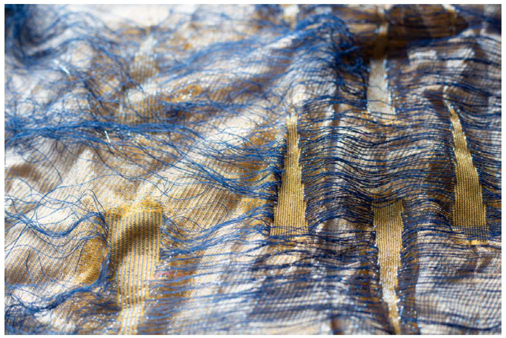


3 / 1 plain weave

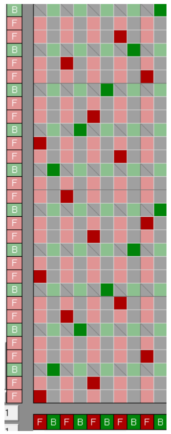


8 shaft satin

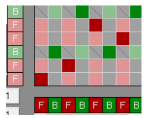
3 / 1 plain weave with monofilament in 30 p / cm. 8 shaft satin with light cotton, 20 p / cm. The mix of the tighter plain weave structure and the looser 8 shaft satin structure causes a wavy shape in the fabric.



Polyester multifilament and lurex in weave, funky form as float. Density 40 p / cm. The funky form shrinks, and becomes darker in color. The blue funky form creates a morie effect with the blue lurex in the weave.

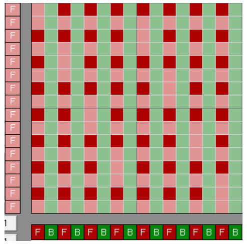


5 shaft satin with every fourth as floats

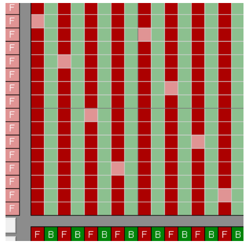


broken twill where the float is woven

6.2 BLACK & WHITE POLYESTER



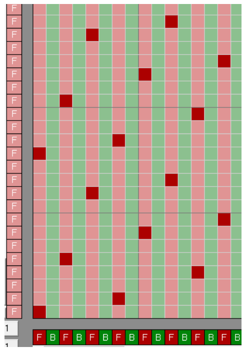
8 shaft satin with every other as floating



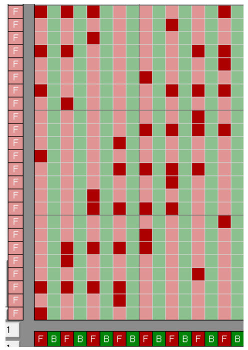
8 shaft satin with every other as float woven down

Cotton as floats, polyester multifilament in weave. Density ranging from 35, 30, 25 to 20 p / cm in bottom. The larger gap between the change of density is not as visible as in next sample. Longer floats make them bundle on the surface.

Cotton in weft. Density ranging from 36 p / cm in top, to 1 p / cm in bottom. The density changes each 15 cm with 3 p in each part.

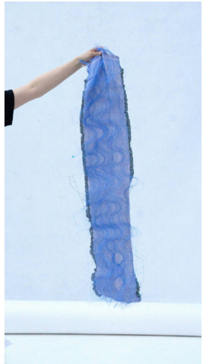


8 shaft satin with every third weft as float

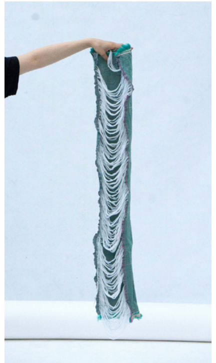


8 shaft satin with every third weft as float, here woven down

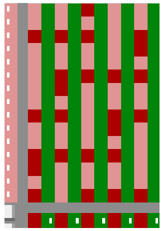
6.2 BLACK & WHITE POLYESTER



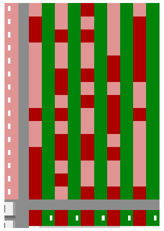
Polyester multifilament in weave and monofilament in floats. The density is 60 p / cm. The intention of the floats over the weave was to create a moiré effect when the wind moves the monofilament floats. The moiré effect occured when turning the piece, but the monofilament moved too little with the wind.



Polyester multifilament in weave and the white part of the warp is used as floats on top. The density is 60 p / cm. The intention was the same here, as the monofilament is a stiffer material, the warp floats was thought to be more inclined to move. The moiré effect did occur, but where as apparent and therefore this idea was scrapped in favor for other.



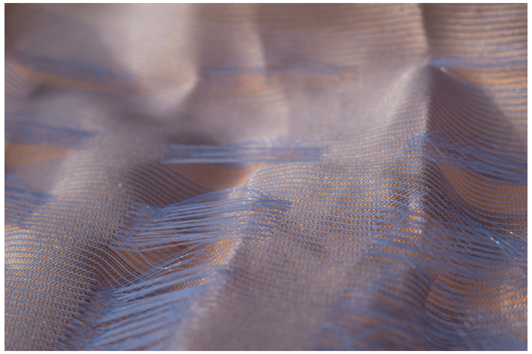
Satin weave with every third as weft floats.

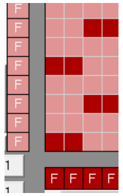


Satin weave with the weft floats woven.

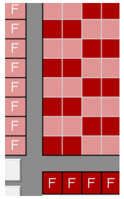
The same type of weave structures where used in both samples, just that the weft floats that were used in the blue, where not used in the green.

6.3 MONOFILAMENT



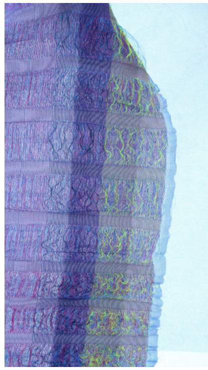


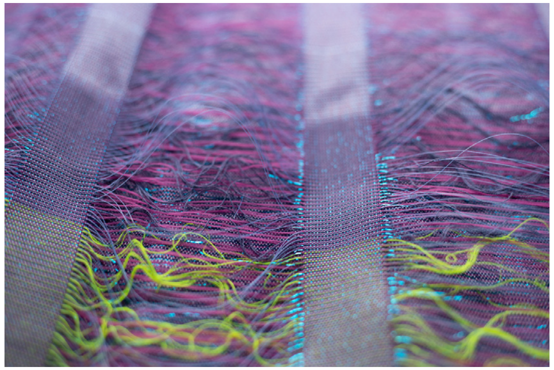
Every other weft is used as weft floats in a pattern

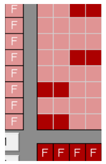


The main part of the textile is woven in a panama

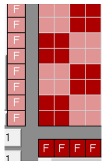
Pemotex (shrinking yarn), polyester multifilament and monofilament in weft. The density is 10 p / cm. The intention with this sample was that the shrinking yarn would shrink the fabric, and the blue polyester mutlifilament would pop out of the surface. Because of the too high density, the fabric did not shrink, and the opposite happened; the multifilament which is a stretchy yarn, usually used for knit shrunk instead.







Every other weft is floating in rows



The wefts are woven in hopsack between the rows. This was thought to allow them to shrink but it was too tight.

Form funky, polyester multifilament, neon synthetic yarn, blue monofilament, lurex in weft. Various densities in weft, that is making the shades in the textile (left image).