Textile Farming: Living Indoors

Horticultural practices are increasingly entering the private realm due to the popularity of urban gardening, indoor gardening systems, and architectural propositions to join living spaces for people and vegetable cultivation in order to promote more resilient and sustainable ways of living. While new research into symbiotic processes between living organisms and their ability to sense and reason triggers new growth in art, culture, design, and architecture, the organisation of indoor plants remains mainly unaffected. This is due to the fact that many of the examples that aim to bring together people and plants in an architectural context are characterised by rigid materials and the belief in systems that separate people and plants from each other and thus make relatively unnatural environments, compositions, and expressions. By proposing an alternative perspective on this, On Textile Farming explores textile as flexible systems for integrating plant growth into textiles. The collaboration with AB Ludvig Svensson, a developer and producer of textiles for interiors and greenhouses, involved a joint approach as the two distinct areas of climate screens and interior textiles. Through experimental methods, interactions between plants and textiles were explored using double-weave structures to integrate seedlings and substrates. A methodological framework is proposed wherein the processes and materials of textile and spatial design are seen as environmental parameters, e.g., temperature, climate, and material behaviour. The design concepts ‘textile permeability’, ‘seasonal textiles’, and ‘textile climate’ describe the interactions between plants, textiles, and space, and can be seen as first steps towards an interior textile ecosystem in which spaces are composed of relationships between biotic and abiotic components, causing the natural and the artificial to intersect. Spatial permeability, ‘seasonal interiors’ and ‘spatial climates’ expand the three textile concepts towards space and describe interactions between different spatial qualities that were explored through environmental design. This, an experimental house was built in a rural region of Sweden and lived in. In this context, textiles become flexible interfaces between the inside and the outside, guiding growth and melting into seasonal expressions that blur the lines between nature and architecture.
ON TEXTILE FARMING:

LIVING INDOORS

SVENJA KEUNE
Horticultural practices are increasingly entering the private realm due to the popularity of urban gardening, indoor gardening systems, and architectural propositions to join living spaces for people and vegetable cultivation in order to promote more resilient and sustainable ways of living. While new research into symbiotic processes between living organisms and their ability to sense and reason triggers new works of art, culture, design, and architecture, the organisation of indoor plants remains mainly unaffected. This is due to the fact that many of the examples that aim to bring together people and plants in an architectural context are characterised by rigid materials and technical systems that separate people and plants from each other and feature relatively unnatural environments, compositions, and expressions. In proposing an alternative perspective on this, On Textile Farming explores textiles as flexible systems for integrating plant growth in textile materials. The collaboration with AB Ludvig Svensson, a developer and producer of textiles for interiors and greenhouses, involved a joint approach to the two distinct areas of climate screens and interior textiles. Through experimental methods, interactions between plants and textiles were explored using double-weave structures to integrate seeds and substrate. A methodological framework is proposed wherein the processes and materials of textile and spatial design open up for environmental parameters, e.g. changes in time, climate, and material behaviour. The design concepts ‘textile permeability’, ‘seasonal textiles’, and ‘textile climate’ describe the interactions between plants, textiles, and space, and can be seen as first steps towards an interior textile ecosystem in which spaces are composed of relationships between biotic and abiotic components, causing the natural and the artificial to intersect. ‘Spatial permeability’, ‘seasonal interiors’ and ‘spatial climates’ expand the three textile concepts towards space and describe interactions between different spatial qualities that were explored through autobiographical research; for this, an experimental house was built in a rural region of Sweden and lived in. In this context, textiles became flexible interfaces between the inside and the outside, guiding growth and melting into seasonal expressions that blurred nature and artifice.
I wish to deeply thank my network of family, friends, colleagues, supervisors, mentors, and other contacts who inspired me during this journey. In particular, the ArcInTex ETN has grown into a special kind of research family, and I feel honoured to have had the opportunity to be a part of this unique European Training Network, in which personal and professional exchange were equally important. I want to thank all of the ArcInTex ETN supervisors: Lars Hallnäs, Delia Dumitrescu, Clemens Thornquist, Linda Worbin, Clare Johnston, Ian Higgins, Jo-Anne Bichard, Norbert Palz, Gesche Joost, Katharina Bredies, Oscar Tomico Plasencia, Egle Ganda Bogdaniene, Jolanta Vazalinskiene, George Stylios, Dorte Bo Bojesen, Koen van Os, and the network manager Agneta Nordlund Andersson for their tireless work in bringing this special programme to life and introducing me to my fellow PhD students and friends. These are Daniel Suarez, Iva Resetar, Marina Castan Cabrero, Jyoti Kapur, Bastian Beyer, Ana Piñeyro, Sara Lundberg, Juste Peciulyte, Ramyah Gowrishankar, Vidmina Stasiulyte, Troy Nachtigall, Angella Mackey, Ana Ines Rodrigues, and Maike Schultz.

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INTRODUCTION

The context of this work relates first and foremost to the conditions of the ArcInTex European Training Network, the research network that facilitated this research; Svensson AB, the company where this research took place; and the Swedish School of Textiles at the University of Borås, which provided the academic research environment for this research.

ArcInTex is an international research-through-design network; its members come from both academia and industry, and have united in order to develop ideas, techniques, methods, and programmes for new perspectives on design in relation to building and dwelling. As part of a collaborative effort, new expressions, interactions, and forms of spatial design are created by exploring the synergies between architecture, interaction design, and textiles. Here, textile thinking is a fundamental part of the research program. The network’s activities include joint research projects such as the European Training Network, which is supported by the European Union’s Horizon 2020 research and innovation programme under a Marie Skłodowska-Curie grant agreement. The consortium consists of the Royal College of Art (UK), Heriot-Watt University (UK), Eindhoven University of Technology (NL), Vilnius Academy of Arts (LT), Berlin University of the Arts (DE), University of Borås (SE), and the companies Philips (NL) and AB Ludvig Svensson (SE). 15 PhD students have been employed to formulate and present design programmes in order to introduce new techniques, methods, and perspectives relating to design aesthetics (ArcInTex ETN).

This research is the result of the brief/task given to the author (designated Early Stage Researcher 7) to develop 'Textile structures for adaptive and responsive interiors (textile design)'. The position is placed in Work Package 3, which focuses on ‘Textile thinking for adaptive and responsive interior design – the scale of the interior’. As one of two industrial positions, the project is carried out with Svensson AB in Rinna and supervised by the Swedish School of Textiles in Borås, and so is involved in both the industry and academia.

At the Swedish School of Textiles, this research took place within the Smart Textiles research group and Smart Textiles Design Lab, which research how new technologies challenge and affect the textile design field, textile materials, methods of design and manufacturing, and their applications. Furthermore, how these relate to other disciplines, such as interaction design and computational technology (Hallnäs &
INTRODUCTION

Redström, 2006; 2008; Landin, 2009; Persson, 2013) and architecture (Dumitrescu, 2013) is explored. Developments in the field of smart textiles have shifted both the functionality and expressions of textiles, from static and passive to dynamic and active (Worbin, 2010; Dumitrescu et al., 2014). The temporal and dynamic aspects of smart textiles and smart materials are therefore a common research interest within the group as well as international, where recent research contributions have challenged commonplace views on materiality and opened the door to programmable, responsive and living materials, connecting to the comparatively new research field of active matter and biodesign. Here, inputs from information technology and computation, biotechnology and biology, and contemporary materialist philosophies lead to interdisciplinary approaches and emerging materials (Tibbits, 2017; Kretzer, 2017; Bogiatzakē, 2018).

AB Ludvig Svensson, a Swedish company that is currently being run by the fourth generation of the Svensson family, started production in 1887, at the time of industrialisation and steam-powered machines. The founder, Ludvig Svensson, devoted himself to a world of woven textiles, established Sweden’s first curtain factory during the first industrial revolution, and made an entire region famous for its textile production. Today, the company’s production primarily takes place in Kinna, Sweden, and at a smaller production plant in Qingpu, Shanghai, China (AB Ludvig Svensson, n.d.). Man-made fibres, such as acrylic and polyester, and the first warp-knit machines were introduced during the 1950s and 1960s, creating a new business area that involved the use of warp-knitting and man-made materials on a large scale. In developing textile-based solutions for climate control and energy efficiency in the 1970s, AB Ludvig Svensson began its journey towards becoming a pioneer and world leader in functional climate screens for greenhouses, supporting the global trend of developing textile-based solutions for climate control and energy efficiency in the 1970s.

The Climate Screen (CS) department provides functional solutions and works in close collaboration with growers from all over the world to develop products that satisfy their needs with regard to mitigating the effects of climate conditions so as to ensure optimal conditions for crop production in greenhouse environments. With the intention of creating better climates for plants and businesses, the range of products includes screens for e.g. climate control, weed control, and insect control. The products developed by the CS department are based on polyolefin, polyester, aluminium, and modacrylic.

Although the horticultural sector, ever-adapting to the needs of a growing world population, is constantly expanding into new environments, e.g. indoors (Despomier, 2011; 2012; 2013; Cadenbach, 2014) and outdoors (Pons et al., 2015; Gotham Greens, 2017), a growing interest in sustainable and adaptable forms of living has led to increases in the number of eco-villages, nature houses, and urban and indoor gardens. Consequently the spaces in which people live and crops grow are increasingly intersecting – opening up for developments that bridge both areas, wherein aesthetic perspectives are as important as functional ones. Hybrid homes (Greenhouseliving, 2015; Fearson, 2016; Grüntuch-Ernst, 2018) and systems designed for hydroponic plant breeding in domestic interiors (Aouf, 2016) are examples of the merging of spaces for living with spaces for plant cultivation, which opens up for innovative solutions that suit both people and plants. However, many architectural propositions are currently shaped by commercial horticultural practices, which are often based on rigid materials and shelving systems, and exclude the natural biotic environment in which plants generally thrive in nature. At a time when large-scale damage to natural processes is being caused by the artificial control of growth processes, e.g. by industrialized agriculture, the ways in which we handle plants (and of course all other living beings) and live with them should be reconsidered. This is the case not only outdoors but indoors, in the spaces in which we live and interact with plants on a daily basis, and which are thus the perfect places for reconsideration to begin. Therefore, complementary aesthetic perspectives are needed in order to illustrate, promote, and shape the environments in which living and growing intersect, and to represent and enhance their hybrid natures. This intersection of perspectives inspired me to undertake research that speculatively connects Svensson’s two distinct areas of interior textiles and climate screens. Today, the merging of the departments is reflected in the corporate strategy of the company.
INTRODUCTION

This thesis rests on the Licentiate Thesis (On Textile Farming: Seeds as a Material for Textile Design, 2018), in which seeds are explored as dynamic materials for textile design through their integration in textile constructions such as knitted tubes, spun fibres, and woven pockets. Methods of insertion and activation are described, expressions of transformations through biological growth are explored, life spans are documented, and scenarios that speculate regarding living and actively interacting with textiles in which plants are integrated are presented. This PhD thesis is based on the earlier research, and presents new iterations of double-weave experiments in which plants are integrated and concepts such as ‘textile climate’, ‘textile permeability’, and ‘seasonal textiles’ – along with their spatial equivalents of ‘spatial climate’, ‘spatial permeability’, and ‘seasonal interiors’ – are explored.


List of appended publications:


The appended papers are listed in chronological order, as they show how the research work of On Textile Farming was developed, and are presented in brief below.

Publication 1 presents reflections from a two-day workshop on textile interactions; the participants and paper’s authors focused on edible materials, e.g. popcorn and coffee beans, which were inserted into tubular knits and used as materials for hand-weaving. The experiments were based on the methods of insertion and activation of the On Textile Farming research project, and were used to investigate and reflect on edible textiles as a new hybrid form of media by relating them to examples in contemporary art and design practices. The publication thus relates On Textile Farming to another context than that of the interior and architecture – edible textiles and fashion, fibres from food waste, and fashion made using mycelium – and so presented a perspective on the design methods of contemporary fashion. This publication links to the chapters ‘Research Process and Methods’ and ‘Context’.

Publication 2 focused on early design examples in which the potential of transformation through growth was added to textile structures through the inclusion of seeds, which thus constituted an alternative to other active materials. The methods and processes by which seeds were integrated into textile materials are described, as are their further processing into textile structures through the use of different textile techniques, e.g. knitting, crocheting, and hand-weaving. These early experiments laid the foundation for the examples presented in this thesis. This publication links to the chapters ‘Research Process and Methods’ and ‘Exploring Textiles as Plant Mediators’.
Publication 3 describes an early experiment in which a textile seed material was crocheted into a shape that had been filled with soil. The structure was documented in various stages of its life cycle, in which it served as a textile envelope. The seeds functioned as a dynamic material, and so a focus was the added stages of transformation and the aesthetic potential of degradation in relation to textile expressions and interiors. This publication developed an early form of the concepts of temporality and seasonality in textile expressions, and laid the foundation for how the examples presented in this thesis were documented and analyzed. It also proposed an alternative lifecycle model for interior textiles presented in the Licentiate Thesis, and developed the methodological framework.

This publication was the foundation for the chapter ‘Exploring Textiles as Plant Mediators’.

Publication 4 describes a joint teaching encounter in which first-year textile design and first-year architecture students from Chalmers University of Technology participated in a workshop on building indoor gardening structures with textiles, substrate, and seeds. The methods of inserting soil and substrate into textile structures developed during the On Textile Farming research project were shared with the students, and presentations and discussions relating to indoor gardening, sustainability, and creating installations to combine textile and spatial perspectives were held in the students’ atelier. This publication thus relates the methods and context of On Textile Farming to cross-disciplinary teaching in design, and focused on the pedagogical challenges that arose as a result of the different traditions and disciplines of two fields and institutions, particularly during the early stages of the students’ studies. Differences in research and undergraduate teaching are discussed, particularly in relation to fully exploring the level of complexity of a design task given to students. This publication links to the chapters ‘Research Process and Methods’ and ‘Exploring Ways of Living Between the Inside and the Outside’.

Publication 5 presents the first iteration of Jacquard textiles woven at AB Ludvig Svensson, which were exhibited in the form of an installation at the Textile Museum of Sweden in Borås and combined plants and the interior. The textile design and production, along with the methods of inserting seeds and substrate into the textile envelopes, are presented. Living and interacting with interior textiles in which plants are integrated was discussed, as was how they can mediate between the inside and the outside. The resulting scenarios were described in the Licentiate Thesis, and served as a foundation for the explorations of ways of living and the notion of textiles as mediators.

This publication was the foundation for the chapters ‘Research Process and Methods’ and ‘Textiles as Plant Mediators’.

Publication 6 presents one part of the second iteration of Jacquard textiles woven at AB Ludvig Svensson, with a focus on circular envelopes to incorporate plants. The publication therefore supports the examples with circular envelopes in the ‘Textiles as Plant Mediators’ chapter. The experiments resulted in two concepts – ‘textile permeability’ and ‘textile climate’ – which are described and reflected on with regard to designing and understanding interiors as ecosystems. This publication thus strengthens the design concepts and methodological framework of the On Textile Farming research project.

This publication links to the chapters ‘Textiles as Plant Mediators’ and ‘A Methodological Framework’.

Publication 7 presents the autobiographical journey of the On Textile Farming research project in the form of a diary in order to document and reflect on the experiences of everyday living. As a result, relatively personal layers of the artistic research project are described, including subtle experiences and observations that were difficult to describe in a factual way. Three short stories are presented, and are framed by factual accounts relating to the biological perspective on the experiences and discussions relating to what they add to or open up for with regard to textile design and the design of indoor spaces.

This publication links to the chapters ‘Research Process and Methods’ and ‘Ways of Living’.
The contextual framework comprises approaches to designing environments in which people live and plants grow separately. This is to highlight the differences and similarities between both worlds which *On Textile Farming* aims to merge. The 'Designing Habitats for People' chapter examines approaches to sustainable living research and the actual environments in which the developments take place and their implications are explored and examined, namely design research labs, living labs and peoples homes. The 'Designing Habitats for Plants' chapter provides an overview on horticultural practices, parameters important for plant growth, and information on the biology of plants using a textile design perspective.
RESEARCHING SUSTAINABLE LIVING

Sustainability plays a major role in this research, not only because it is ingrained in the ArChIn Tex ETN, the Swedish School of Textiles, and AB Ludvig Svensson, but because of a personal and moral issue: How does one live in a time in which we are dealing with an environmental crisis and experiencing its consequences first-hand? Extreme climate events are aggravating existing risks to livelihoods, biodiversity, human and ecosystem health, infrastructure, and food systems (IPCC; 2019).

Even if there is a simple-sounding definition of the term, ‘sustainability’ is one of the most complex issues of our time: the principle is, of course, clear, but its implementation is not. Keyson et al. share their opinion about what sustainable life means: Fundamental changes in our everyday lives, towards lifestyles that use as few resources and cause as little environmental damage as possible. Most everyday activities, e.g. cooking, washing, and eating, and our use of electronic devices, are affected by this, and so need to be rethought (Keyson et al., 2017). Reitan states that human societies must become as attuned and supportive to their local and regional ecosystems, and what they can sustain, as possible (2005). There are many different opinions with regard to the changes we might make and how their implementation could be achieved, but with such a complex topic there are no simple solutions – and, above all, there is not just one. As Manzini and Jégou state:

*Design activity that leads to sustainability is not a one-sided, unitary project based on a single way of seeing things. Instead, it is a complex social learning process, a vast intertwining of initiatives in which we proceed through partial successes, errors and unforeseen effects, learning by experience.* (2014: 14).

They are of the opinion that “we are all designers of our own lives – and so of our own future”, and therefore call for more “possible scenarios for living strategies” (Ibid.) that promote positive choices rather than disastrous events.
Designing Habitats for People

Research and design labs such as the SPACE10 Future Living Lab and Design Research Lab at Berlin University of the Arts are infrastructures in which design research projects are carried out in close collaboration with academia, the industry, and society in order to bridge the gap between each group and between innovations and the communities in which they should be adopted. These labs are characterised by their diversity, large networks, specialists from various fields, complex facilities, and holding of events, exhibitions, and workshops. As such, they are catalysts for innovation, and curate how they are presented to and discussed within society. The links between academia, companies, and society are very significant for all concerned; as SPACE10, which is supported by IKEA, states on their website: “We inspire and challenge [IKEA] to find new ways of living up to their original promise of creating a better everyday life for the many people.” (SPACE10, 2019). It is possible to argue that IKEA supports the laboratory in order to perform market research and develop future visions and concepts that are not influenced by economic pressures and existing strategies from a 3-5 year perspective on the future and with a focus on product development, and the freedom to speculate and think critically. Therefore, SPACE10 is able to inspire and challenge IKEA to relate their products to social needs.

The home is an important factor in relation to sustainability, and Kuijer and De Jong argue that it is closely related to production and consumption (2011). In industrialised nations, the largest share of products and services consumed by private households are related to food, mobility, and housing, and this demand far exceeds sustainable levels (EEA, 2013; Lettenmeier et al., 2014). It has been shown, however, that sustainable patterns cannot be achieved solely through technological innovations, and that user influence and behaviour determines whether a system is sustainable or not. This is a significant development since e.g. comfort temperatures are highly subjective, and are modified by climate and social custom (Nicol & Pagliano, 2007). Ignorance of the desires of users relating to e.g. compatibility with lifestyles, aesthetics, and comfort can lead to solutions not being adopted or outright rejected, or even to changes in behaviour that create unforeseen negative effects (Scott et al., 2009; Liedtke et al., 2012a; Sorrell, 2007; Druckman et al., 2011).

In comparison to design labs, living labs go one step further by developing concepts and products in real spaces and alongside users. Development is primarily undertaken through aligning the common grounds of industrial, academic, and public institutions who see a need for a unique environment and infrastructure for developing and testing products, services, legislation, and combinations of these directly with users (Keyson et al., 2017). Living labs provide a methodology and environment that is particularly well suited to investigating user participation in innovative processes, involve users as co-creators, and allow experimentation in real-world settings (Almirall & Wareham, 2008). As a result, it is the perfect environment for studying the relationships between developments that are intended to improve sustainability in households and how users deal with these developments. The term ‘living lab’ generally denotes a type of laboratory in which the level of influence of the end users of products is greater than normal. In some, users are observed rather than involved in shaping scenarios; in others, innovative ideas, scenarios, concepts, and related technological artefacts are developed, researched, experimented with, and evaluated alongside users, who are thus empowered to participate on a greater scale than other user-centred research methods allow (Pallot & Pawar, 2012; Eriksson et al., 2005; Niitamo et al., 2006; Schuurman et al., 2012; Krogsie, 2012). In the move away from techno-centricity and towards user-centricity, the question becomes how people, with the assistance of technology, can develop sustainable practices (Kuijer & De Jong, 2011; Scott et al., 2009; Liedtke et al., 2012a; Krogsie et al., 2013; Schwartz et al., 2014). The insights of users are of key importance to sustainable development during product development and testing in order to understand the impact of the developed system or product. Living Labs make it possible to maximise these benefits and predict the adoption and usage of new or hypothetical products, services, and environments. A living lab is therefore an experiential environment in which practice-oriented design experiments can be carried out and user habits observed and analysed in order to improve knowledge and support sustainable innovation and transition, reducing the time needed between design and evaluation (Femenías & Hagbert 2013). Through these co-design and user-centred processes, users immerse themselves in a creative social space in order to shape and experience their own possible future (Keyson et al., 2017).

Designing and exploring living practices in an autobiographical manner is often undertaken by architects and artists who build and live in their own structures in order to explore their implications and provide working examples that illustrate particular techniques, technologies, or philosophies.

Price, a graphic artist lives underground, and has explored the building of different kinds of homes for almost all his life. In a video interview and guided tour around his property he shares his experiences with Dirksen (2015), a journalist who makes videos about simple living and philosophies of life. Price explains that he has been living
DESIGNING HABITATS FOR PEOPLE

Andrea Zittel moved from New York to the desert near Joshua Tree to undertake her “life practice”, which includes more than 60 acres with permanent sculpture installations, informal classrooms, shipping container workspaces, dorm-like guest quarters, and a giant studio with rooms for weaving textiles and crafting rustic clay bowls. She states that “[t]here’s this privileged position of being an artist where you can do things on a more experimental nature simply to see what happens.” Zittel argues that “[d]esign should talk about life and living” (Art21, 2015), and explores which structures best facilitate creativity, serenity, and unity. Through her practice, Zittel investigates what it means to live and how much space, shelter, community, clothing, and tools one needs to survive and thrive. She invites others to join in her experiment and spend some time in the “Experimental Living Cabins”, which are somewhere between a retreat, a residency, and a campsite. Bolick, a journalist, wrote about the experience of living there, describing the positive effects that resulted from Zittel’s work: feeling calm, soothed, stimulated, and never bored, restless, or lonely. She felt that the restriction to a few impressions and utensils had a positive effect on her overall wellbeing, and sharpened her observations such that she had a greater focus on details (Bolick, 2017).

The examples of both Price and Zittel suggest that a lack of comfort does not have to be perceived as limiting, and can have a positive effect on wellbeing, creativity, and focus. Decisions that could initially be perceived to be restrictive, e.g. the absence of a fridge, can be made into a positive choice and experience by e.g. changing one’s lifestyle such that the fridge becomes obsolete, or using local resources to invent a substitute. This type of experience, and the increased level of self-determination regarding one’s way of living by deciding for oneself which materials, premises, and equipment one is surrounded by in order to experience one’s own impact on the environment – while at the same time adjusting the comfort level so as to ensure a sense of empowerment with regard to the experience – connects largely to the second part of this research.

At the Department of Architecture at the Rotterdam University of Applied Sciences, sustainability projects are developed, built, and researched in the ateliers of SUS. The Concept House Instituut van Bouwen Bedrijfskunde (CHIBB), which began in 2015, was a three-year pilot project in which a family lived in a greenhouse home that was planned, designed, developed, and built by students under the supervision of Arjan Karsenberg, Associate Professor in Sustainable Architecture and Urban Design, and in collaboration with teachers, companies, and experts (SUS ateliers). The students gained practical and theoretical experience as a result of the project, and thus

in homes he built himself for the past 25 years and that he dreams of being 12 years old again – when the world was still a magical place and the days were for playing, dreaming, and wonderment. The land he rents contains a meadow and a small forest, and part of it is bordered by a stream. Price has explored different living conditions and types of building, such as tents, huts, cabins, and holes, in different parts of the area. Over time he has learned how the seasons work in the piece of nature he calls his home – from which direction the wind blows, where the sun shines and shadows fall at certain times of day. He was able to experience the changes enacted by nature, and adjusted his living space over and over again.

Today, he lives underground in two holes – one that was developed for living, and one for working. All of the buildings that remain blend into the topology and vegetation of the area. Price says that he wants to be like a squirrel, and that this informs how he builds and adapts his buildings. The deer do not fear him – their trails lead over the roof of his house, and they continue to eat undisturbed when their paths cross. Even though his life is very simple he has everything he needs, including a sauna and an outhouse that also serves as a gallery and tool storage. He is of the opinion that having fewer belongings means having more experiences. Due to his frugal way of life he has a great deal of time, and lives by the motto “everything I do is a joy”. (Dirksen, 2015). Price’s approach to building is quite different from those generally utilised in architecture, as he examines the piece of land that he is living on over time. Instead of building a large house and adapting the place and vegetation such that they fit the building, he designs his buildings based on the topology of the space. Prices inhabited his prototype homes for a few years, constantly adjusting them. As and when they no longer suit his ideas, he uses the materials to build another home in a different area of the land. The site here consequently serves as a foundation that is explored through living, that inspires and informs the next experimental house, and that is a fundamental part of the everyday living area. This example is therefore a particular, site-specific approach that exemplifies the fact that designing one’s own living environment based on local resources and recycling can take place. Most significantly, Price’s tinkering with his own home and way of living strongly connect to On Textile Farming as a research programme. In addition, the approach of exploring, observing, analysing, and adapting to the potentials of a given space and its microclimates in relation to the elements and seasons inspired the second part of this research, which relates to the playfulness and simplicity of living as much outdoors as indoors, in constant flux. For Price, building and living is a lifelong learning experience, and involves continuous practice.
DESIGNING HABITATS FOR PEOPLE

learned to incorporate the vision of the institution – to integrate sustainability as an underlying foundation on which theory and practice rest – into their practice. The predominant research topics and principles included compact and flexible structures, bio-based and recycled materials, design for disassembly, linking functions and flows, comfort in relation to energy and the indoor climate, and measuring load capacity in different stages of the project (Hogeschool Rotterdam). The family of five that lived in the CHIBB from 2015 to 2018 shared their motivation and experiences in interviews, videos, and social media. Scholten, who was one of the residents of the CHIBB, stated that today’s world demands changes in how we live and act, and that the most important of these relate to our homes, e.g. the materials we use in their construction; she goes on to state that we have to experiment, learn from people who have already lived in harmony with nature, and share what we have learned. (Scholten, n.d.). By living in the structure that the students designed and built, the family experienced and reflected on everyday living over the course of the experiment.

Scholten shared several insights regarding the structure, climatic conditions, logic of the floorplan, and how these affected how the family used and arranged their lives in the greenhouse home. Due to electrical problems a gas stove was installed on the balcony, which was covered by the greenhouse. This outdoor kitchen, Scholten asserts, positively affected her wellbeing due to being as well-lit as an outside space, while offering most of the comforts of a room within the building. She felt that it was a special experience to prepare Christmas dinner in a winter coat and to enjoy the meal with friends and family, who also had special, positive experiences. Many of her insights relate to the climatic conditions in the different living areas: the rooftop greenhouse was too hot, for example, and a greenhouse should always have a soil floor as this is the only material that can manage heat. Similarly, Scholten felt that spring and autumn were the most comfortable seasons; that they were not able to live self-sufficiently with regard to growing vegetables; that thermal mass is needed to create a more comfortable climate in winter; that plants do not thrive with too much ventilation; that a chimney can deal with hot air better than a window at the top of the greenhouse; that shade must be created on the exterior; and that glass can be insulated by installing blankets inside, 10 cm from the surface. Many of the insights were very site-specific, and only achieved through living there and experiencing the real-life implications of the building (Dirksen, 2018). Many more resulted from discussions with interested people and experts, and through her stories we learn from these. Scholten is of the opinion that this way of living is not for everyone, but that some must undertake it in order to enable alternatives and share experiences so as to improve the practice. “We moved here to learn”, she states – and this is exactly what was intended with the second part of the On Textile Farming research programme. Scholten’s reflections are based on everyday practices carried out over the course of the three years of the project, which explains the variety of insights relating to living there and possible improvements. She thus accumulated a deeper knowledge than those who built the house, and moreover shaped the everyday nature of the house – just as the house shaped the everyday lives of the family. This example illustrates the fact that the living experience is very much an experiment for those who are already interested in its implications and challenges, and that possess a certain understanding. It also shows that an autobiographical research approach provides deep knowledge of a space and how it can be utilised differently during the different seasons, and that it can offer insights into possible and preferable physical and conceptual improvements.

Rather than adding a greenhouse for growing crops to a residential house, Kono Designs’ Urban Farm is an example of the integration of crops into an interior office space. In a nine-story building in the middle of Tokyo’s metropolitan area, the employees of the Pasona Group Headquarters share their office space with suspended tomato vines, lemon trees, broccoli, and rice paddies, which grow on shelves and in automated hydroponic beds, cling to bars, cover façades and walls, hang down from horizontal structures in ceilings, and are stored below furniture (Andrews, 2013). Professionals teach the employees how to plant, take care of, and harvest the crops, which are then available in the company’s restaurant. The ways in which the plants are organised is thus adapted to the aesthetics of the working space, where metal, plastic, straight lines, squares, boxes, and pipes are the dominant expressions. Although the growth of crops is engineered to be as autonomous as possible, the phases of planting, harvesting, and trimming, in addition to other forms of contact such as observing, touching, and admiring, are forms of physical interaction and a way of merging two worlds: those of people and plants, of theoretical and practical work, and of the artificial and the natural. Through the cycles of cultivation and harvesting, the flow of time is represented in the form of ‘indoor seasons’. The expressions and experiences that arise when natural and artificial components meet are the main focus of this research, and so connect strongly to On Textile Farming. However, the plants in the office space are organised following the layout of offices – based on grids, shelves, and boxes – and so are in aesthetic contrast to the organic shapes of leaves, flowers, fruits, and their colours. On Textile Farming proposes textiles as a means of integrating plants and their development in more flexible ways, based on
were not optimal for carrying out the experiments. The need for an environment – a physical framework – in which explorations with textiles in relation to indoor and outdoor spaces were possible and experiments could be setup, observed, reflected on, and adjusted as necessary led to the building of an experimental living space in which research was conducted through an autobiographical research approach. This setup was favoured over a living lab, since above all, living labs involve the testing of prototypes with defined usage concepts in everyday situations in order to compare design intentions and reflect on how prototypes can be further developed. It was felt that the experimentation would not necessarily benefit from a living lab environment due to the fact that much of the experiments within the research programme were carried out in order to be receptive to how the living practice was informed by the environment, how the environment was informed by the living practice and to develop concepts which consequently were shaped over the time ‘living the research’ and did not exist before.

As a result, it is reasonable to state that there is a mutual relationship between habits and living spaces and that habits can induce changes in living, but habits can also be changed by instituting changes in living (Scott et al., 2012).

The examples described in this chapter make clear that experiencing one’s own environment in one’s own structure is crucial to understanding the implications of each. They also clearly show that sustainable forms of living can be very diverse, and can – but do not need to – include technology.

Over the course of the development of the research programme, it became clear that the spatial conditions in the academic and industrial environments were not optimal for carrying out the experiments. The need for an environment – a physical framework – in which explorations with textiles in relation to indoor and outdoor spaces were possible and experiments could be setup, observed, reflected on, and adjusted as necessary led to the building of an experimental living space in which research was conducted through an autobiographical research approach. This setup was favoured over a living lab, since above all, living labs involve the testing of prototypes with defined usage concepts in everyday situations in order to compare design intentions and reflect on how prototypes can be further developed. It was felt that the experimentation would not necessarily benefit from a living lab environment due to the fact that much of the experiments within the research programme were carried out in order to be receptive to how the living practice was informed by the environment, how the environment was informed by the living practice and to develop concepts which consequently were shaped over the time ‘living the research’ and did not exist before.

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DESIGNING HABITATS FOR PLANTS

GREENHOUSE ARCHITECTURE

Horticulture is all about the growth of plants, e.g. flowers, fruits, and vegetables, outdoors or in a more protected environment, and also includes their establishment and maintenance. In relation to this, greenhouses improve growing conditions and enable a high level of control of abiotic and biotic conditions, which leads to an extended cultivation period, independence from the seasons, higher yields, and an improvement in terms of quality. Greenhouse production is thus more efficient than growing crops in an open field (Vox et al., 2010). Through an improved understanding of crop physiology and new technologies, growth conditions for crops have been improved significantly. Depending on the climate characteristics of the region and the requirements of the crops, today’s greenhouses are built and used not only to shelter plants, but for the effects that they can have on local climates, e.g. providing protection from the sun, the wind, and rain (Castilla, 2013). The manipulation of temperature affects plant growth and morphology, and is therefore critical to their modification. In order to meet their climatic requirements in terms of air temperature, relative humidity, carbon dioxide concentration, sunlight, and incidence of pests and diseases, greenhouses have to be e.g. heated, cooled, ventilated, enriched with carbon dioxide, and protected from pests. Consequently, protected crops strongly influence air, soil, and water due to their need for water, energy, agrochemicals, and waste disposal. In addition to other means of conditioning, covering materials are used to influence and manage greenhouse microclimates (Ibid.). Plastic screens – or ‘climate screens’ as they are called at AB Ludvig Svensson – emerged three decades ago, and are a covering material used to improve the climate for plants. They exhibit various properties and have undergone many improvements, e.g. surface treatments to improve strength and durability, coating to block ultraviolet and infrared radiation, anti-reflective, -dust, and -drip coatings, and the addition of luminescent properties (Picuno, 2014; Diaz et al., 2001). Screens are used as e.g. mulching nets and rain, hail, insect, wind, sun, and frost protection. High-density polyethylene and polypropylene are widely used raw materials, with the latter often being used for non-woven textiles. At AB Ludvig Svensson, however, horticultural products are based on polyolefin, polyester, aluminium, and modacrylic, and are warp-knitted. Screens differ in terms of the type of material used and structure, e.g. mesh size, porosity, type of thread, as well as in terms of radiometric properties such as reflectivity and levels of translucency and opacity (shading percentage; openness factor) in order to e.g. distribute solar radiation in an optimal way. Additionally, they differ in terms of physical properties such as weight, dust repellence, and air permeability, and by mechanical...
characteristics including durability and tensile strength (Castellano et al., 2008). Due to the diverse applications and widespread use of the screens, a great deal of plastic waste accumulates and has to be disposed of. As any change in the properties of the covering material from when it is new is considered to be degradation, developments in product longevity and undisturbed function are very important. An alternative approach is the usage of raw, renewable materials, which are used to form biodegradable materials. These are investigated as environmentally friendly alternatives as they can be mixed with the soil or other organic material and broken down by bacterial flora. Spray soil mulching with a biodegradable waterborne coating is an example of a biodegradable alternative to plastic mulching (Vox et al., 2010). In the early research performed for On Textile Farming, different kinds of common horticultural substrates were used to explore e.g. the amount of energy available in seeds and the qualities and nuances that these substrates bring to textile expressions. For example, soft, white, sterile, and absorbent cotton padding and pressed brown coconut tablets with a stable shape that expand as a result of the presence of moisture were investigated. In the experimental work described in this thesis, growing soil was explored in order to investigate the possibility of integrating plant microbiomes into textiles, the effect that adding soil would have on textile expressions, e.g. weight and brown dust, and how the soil would respond to maintenance, e.g. watering from above or spraying the textile with mist.

Hydroponics is a broad term for all plant growing techniques that are based on water or other substrates, e.g. peat, perlite, rockwool, and mineral wool, instead of soil. Here, the root systems of plants are fertigated (i.e. supplied with water and nutrients) by a flowing, stagnant, or misted nutrient solution in an open or closed system (Ibid.). Closed hydroponic systems are an important part of sustainable crop-growing greenhouse systems (Pardossi et al., 2006; Savvas & Passam, 2002) as they use less water and fertiliser and do not affect soils. Rising prices and environmental issues with mineral wool and peat have spurred on the search for alternative substrates based on e.g. municipal and industrial waste by-products, including timber industry by-products, coconut coir, and high-quality green compost (Vox et al., 2010). Airflow is an important aspect of temperature and humidity, and therefore plant health, and is improved by insect nets with UV absorbance in the UV-A and UV-B ranges and slow-release insecticide treatment, as mesh sizes can be increased without increasing pest penetration pests (Teitel et al., 2018). Radiometric properties are one of the most important parameters of climate screens as a net or screen of one colour absorbs its complementary colour, and therefore influences the spectral distribution of the radiation passing through it. Therefore Castellano et al. suggest that careful selection of material colour in relation to plants’ radiation requirements could optimise production (2008). Photoselective shade nets transform direct light into scattered light to prevent damage through direct exposure to radiation, improve the penetration of light into the inner plant canopy, and protect from various spectral components of solar radiation through integrating chromatic, light-dispersive, and reflective elements in the materials (Shahak et al., 2008). The structure of a textile, e.g. inter-thread spacing and thread width, and the orientation of the fabric/screen with regard to the warp and weft directions affect direct light transmission (Möller et al., 2010; Castellano et al., 2010). Studies regarding the physical responses of flowers, in terms of stem length, flowering, and cut flower weight, to spectral manipulation in the form of coloured nets have been performed (Ben-Yakir et al., 2012; Ovadia et al., 2009), and such screens also serve as optical barriers and pest protection (Ben-Yakir et al., 2012; Antignus et al., 1998). Instead of agrochemicals, biological control agents such as antagonist fungi, bacteria, and insects, have been studied in relation to pest and disease management, and a number are available on the market (Vox et al., 2010). Antagonist fungi have been proven to be more efficiently delivered using bees and bumblebees than being sprayed (Kovach et al., 2000). Biological agents, textile technologies, biodegradable materials, and closed systems thus play a role in creating more sustainable greenhouse systems. Within these approaches, textiles mediate between the outside of a greenhouse and its microclimate through e.g. light modification and insect manipulation.

Two contrasting approaches to horticulture and agriculture have been proposed: On the one hand, a high level of automation and optimisation, using technology both indoors and outdoors (prevailing in both commercial and private contexts); on the other, an emerging view that involves including rather than excluding the natural biosphere of plants and the manifold interrelationships between plants, microorganisms, and insects.

Modern community gardening, urban agriculture, and hybrid housing concepts combine dwellings and spaces for local food production, and are an approach to making cities more sustainable and resilient. Urban agriculture has a variety of positive effects, increasing the availability of healthy and nutritious food (Blaine et al., 2010; Duchemin, Wegmuller & Legault, 2008) and reducing human impact on the environment (Doron, 2005; Flores, 2006; Halweil, 2005; Howard, 2006). In this context, greenhouses are parts of the urban environment in a way that botanical gardens and
private backyards are not. They can be found e.g. above supermarkets (Pons et al., 2015), inside office buildings (Andrews, 2013), and integrated in domestic housing (Frearson, 2016). Despommier proposes 'vertical farming', wherein crops are grown in specially constructed buildings using hydroponic and aeroponic farming methods (Despommier, 2011a; 2011b; 2013). The advantages of protected horticulture in urban settings are season- and weather-independent food production, and thus more reliable food supplies. Alternative products and environments are constantly being developed, and increasingly intersect domestic living practices that are derived from horticultural practices (e.g. aquaponics and hydroponics), supported by electronics that either direct the maintenance actions performed by human beings or form or control part of an autonomous system (Aouf, 2016; Wilson, 2016). These proposals redefine the ways in which plants are organised (Andrews, 2013; Aust, 2010; Wahby et al., 2016), maintained (Aouf, 2016; Camilleri et al., 2015), perceived (Klein, 2019), and used (Wolverton, 1989) in interior spaces. In this context On Textile Farming aims to provide a perspective which merges practices of horticulture and domestic living with aesthetics of growth and decay, utilizing textiles for the flexible and adaptable accommodation and organisation of plants in a spatial and environmental context.

**HORTICULTURAL THINKING IN DESIGN**

Activating the potential of plant material during design processes is a goal that connects On Textile Farming to the field of hortitecture – a term that combines ‘hortus’ (garden) with the field of architecture in order to express the dissolving boundaries between nature and buildings. Here, living plant material is integrated into architectural structures in order to search for the potential that they carry with regard to aesthetic and ecological performance, e.g. providing ecosystem services, reducing the impact on the environment, enhancing wellbeing, and improving microclimatic conditions. Plants are removed from the ground and placed in a new spatial and conceptual context, as an integral part of architecture (Grüntuch-Ernst, 2018).

**On Textile Farming** focuses on two related issues; plants as integral parts of textiles, and ways of living that inform the manner in which the relationship between plants, people, and the environment can be designed. As a result, the research programme brings a horticultural perspective to spatial design based on textiles.

**Hortitecture: The Power of Architecture and Plants** presents three symposia that took place in 2014, 2016, and 2017. The major questions in the field at that time were: “How are plants integrated within building systems? What benefits can a new kind of nature-artefact combination offer? How do plants affect the overall environment and architectural design? What is the aesthetic value, and how can the composition be designed and maintained?” (Ibid.). In order to address these questions, Hortitecture contains contributions from architects, engineers, an artist, a biologist, and a psychologist, showing that the field benefits not only from the perspectives of architects but draws on many different areas.

The following examples can be considered to relate to the field of hortitecture, as well as to different aspects of On Textile Farming, and exemplify aspects of horticultural thinking in design:

Ludwig et al.’s “horticultural way of design thinking and acting” (Ludwig et al., 2012: 86) relates to their research into trees, and how their structural and load-bearing architectural properties can be related to horticultural techniques. Ludwig et al. use vegetable structures to support and facilitate architectural formworks, and the research project *Grow!*, which focuses on the “vivification” of architecture, is a “living plant structure” (2012). By drawing on horticultural techniques such as grafting, Ludwig et al. developed methods and techniques that combine technical joining and
On Textile Farming

Gruber uses a biomimetic approach to develop applications that are inspired by plants. In particular, she highlights the contrasting characteristics that make them highly efficient and very adaptable, such as their combinations of stability and flexibility, water-repellency and absorption, and continuous movement despite being in a fixed location. Plants, furthermore, have extraordinary capabilities in terms of self-healing and responding and adapting to environmental factors, both of which offer potential for design (2009). On Textile Farming aims to explore the potential of plants in relation to textile structures, and how a horticultural perspective on textile design impacts the ways in which interior spaces are designed and lived in. Gruber notes that there are many overlaps between architecture and plants, and analogies between plants and buildings. Plants have developed a diverse array of highly effective mechanisms that could be adopted by the field of architecture, including below-ground root systems that anchor them to the ground, providing stability and orientation and the ability to exchange resources. Comparing the expressions and phenomena of textiles and plants inspired the first set of On Textile Farming experi-

ments. That interactions between above and below ground play a fundamental role in terrestrial ecosystems has been demonstrated by a proliferation of studies in the last two decades (Bardgett & Wardle 2010). However, above- and below-ground components of ecosystems have frequently been considered separately from one another. On Textile Farming, however, explores the above- and below-ground components of plants in the manner of the two sides of a textile, and designs using e.g. the morphogenesis of plants in response to light (phototropism) and gravity (gravitropism) in order to investigate the potentials of the two worlds of plants and textiles.

Collet explores how an understanding of botany and horticultural techniques can inform design processes and complementary, sustainable approaches to manufacturing. Her works Biolace and Botanical Factory use plant systems and a speculative design approach to question the ethics of synthetic nature (Collet, 2012; Collet & Foissac, 2015; Myers, 2015). The former consists of a lace grown by the roots of plants, and so explores synthetic biology and botanical fabrication; the latter investigates the concept of botanical fabrication through an ecosystem of plants that is used to grow products. Here, the morphogenesis of plants is used as a starting point, and how tropisms can affect growth in such a way that a certain shape is formed is explored. Collet is driven by the question of whether ‘living technology’ could lead to a more resilient future by shifting industrial mindsets and instituting design principles that sustain life rather than exploiting natural resources (Collet, 2012). Both projects inspired this research on several levels; the most important aspect was the utilisation of e.g. the morphogenesis of plants and environmental influences in the form of tropisms to interact with plants and design using their growth processes.

Utilising the morphology of plants in order to communicate and work with them is an approach that is also used by Flora Robotica. The project incorporates the fields of computer science, robotics, molecular and cellular biology, zoology, advanced mechatronics, environmental sensing, and architecture, and so takes a highly interdisciplinary approach to investigating and creating societies of symbiotic robot-plant bio-hybrids. Due to their synergies, these hybrids bring new perspectives to plants and robots, and expand the functionality of both with regard to e.g. creating alternative architectural design opportunities such as architectural artefacts and living spaces. Hamann et al. (2015) use robotically braided structures to guide the growth of plants through artificial stimuli. The resulting symbiotic relationship between robots and natural plants can be used to manufacture walls, roofs, and benches over time. This temporal perspective, which combines plants and textiles through textile
DESIGNING HABITATS FOR PLANTS

and horticultural techniques, is what connects this project to On Textile Farming. In Flora Robotica, however, the symbiosis of plants and textiles is structural in nature; plants are biological agents, and the braided textile material does not combine with the material or the surface. This perspective could, however, be incorporated into On Textile Farming in order to create a hybrid in which the two elements cannot be distinguished from one another and the textile components add functional aspects beyond a textile formwork. This could involve e.g. the transportation of water or accommodation of plants whose above-ground parts are guided by a braided structure, while the below-ground parts root in the textile envelopes, connect them, and so strengthen the construction and stabilise its position.

This textile from plant roots is a natural material. The advantage, I think, is that because it weaves itself below ground, you don’t need an artificial weaving machine. Once I find the process of how to make it as strong as possible and find the right roots to make the weaving very strong, it could be suited for many things in architecture. (Scherer quoted in Grüntuch-Ernst, 2018: 255)

Scherer uses root systems to grow fabrics that are similar to lace. Her work ‘Inter-woven’ is driven by her interest in plant intelligence; underground templates are used to guide the growth of roots to create a certain horizontal pattern, which is then exposed and displayed (Ibid.). Scherer describes how the roots weave a dense, three-dimensional network, guided by tropisms and the mould in which the seeds and substrate are placed. There is an obvious comparison here with the threads of a Jacquard loom, as every root has its own agenda – just like the warp threads of a Jacquard loom. One difference, however, is the way the network emerges within a confined space, controlled by the surrounding environment and the plant’s agenda. There is no control over each of the roots as there is in a loom over every thread, but they both create a planned pattern and arrive at an intended result. This fascination with roots, and the analogy with threads and the weaving process, connects this work to On Textile Farming.

We are a developer of ropes, and we fill these ropes with seeds—and the seeds and the ropes are watered top-down with an irrigation system. The seeds then start to sprout and grow out of the ropes. (Weisel, quoted in Grüntuch-Ernst, 2018: 242)

Weisel, on the other hand, integrates seeds in ropes that are suspended vertically, and is interested in using the solar energy that buildings are exposed to but which is generally not used. Scherer produces a textile structure through growth, while Weisel uses a textile structure to provide a template/substrate in which seeds can grow (Grüntuch-Ernst, 2018), connecting Weisel’s work to On Textile Farming in which several methods of integrating seeds and expressions of growth are explored with regard to textile design. While Weisel uses a system of ropes next to one another in order to create an architectural façade, this research explores two- and three-dimensional structures from the scale of the body to that of architecture in a variety of different textile materials, e.g. tubular yarns, cotton fibres, wool fibres, and techniques such as crocheting, weaving, and felting in order to integrate seeds (Keune, 2018). Weisel develops the suspended ropes as a means of façade farming, which involves producing food at the same time as vertically decorating an architectural surface with greenery. On Textile Farming focuses on the spaces between indoors and outdoors, and uses explorations of textiles and plants to invite encounters and envision future potentials with regard to new aesthetic concepts and applications.

Cruz and Beckett invite living organisms to inhabit architectural surfaces with the concept of "architectural bark", and developed bioreceptive design as a new research field (Cruz & Beckett, 2016) in order to explore ways of directly embedding living organisms into the architectural fabric itself, building vegetated envelopes, roofs, and façades as examples of urban greenery (Ottelé, 2011). In these structures, the façade itself hosts microorganisms, cryptogams, and more complex plants (Cruz & Beckett, 2016). The Bioreceptive Façade Panels consist of bioreceptive seeded concrete panels with structural characteristics that differ in terms of e.g. the level of porosity in order to create the proper conditions for the settlement and growth of cryptogamic covers (e.g. algae, lichens, and mosses). In this process of biocolonisation no additional maintenance is needed, and so the panels provide an alternative to existing ‘green walls’. The bioreceptivity of a material, as well as the environmental influences, are major factors with regard to supporting processes of biocolonisation taking place (Beckett, 2018; Syn.de.Bio, 2015; Cruz & Beckett, 2016). Guillitte, a bioengineer, defines ‘bioreceptivity’ as “the aptitude of a material (or any other inanimate object) to be colonised by one or several groups of living organisms without necessarily undergoing any biodeterioration” (quoted in Cruz and Beckett, 2016: 53). In order to explore the relationship between the substrate and surface areas that enhance or inhibit growth, Cruz and Beckett borrowed from the field of tissue engineering; here, research is performed to develop bioscaffolds, which are biocompatible substitutes for biological structures that exhibit a certain porosity and feature voids and pores to provide space for the attachment and growth of cells. Instead of concrete, On Textile...
THE BIOLOGY OF PLANTS

Plants provide materials for textiles, fibres for the fabrication of yarn, and dyes to colour them. However, new discoveries with regard to e.g. plant perception and communication have challenged our understanding of plants; no longer are they biological automata with pre-programmed reflexes towards connected subjects in a network of relationships. As our culture has been based on the cultivation of plants since the Agricultural Revolution, we are part of these relationships. Koechlin argues that, if plants are more than mere objects, our relationships with them should be questioned anew (2015). This requires not only a rethinking of agricultural practices, but of how we deal with plants in everyday life, and how we live with them.

This chapter deals with the biology of plants, their cultivation in greenhouses, and how horticultural practices and design thinking could be transferred to the textile design field. General facts and recent research insights into the physiology of plants and the ways in which plants relate to their environment are presented and examined from a textile design perspective, with particular regard to the ways in which they could inspire or be transferred to the design of adaptive and responsive surfaces.

“What drives life is […] a little current, kept up by the sunshine” (Szent-Györgyi, quoted in Raven et al., 2005: 1)

Photosynthesis is the process by which plants absorb the radiant energy of the sun. By forming sugars and releasing oxygen as a by-product, this energy becomes available in physical/chemical form, and is shared by plants in order to invest in many different kinds of symbiosis. This process serves not only plants, but all other living beings. In order to ensure the availability of nutrients for uptake, roots exude chemicals into the soil and interact with bacteria and mycorrhizal fungi. In mixed cultures with undisturbed and healthy soil conditions, a mycorrhizal fungi network can become a dynamic marketplace in which nutrients are exchanged and a resilient community of plants is created. Another symbiosis that the roots of e.g. beans and pea plants enter into is based on nitrogen-fixing bacteria known as rhizobia, which are housed in root nodules and provided with nutrients. They even detect the efficiency of colonies and reward the most cooperative ones (Simard, 2012; Stamets, 2005; Raven et al., 2005).

These symbioses increase the resilience of a plant significantly, which explains the heavy investment in these relationships. In ‘Plant whispers: A journey through new realms of science’ Koechlin provides an inspiring overview by summarizing on recent insights.
findings in plant science and illustrates a different perspective on how to perceive, explore, understand, see and dream about plants (2015). This general shift proposes that a plant is a network that maintains intimate relationships with its environment through the way in which it develops. The complex cells of plants build a cooperative conglomerate in which each cell is an independent creature (just as a bee is part of a beehive), but so closely linked to the others that they form an organism (like a beehive) that is more than the sum of the individual elements (Ibid.). The way in which they work together gives the impression of an elegant, meaningful overall coordination, and so we perceive the many cells as a single organism. Through this structure it is possible for the plant to never stop growing and developing, and plants can add cells to their bodies indefinitely. The cell wall consists primarily of cellulose, which gives the cell and thus the entire plant body a more or less solid form that is permeable to water, dissolved nutrients, and gases, facilitating exchange. As plants can reproduce from a single cell they have more regenerative power on a cellular level than animals, including humans (Ibid.). Due to this, plant parts can be transplanted to other plants, and are able to connect such that their tissues are joined and they continue to grow together. Ludwig et al. utilizes this technique for the “vegetal technical compound structures” (2012: 82), usually ‘grafting’ is used in horticulture to duplicate desired genes such that the stem of e.g. a pear tree is grafted to the rootstock of e.g. an apple tree, and continues to grow there. In this way, the grafted plant consists of two elements that were chosen to improve the performance of the plant as a whole – in the example, an effective rootstock and the stem of a productive and tasty fruit-producing pear tree.

Plants master communication among their cells and with their surroundings in order to create relationships between these, and thus need to develop an understanding of their environment. They communicate through electrical impulses, as well as possibly through sounds, and using both above- and below-ground scents. Above ground, a plant can attract beneficial insects and animals, and warn its neighbours in case of an attack. An apple tree, for example, can attract great tits by using a particular scent when it is attacked by a certain kind of caterpillar (Amo et al., 2013). Below ground, plants communicate with insects, bacteria, and fungi using water-dissolved signalling substances.

Plants can perceive more than 15 different environmental factors, including chemicals, touch, temperature, electricity, sound, and light. Through that range of perception they can know ‘who’ is growing in their neighbourhood and whether neighbour-

ing plants are relatives or of the same species (Koechlin, 2015). When resources are scarce, choosing the right strategy can influence whether or not a plant survives. The growth of roots is emphasised when water or soil nutrients are limited (Bloom et al., 1985); at these times, the plant invests its energy in finding the needed resources. In order to decide on the direction in which to develop, the plant needs to estimate the likelihood of success, and has developed different strategies to facilitate this. Gagliano et al. propose that roots detect water sources through acoustic vibrations, and direct their growth towards these in order to encounter the expected substrate moisture, which then assists in finding the exact location of the water source (2017). Through their intimate and complex connection with the environment, plants thus embody location individualities - and this leads to biodiversity (Koechlin, 2015).

The growing and turning of plants in response to these environmental stimuli is termed ‘tropism’. Although most plants grow in the ground and cannot leave their position, they are able to move and are often even defined by their “non-locomo-
tive types of movement” (Marder, 2015: 186). Based on this perspective, plants are highly dynamic. There are a number of ‘growth patterns’ or tropisms; ‘phototropism’ is a plant’s response to light, ‘thermotropism’ is movement or growth in response to temperature, ‘thigmotropism’ is response to physical contact, and ‘aerotropism’ the growth of plants towards or away from a source of oxygen. When a beneficial stimulus has been perceived by the plant a signal is transmitted, which leads to a change on the cellular level that triggers the growth response. Consequently, plants are very sensitive and attentive beings that are able to ‘understand’ their environments and respond to them with diverse patterns of growth. This range of possibilities for impression, expression, sensing, and acting could shine a new light on the design of adaptive and responsive surfaces.

‘Gravitropism’ is a gravity-directed process of growth that affects a plant’s organs, such as shoots and roots, and is therefore a fundamental guide for growth (Salisbury, 2010). Shoots direct themselves upwards for the purposes of photosynthesis and gas exchange, whereas roots grow downwards in search of water and mineral ions. Gravity is sensed by the tip of the root, causing adjustments in growth direction. During the process of germination, gravitropism guides the growth of roots, as evolution dictates that roots that grow in the direction of gravity are more likely to find soil and therefore substrate in which to stabilise, and from which to absorb nutrients and water. The shoots direct themselves in the opposite direction, towards light (Myers et al., 1994), in what is termed ‘phototropism’. Unlike animals, which
DESIGNING HABITATS FOR PLANTS

can only detect gradients of light using the photoreceptor cells in their eyes, plants are able to sense light using each cell, including the roots. In order to perform photosynthesis, the leaves and green stems orient towards light, with some adjusting their leaves and flower heads towards the sun during the day (Christie & Murphy, 2013). ‘Hydrotropism’ is the movement or growth response of an organism towards water. In plants, the root tips sense different levels of moisture in the soil and direct themselves towards more saturated areas in order to access water (Dietrich, 2018). ‘Chemotropism’ is a movement or growth response to chemicals. Plant roots sense and react to chemicals, such as nutrients in the soil. If these are disparate, distributed roots differentially grow towards richer microenvironments (Weaver, 1926). This selective root growth is also carried out in order to avoid obstacles such as inanimate objects or respond to competing roots (Verma & Zhang, 1992; Gersani & Sachs 1992).

The cycles of growth are influenced by the seasons, and plants are classified as annuals, biennials, or perennials. Annuals perform their entire life cycle within one growing season, which can be as little as two weeks. Their stems are not only vascular systems for transporting substances between the photosynthetic and non-photosynthetic parts of the plant body, but themselves photosynthetic organs. The growth of annual plants is based largely on primary growth, which occurs at the tips of stems and roots, which elongate and develop primary tissue. Plants that live longer develop a thick, woody stem, which is called secondary growth. The stem functions primarily as a vascular system. Biennials develop roots, a stem, and leaves during the first growing season; flowering, fruiting, and seed formation take place during the second. Annuals and biennials focus mostly on primary growth due to their short life cycles. Perennials can grow for hundreds of years, depending on the species. Most stop growing during unfavourable seasons, while others remain dormant underground.

The location of a plant is determined by where a seed germinates and roots in the soil. During its growth, it tries to take up the space needed for its full development. This space is calculated when seeds are sown for cultivation. In order to extend the growth phases or achieve earlier yields, seedlings are often pre-grown in denser arrangements and later planted at the correct intervals. The root system, which in most cases is the underground part of terrestrial plants, is a major part of the plant’s body in terms of function and mass. The roots of a plant are branching organs that absorb water and nutrients, anchor and support the plant’s body, and store nutrients. The plant’s root system also serves as a natural means of reproduction. There are two primary types of root; taproots and fibrous roots. During the process of germination, the radicle (the embryonic root) is the first part that emerges from the seed. Taproots develop from the radicle and form the primary root, branching into secondary then tertiary roots. A taproot is able to store a large amount of carbohydrates and water due to its central dominant root, which is relatively large. From there, other roots sprout laterally. Root vegetables are taproot systems that have been cultivated. Typical taproot shapes include conical (e.g. carrots), fusiform (radishes), and napi-form (turnips). For most other species the radicle disappears after some time, and the plant develops a fibrous root system that lacks a main, downward-growing root but is more efficient in absorbing nutrients from shallow sources due to its extensive exposure to nutrients and water. Plant species with fibrous roots, e.g. grasses, stabilise soil and prevent erosion. The extent, depth, and spread of a root system depends on the species and below-ground conditions, such as moisture, temperature, and soil quality. The roots of maize plants extend one metre around the plant and to a depth of 1.5 metres; alfalfa plants easily reach a depth of six metres or more. The surface area of the root system of a rye plant can measure up to 639 square metres while being confined to just 6 litres of soil (Raven et al., 2005). However, a plant maintains a balance between its shoot and root systems such that the surfaces areas for photosynthesising and the absorption of water and minerals are closely interdependent. When a plant is transplanted to a different location, the feeder roots in particular are damaged. Shoots can be cut, however, to help repair this damage (Ibid.).

Plants travel, even though they are tied to their location. In order to leave this and spread out, they have developed strategies for dispersing their pollen and seeds (e.g. grains, nuts, kernels, pulses, and pips). Various agents, including animals, insects, and the elements, help with the dispersal, and many fruits and seeds have evolved to suit one or another dispersal method. Some pollen and seeds travel with the wind, while others ‘catch a ride’ by sticking to insects or being eaten by birds, bats, and mammals (Hanson, 2015).

Our culture is based on the domestication of plants and crops, such as weed, corn, and potatoes. The promise of a stable food supply and less work motivated us to settle down. There is thus a mutual influence between plants and people. Hanson argues that “[f]ruit influences our behaviour because it evolved to do so” (2015: 184) and uses the apple as an example, which was domesticated from a single species to create thousands of varieties all over the world. Pollan argues that ‘coevolution’ is a better term than domestication for describing the relationship between people and plants, and that the two maintain a mutual and intimate relationship in which we are not only subjects, manipulating plants to serve our desires, but also objects of their intentions, wishes, and needs (2002).
We live in a world of seeds. [...] They give us food and fuels, intoxicants and poisons, oils, dyes, fibres and spices. (Hanson, 2015: xxiv)

There are estimated to be between 200,000 and 4,200,000 species of spermatophytes (seed plants), which means that they are difficult to categorise. Consequently, there is a rich diversity of grains, nuts, kernels, pulses, and pips, varying in size, shape, surface typology, colour, dispersal, and germination. The seed of a higher plant is part of its process of reproduction, and constitutes both the starting point and the result of its life cycle. The orchid seed is the smallest type, weighing just one millionth of a gramme, while the seed of the sea coconut is the heaviest at over 20 kg. In general, small seeds ripen more quickly and can be dispersed sooner, which is important for most annuals. They can also be produced in larger quantities, which helps to ensure that at least a few seeds will end up in a favourable location for growth (Hanson, 2015). Seeds carry information about their context, and combine the past, present, and future by representing a past development in the present and carrying it into the future. They can barely be understood by examining their physical appearances.

The blueprint contained in a seed is not comparable with a blueprint of a building when one considers that plants are continuously shaped by their environment. One cannot know whether the seed will even germinate and – if it does – where it may take root; let alone predict how the plant may be formed by its interplay with the environment, which events will potentially shape its existence, and how this will be manifested in the plant. Plants are consequently massmanufactured unique structures and there are many sensing, timing, and response strategies hidden in a seed that could provide an alternative perspective on adaptive and responsive structures.

Dormancy is a plant’s strategy for seed preservation, from which we benefit at least equally, since our diet is based on them. A dormant seed contains an embryonic plant, and its first meal during the germination process. Both are protected by the seed coat, which is the outermost layer. Plants seeds require different energy sources, such as starches, fats, oils, and proteins, which provide effective survival packages for the tiny plants and their journeys. This stored energy is fundamental to the diets of many animals. Moreover, its importance to human culture is represented by the price of e.g. wheat and rice, which are negotiated on the stock exchange.

The seed coat is not only a defence against adverse external conditions, but communicates information regarding the exterior to the interior. It therefore maintains specific levels of metabolic and photosynthetic activity, and is permeable in order to facilitate gas exchange (Radchuk & Borisjuk, 2014) and thus mediates between the seed and the environment. The seed coat often contributes to dispersal by facilitating gliding on the wind, floating in water, being carried in the intestines of an animal, or simply falling down from a high tree. Consequently, seeds are ‘survival capsules’ – highly specialised and adapted to the conditions that they have to find and deal with until they sense that the time for germination has come. Thus, seeds vary in activity and readiness to germinate. While some seeds germinate as soon as they make contact with water, others only germinate following exposure to a certain combination of environmental conditions that ensure the correct timing for seed germination, which is a major stage in the life cycles of plants (Smykal et al., 2014). Thus, the dormancies of seeds tie into strategies for spreading or delaying germination until the environmental conditions are favourable to development. Delays in germination have evolved in most non-cultivated plants, the most common of which today is desiccation (Toole et al., 1956).

The life cycle of an annual seed plant begins with a dormant seed that has been dispersed or sowed. When it senses that conditions are optimal, the seed activates its metabolic machinery and begins to germinate. The young seedling grows, developing its root system, stems, and leaves. In this period of growth before flowering the plant is usually harvested, which reduces its life cycle. If it is not harvested it matures and develops flowers, which are eventually pollinated, and the seeds develop as a result of fertilisation. The seeds are dispersed and lie dormant for the next growing season to arrive. The soil is thus not only a substrate to take root and find nutrients in but storage or a seed bank, a place where seeds sleep and wait for the right time to wake up and develop. Hanson describes the soil as a place where “hundreds or thousands of fierce rivals, from many species and generations, all lie side by side together in wait.” The onset of germination is then “the trigger of an intense struggle to get established” (2015: 93).

Germination is dependent on many internal and external factors; the three most important are water, oxygen, and temperature. Small seeds (e.g. those of lettuce) and many weeds also require exposure to light (Raven, 2005). However, some seeds need to sense a range of conditions over time, such as times of frost prior to the more temperate climate in which they will germinate. In this way they can be certain to germinate in spring, and not on a warm autumn day. Developing a strategy for estimating the right time and minimising the potential of falling afoul of changing weather conditions is therefore critical to survival. Today a great deal of seed dispersal is
undertaken by people, e.g. farmers and gardeners, who want to determine what, where, and how long plants take to grow before they are harvested. Consequently, timing is also important for them, and in order to successfully grow certain plants they have to e.g. keep seeds in the fridge or freezer for a while. The onset of germination is perceptible as an increase in respiration and water absorption (Toole et al., 1956) and the lengthening of the radicle, which is the first structure to emerge through the seed coat. This enables the developing seedling to anchor itself in the soil and absorb water. However, if the seed is fully immersed in water its access to oxygen is prevented, which can cause problems. The taproot grows and develops branching lateral roots. Germination can take place above ground (and is thus epigeal) or below ground (hypogeal). The way in which the shoot emerges from the seed varies between plant groups, and is relevant to this research; as the seeds were integrated in textiles, the shoots had to make their way through the textile structure in order to access light for photosynthetic activity. Thus, the different processes determined how the seedlings interacted with the textiles. During epigeal germination, the embryonic leaves (cotyledons), still unfolded and covered by the seed coat, are pushed into the air by the elongating embryonic stem (hypocotyl). The leaves then unfold, and the food stored in the seed is digested and transported to the growing parts of the young plant. By the time it is used up, the plant can sustain itself through photosynthesis. In hypogeal germination, the cotyledons remain underground, and the epicotyl rather than the hypocotyl elongates. For this type of germinating plant it is thus easier to break through the substrate (soil or cloth) due to the lack of a seed coat, which can decrease the upwards force. Seedlings with two embryonic leaves are termed ‘dicotyledonous’ (‘dicots’), an example of which is chickpeas, whereas seedlings with one embryonic leaf are called monocotyledons (‘monocots’), e.g. barley and maize (members of the grass family). In these two types of germination the leaves are generally lifted up by creating a hook (Figure 1), but maize seeds, for example, push their coleoptile straight upwards. As monocots, they have one embryonic cotyledon. The surface area that penetrates the substrate is therefore much smaller than in other modes of germination. However, the time from germination to independence (the point at which a seedling can sustain itself and is an independent organism) is the most vulnerable period of a plant’s life cycle, and it can be easily disturbed and die to various insect pests, parasitic fungi, and water stress (Raven, 2005).

The Licentiate Thesis introduced seeds as materials for textile design, and these were chosen based on their size, shape, colour, type of germination, and expression during growth. As the seeds were placed in textile envelopes containing substrate and thus invisible to the naked eye, their shape, size, and internal amount of energy was less relevant from a design perspective. Seeds with a relatively small size were easy to insert, and were therefore chosen to be used in the examples presented in this thesis.

As plants are increasingly being acknowledged as living beings that are sensitive, attentive, and active subjects with a certain degree of intention, our relationships with plants and responsibilities with regard to their use (taking advantage of/using them) have been and are still being questioned (Stone, 2010; Koechlin et al., 2009; Hall). As a result of years of thought and discussions regarding the nature of plants and their rights, a group of German biologists, philosophers, farmers, engineers, and plant physiologists published several theses on the rights of plants, based on the ethic of Schweitzer, who argues for reverence towards all that lives and a responsibility to preserve and promote it. The eight guidelines include the right to existence and being (sosein) independent of human desire, and suggest that interventions should only be taken after careful consideration of the needs of both sides. They invite us to rediscover plants based on four lines of argumentation: the
DESIGNING HABITATS FOR PLANTS

plant, plants and the environment, plants and humans, and the eligibility of plants. Ongoing research into plants, their physiologies, and their perceptions, responses, and interactions with the world keeps this discussion going and – along with how little we still know – it leaves room for speculation and discovery. This influenced how the explorations that took place within the scope of this research were conceived of, carried out, observed, and reflected and speculated upon.
The proposal to bridge the two departments of AB Ludvig Svensson was motivated by the company's philosophy of “improving climates for people and plants” (Svensson Climate Screens, 2015) and its history as a curtain manufacturer from the point at which the two departments separated. The IT department has a great deal of knowledge and experience of colours, patterns, and weave structures, which are used to design and develop woven upholstery fabrics and curtains for different contexts (transportation, solar control, sound testing, eco labelling), while the CS department benefits from a close relationship with plant growers and knowledge regarding how to create climate-control systems using textiles. Bringing together elements of growing crops and traditional interiors requires alternative ways of understanding, developing, designing, and producing textiles. As the general conditions for this already exist at AB Ludvig Svensson but the departments operate separately, the combining of the IT and CS departments for the purpose of an artistic research project opened up for developing perspectives that illustrate the passion for innovative solutions and complementary markets that AB Ludvig Svensson has exemplified throughout its history. In order to continuously push forward innovations, research is an important driver, and if not influenced by economic pressures, existing strategies, a focus on product development, and a 3-5 year perspective on the future, it is able to be driven by critical thinking and speculation, and influenced by emerging research fields and areas of interest from which new product families, applications, and business areas can be derived.

Through experimental methods, this research examined the intersection of interior textiles and living systems such as plants, and explored the design possibilities offered by biological and textile transformations and transience. These hybrids thus question the prevailing frameworks relating to durability, washability, neatness, and immutability in interiors, and challenge the current range of textile expressions, positing a shift from passive expressions, or dynamic and reversible expressions, such as a colour changing patterned textile, to dynamic and irreversible ones, e.g. patterned textiles transforming by growing grass. These systems and living materials also open up for a range of different interactions, e.g. watering and harvesting, expanding the programme of textile interaction design (Hallnäs & Redström, 2008) using a biological perspective. This biological perspective requires complementary variables such as relative humidity, light, and time with regard to textile design processes.
Modern systems for interior gardening that combine both functional (e.g. food supply, air purification) and aesthetic values are currently experiencing exceptional popularity, ensuring the prevalence of a different viewpoint on horticultural landscapes on the scale of the interior. Rather than simply providing functional solutions for indoor gardens, the artistic research programme aimed to propose a set of design principles for textiles and interior spaces. These principles opened up for alternative perspectives on future forms of living with plants, and suggested ways in which textile design knowledge, together with a “horticultural way of design thinking and acting” (Ludwig et al., 2012: 86) can generate alternative aesthetics and interactions in interior spaces.

By exploring the intersection between living and growing, alternative perspectives on living, involving organising and maintaining plants in hybrid spaces, arise. In order to explore the possible scenarios in which these alternative forms of hybrid cohabitation can take place, a range of interior textiles, was manufactured in collaboration with AB Ludvig Svensson, setup, and lived with, in a prototype house in a rural area in Sweden.

The textile hybrids took on the form of woven structures that hold the potential for transformation as a result of integrated seeds, and are able to function as conventional home textiles or be activated and, based on the parameters of their transformations, adapt to their intended expressions, use and location. They migrate from indoors to outdoors, illustrating aspects of a biological cycle that is influenced by both the environment and human management. Through their ability to migrate and transform, these textiles close the gap between the interior and the exterior, different environments, and nature and artifice.

The prototype house took on the form of a Tiny House on Wheels with a greenhouse attached to it and was able to adjust to different setups in relation to the textile plant structures, environmental influences and personal preferences. Through its ability to open and close, the Tiny House on Wheels provided a framework through which inside, outside and between spaces could be flexibly explored, and thus blurred the boundaries in between inside and outside, nature and architecture.

The programme explored two primary areas through experimental design research:

I Textile expressions, using seeds as dynamic materials for textile design

II Forms of indoor gardening through textile design materials
Within the framework of the Arcintex ETN, the On Textile Farming research programme opens a space in search of alternative ways and forms of living. This has been undertaken in two ways: Firstly, by approaching textiles and plants through art and design (Frayling, 1993; Archer, 1995; Cross, 2001; 2006) wherein experimentation and reflection were the core processes in order to explore responsive textile structures that challenge the boundaries between natural and artificial materials. Here, textiles mediate the intersection of living and growing, people and plants, inside and outside. Secondly, by approaching interior spaces using autobiographical research (Neustädter et al., 2014; Neustädter & Sengers, 2012) in the form of building a prototype house and living in it, creating spatial settings that promote ‘reflecting in action’ and ‘reflecting on action’ (Schön, 1992) and allow unexpected insights to result from experimentation and reflection, leading to new concepts and “new forms of knowledge” (Rendell, 2005) that express “the language of experience” (Stappers, 2007: 87) and open up the field to alternative perspectives.

1. Exploring Dynamic Textile Expressions by Integrating Plant Growth

Since much of the research experiments and examples demand certain environmental conditions, the research process followed the seasons whenever possible. This means that the survey of the field and the design and production of textiles was focused on in winter, followed by the setup and activation of the experiments in spring. From spring over summer to early autumn, following the growing season, the examples were observed and documented, then analysed and reflected on (Figure 2). With the approaching second winter and the experiences of the summer in mind, the concept development could start and lead to an iteration of the design, an in depth literature review and another textile production to prepare for the second ‘growing season’. Disturbances in this research process (due to different schedules in academia or industry) had a long-felt negative influence on the following research experiments, which makes the On Textile Farming research programme seasonal bound and less flexible towards conventional research processes, but however more compatible with the rhythms of nature and therefore to our nature.
The theoretical approach was built on a combination of different areas of research, with textile design and spatial design being brought together by what Ludwig terms a “horticultural way of design thinking and acting” (Ludwig et al., 2012: 86) and textile thinking. In relation to this research, this involved examining textile materials, structures, and patterns from a horticultural perspective and taking inspiration from biological phenomena and plant physiology (e.g. tropisms), and agricultural and horticultural methods, principles, and concepts, e.g. permaculture. Textile thinking in relation to this research means considering non-textile materials, such as plants, from a textile point of view by e.g. comparing roots and threads, and relating the two to textile techniques such as sewing and stitching. In this way both perspectives – the textile and the biological – are merged.

On Textile Farming explores fabrics woven using the materials and machines used for interior textiles, in relation to textiles in horticulture. Weaving was chosen as a foundational technique to work with for several reasons: it is the main technique used to fabricate interior textiles at AB Ludvig Svensson, and the climate screens are warp-knitted, which as a technique falls somewhere between weaving and knitting. The two systems of threads that are significant in the weaving technique allow a large variety of materials and colours to be used and facilitates more extensive manipulation of the cloth by moving the threads than is possible in e.g. knitting. In addition, a larger variety of structures is possible, allowing for open and dense or single and layered areas next to one another, and contrasting qualities (such as being flexible and stiff) in the same fabric. Experimental materials that are not suitable for an industrial loom but that have desirable combinations of qualities can be tested using hand-weaving, which was used to explore the seed yarns in an earlier stage of this research (Keune, 2018). In order to scale up the examples but limit the variables, the explorations focused on separate envelopes in different colours and with different structures and geometrical shapes, e.g. circles, squares, and stripes. Hence, double-weave structures with various geometrical envelopes were woven as envelopes for plants and substrate. The methods for the insertion of plants and substrate, activation of growth and transformation, and maintenance that had been developed and documented over the course of this research were used (Ibid.).

Figure 2: An overview of the research process (after the Licentiate) for the two primary areas - shaped by the seasons.
was a useful method and shaped the entire research process. Gaver and Bowers suggest selecting a collection of designs and re-presenting and annotating them with brief textual accounts as a method of communicating design research, arguing that this methodology is very familiar to designers and artists. Biggs also emphasises the importance of the link between research artefacts and text in communicating knowledge effectively, and highlights their interdependency (2004). In the context of this research, the annotated portfolio was not used solely to communicate research; instead, as a portfolio reflects the multidimensional nature of artefacts and provides space for interpretation and appropriation, it was used to document and analyse the experiments, sort the data, and reflect on similarities and differences in expressions and the principles and parameters that caused these.

Textual accounts were always created in order to build up a complete database of information for reading about, analysing, and reflecting on the images. In the 'Examples' chapter, the experiments are presented with regard to the annotated portfolio in order to summarise the experiments (to aid in e.g. viewing the photographs in the intended way) so as to clarify from which perspective and based on which considerations they were performed, the findings that they led to, and their connections to other artefacts (and the photographic representations of these). The main principles that were observed, e.g. the suppression of stems and leaves by a dense weave structure, were generalised by developing graphical abstractions that over the course of many iterations led to the design concepts that are presented in the 'A Methodological Framework' chapter. The framework therefore suggest changes “in how things are done” in order to advance the practice itself (Jones 1992: 6) and propose alternatives to already-existing methods or situations in design (Cross, 2007).

Reading about new findings in plant science and regenerative practices in agriculture and gardening constantly influenced the practical work and the observations, which were undertaken using photography. This provided a level of awareness and interest beyond the usual working hours with regard to the manifold relationships between e.g. plants, insects, microorganisms, and animals (including humans). The photographs were taken with a view to documenting and speculating on these possible symbioses. Artefacts made from living components “are singular and unique, with aesthetic qualities that arise from the understanding of the artifacts’ growth constraints and the bonds that are created with them” (Pinto et al., 2015: 2). Horváth argues that experiments reveal information with regard to influences and implications, inputs and outputs, and the relationships between these (2016). As a result, theoretical and observational approaches are fundamental and a photographic diary was used to observe phenomena over time, compare them, reflect on experiences, document key aspects, revisit past expressions and experiences (on the basis that the structures were made of textile and biological materials and so had temporal natures), and speculate on possible symbioses between textiles and plants. The images were analysed by categorising them in order to understand the various patterns of growth, along with the similarities and differences between examples (Figure 3). The 'annotated portfolio' (Löwgren, 2013; Bowers, 2012; Gaver & Bowers, 2012)
2. Exploring Ways of Living Between the Inside and the Outside

Due to the difficulties inherent in maintaining experiments without automated systems involving textiles and plants in academic and industrial environments, it became necessary to consider a different research method—one in which the research project and private life were more interlinked so as to allow more time to be spent on experimenting, maintaining, observing, and reflecting (Keune, 2019). Thus, an autobiographical design approach was chosen, which according to Neustaedter and Sengers allows researchers to “build a system, use it themselves, use this experience to learn about the design space, and evaluate and iterate the design based on their own experiences.” (2012a; b 28). They argue that such an approach should rest on the designer’s need to be confident that there is real engagement, that the system works from the start, that there should be rigour in documentation, and that it is lived with for a long period of time (Ibid). A suitable environment was needed to facilitate such an endeavour, in which the experiments could be integrated and ways of living could be explored by staging or gradually implementing alternative practices, systems, and environments. These needed to be interwoven into everyday life, and being exposed to and surrounded by design decisions in an intimate way was a prerequisite for exploring, evaluating, and iterating them. This led to the process of designing, planning, and building ‘Petersilie’, a ‘Tiny House on Wheels’ that also featured a greenhouse. This environment provided a framework in which to tinker and sketch with textiles and ways of living, supporting iterative creative processes both physically and conceptually in terms of imagining, designing, creating, testing, reflecting and speculating on, manipulating, and redesigning concepts. Sharing a living and working space with the design experiments allowed spontaneous observations and creative processes to occur, and this was supported by a space that was possible to adjust to new design ideas. Due to Petersilie constituting a joint living and research space, a deeper and more holistic understanding was achieved through the length of engagement and entanglement of private life and research work. The artefact was a building and a tool for generating multidisciplinary knowledge, and merged many aspects, including the floor plan, energy systems, embedding of the building in the environment, integration of textile artefacts, and experimental living practices, providing a framework for everyday living respectively ‘living my research’. Aspects of permaculture design, e.g. multifunctionality, nutrient cycles, and water and waste-management systems, inspired the explorations within the prototype.
house, and started with the mantra of ‘integrate rather than segregate’. In order to connect the inside and the outside, exterior expressions and experiences, e.g. plants, the branches of a tree, and vermicompost, were integrated with interior ones. The implementation of ‘small and slow solutions’ supported this by promoting direct contact with resources; for example, fresh water and grey water tanks needed to be filled and emptied, and a manual juicer was used to produce juice using herbs from the garden and feed worms with the scraps, who break down leftovers and provide nutrients to the garden. Observing and interacting with the place and systems helped to slowly provide an understanding of the potentials of ‘catching’ and storing energy in different forms and using and valuing diversity in terms of how the systems and everyday practices were connected. Simple, small, and slow solutions also allowed creative usage of and responses to change to take place, and for these to be considered within the process so as to enable objects to be used for multiple purposes (Figure 4). Therefore, the house and its inhabitation were designed to change according to various conditions, e.g. the seasons. During late spring, summer, and early autumn the greenhouse was part of the living room; during winter, it was more of a storage space or entrance. Another principle of permaculture is that a system should always provide multiple benefits and possibilities with regard to basic needs; this should be the case in order to ensure a system’s resilience. Consequently, Petersilie constituted a working prototype, an open framework that was easy to adjust and expand. It is an artefact in itself, but also provides an environment in which other artefacts can be placed, explored, and lived with. The house and the autobiographical research approach provided an environment in which to tinker with design creations, and allowed for a deeper and more holistic understanding through the quantitative and qualitative use of time. A diary of photographs, videos, and autobiographical stories presenting key observations and experiences was created (Figure 5) and published via Instagram (@textilefarming) and as a publication (Keune, 2019). The systems of the house are not directly connected to textile design, but the process of planning and living in the house led to deeper insights and assisted with the development of concepts and generalisations relating to textiles and plants in interior spaces. Both research paths inspired and informed each other as a result of comparisons between the results and the creation of relationships between the scale of textiles and the scale of space, e.g. textile permeability and spatial permeability.
A METHODOLOGICAL FRAMEWORK

The On Textile Farming research programme explored plants in relation to the design of interior textiles by integrating them into textile structures. However, this research did not focus solely on designing textiles that incorporated plants; instead, the experimental work with textiles was a method of developing a conceptual framework for how interiors relate to exterior spaces (e.g., the landscape, seasons, and weather) and their inhabitants (e.g., microorganisms, animals, and insects), and the roles that textiles could play in these scenarios (e.g., mediating between the inside and outside). Approaches to designing textile expressions with plants were investigated from two perspectives: i) a biological perspective on textile design, and ii) a textile perspective on plants, opened up with regard to spatial design. This novel paradigm in textile design provided an alternative perspective on the ways in which textiles can be designed, represented, and handled as materials for interiors. Therefore, this research proposes a conceptual framework for textile design and a novel way to consider plants and environmental factors when designing interiors. The results address different scales of design and the ways in which they are related when designing.

On Textile Farming consequently presents a conceptual framework that relates two design perspectives – the textile and the interior:

1. Designing dynamic textile expressions by integrating plant growth

2. Suggesting ways of living between the inside and the outside
1. DESIGNING DYNAMIC TEXTILE EXPRESSIONS BY INTEGRATING PLANT GROWTH

The design of textile expressions featuring plants was investigated from two intertwined perspectives: i) a biological perspective on textile design, and ii) a textile perspective on plants. In this research, the integration of plants in textiles was a method of developing a conceptual framework that would strengthen and re-establish the connections between interior and exterior spaces, the built and our ‘natural’ surroundings. Therefore, the developed design notions were intended to merge the expressions and qualities of textiles with those of plants, such that they became one. This demanded a range of changes in how textiles are thought about, designed, used, and cared for, as the principles, life spans, and life cycles of textiles and plants differ and can be very diverse. With regard to the decisions that were made on the textile design scale, textile components could be chosen and designed in two ways: to last or to fade. With the former, textile components could last and host several generations of plants, functioning as permanent templates in which seeds and plants are integrated or could integrate themselves. Annual plants, for example, are harvested and new seeds can be integrated for another growing season; alternatively, they can multiply through seeds or offshoots. Textile components could also be chosen and designed as a transient substrate that followed and promoted the life span of the hosted plant. Here, the textile structure could degrade after it had been planted outside, supporting the plants during their maturation and then being composted having served its purpose. The biological components could be chosen with different aspects in mind, including periods of dormancy and growth, along with longevity (annual, biennial, or perennial). Lettuce (an annual) was selected for its short life span and singular transformation, and for future iterations e.g. shrubs could be chosen for their long life span and annually recurring transformation.
The parameter slider bars in Figure 6 (hereafter referred to as ‘sliders’ and graphs) are graphical representations of how textiles and plants merge, and through which factors they interact. The sliders were used to characterize the images presented in the ‘Examples’ chapter and their relation to the underlying concepts. The level of abstraction was chosen in order to provide a simple framework for textile designers and others who are interested in merging textile and biological perspectives in relation to textile structures and interiors.

The first slider in Figure 6 represents the level of permeability towards or against which a textile plant structure can be designed for or described with. The textile structures, as facilitators of plant growth, allowed the integration of plants (e.g. in the form of seeds) and interactions in the form of e.g. an open weave structure for pea shoots to climb, or a dense structure to prevent sprouts permeating a specific area. Along with this textile permeability, the positioning of the plants within the structure had to be considered; pea plants, for example, require a certain amount of space below ground in order for their root systems to stabilise the plant and take up water and nutrients, and above ground in order to climb and flower. The size of the envelopes and orientation of the textile structures as plant mediators determined the transformation of the plants, e.g. whether root systems grew downwards within an...
The second slider in Figure 6 illustrates a simplified representation of a life span from dormant to dormant via one or several transformative stages. It can be used to design the life span of a textile plant structure or to describe one. A textile’s transformation is often caused by use or exposure to the elements, e.g. water, wind, or sunlight, over time, and can result in e.g. tearing, abrasion, loss of colour, or pilling. The transformations of a plant often start with the seeds’ exposure to water and sunlight, and result in a complex pattern of growth guided by e.g. wind, the directionality of light, other plants, and nutrients in the soil. Therefore, the life spans of the textile components and biological components, as well as the stages within these, build the foundation for designing irreversible, dynamic, and temporal expressions. Consequently, two different relationships with time need to be kept in mind when designing textiles in which plants are to be integrated.

The third slider in Figure 6 represents the degree to which a structure with integrated plants is designed for or exhibits textile or biological expressions. When incorporating plants in textiles and guiding their growth, the aesthetic qualities of the form of the plant and its life span have to be considered and envisioned. This means that the different visual expressions of a plant over the course of its life span have to be understood by the textile designer, and the textile designed based on this knowledge. This can be undertaken to benefit the textile expressions, through e.g. the growth of fringes, or for biological expressions, e.g. the growth of a flowering nasturtium. Here, textile and biological components can blend, contrast, or exist in harmony; the growth of roots, for example, blends with a textile structure due to the similarity to textile fringes, while green nasturtium leaves contrast with a red weave and a dense coverage of green grass contrasts with the grey colour of a weave, but blends through the dense surface coverage and similar thickness of grass leaves and textile threads, creating an aesthetic balance and harmony. The same can be achieved from a biological perspective, e.g. red nasturtium flowers can be blended with a red weave. Growing fringes from roots and flowering nasturtium are distinct, however. A textile perspective demands a high density of seeds and the exposure of roots, while a biological perspective demands the right conditions for one nasturtium plant to grow until it develops flowers. Just as there can be a hierarchy in the design process, there can be a hierarchy when designing expressions that change over time, and this can be undertaken according to the life span of either the textile or the biological material. However, it is the space between a blend and a contrast – a biological and a textile perspective – in which harmony is created and charged with both extremes, and so enables the two to meet on an equal footing.

The fourth slider in Figure 6 illustrates the degree to which the textile plant structure was designed or exhibits a biological perspective or a textile perspective. Designers must expand their palette of textile design processes with botanical and a “horticultural way of design thinking and acting” (Ludwig, 2012: 86). Two key perspectives are at play here: A textile design perspective, wherein expressions of growth are used to enhance the expression of a textile, e.g. by growing grass fringes on the textile’s surface. A biological/horticultural point of view, however, is concerned with creating textile conditions that benefit the development of a specific plant. The textile design consequently follows the needs and expressions of the plant and its life span, i.e. little space and nutrients at the beginning, much vertical space for the root system, and a sufficient mixture of nutrients for flowering. The plants and their temporality thus became guiding principles for the textile design practice and its processes, and so there is a hierarchy in the design process. However, designing textile structures such that they better integrate and accommodate plant growth involves intertwining both perspectives.

The textile designer becomes a designer of an ongoing process, and needs to envision and design alternative modes of designing and producing textiles, and envision and design temporal aesthetics due to the fact that natural and artificial materials and their different relationships with time merge. The textile designer needs to envision and design textile interactions of a new type, moreover, in which both textile and biological perspectives meet and envision and design the role of the plant’s ecosystems in the context of textile design.
Weaving a textile with permeability in mind is an attempt to guide growth and mediate between what is inside (below ground) and outside (above ground) a textile envelope. This has been undertaken by exploring weave structures with different levels of openness, which determine the level of permeability in relation to the plant and the type of germination. Textile permeability can be compared to the openness factor of solar screens, which AB Ludvig Svensson uses to describe the qualities of the interior textiles they produce to provide shade. A low value is given to structures that block more sunlight and are less translucent, while a high value denotes structures that allow more sunlight to permeate the fabric. In this context, the interactions between plants, weave construction, and the above-ground area are described by the slider in Figure 7. In this thesis, the term ‘construction’ is used to refer to the textile binding and the way the textile was constructed, whereas the term ‘structure’ is used to refer to the textile and textile-plant combination as a whole. A high permeability means that roots, stems, and leaves are able to grow through a weave, while a low permeability means that plants are restricted in their growth and expansion throughout a weave construction or in certain parts. However, textile permeability also affects the ways in which moisture can be absorbed and evaporates, and soil and moisture can be contained; thus, it may occur that a construction that is easy for roots and stems to permeate may also allow soil and moisture to leak out.

Figure 7: A slider that can be used to design or describe the degree to which the textile construction enables or prevents plants permeating it.
Figure 8: Plants in a textile envelope on impermeable and permeable surfaces.

The combination of a textile and seeds can be placed on either permeable or impermeable surfaces (Figure 8). On an impermeable surface, the roots spread horizontally in search of water and nutrients. In order to develop in a healthy way, moisture is required, and must be available in the microclimate. As the plant cannot permeate the surface on which it rests, it can only stabilise itself through horizontal outgrowth. The textile structure can still be moved, and so is mobile. A textile-plant structure placed on a permeable surface such as soil can permeate this and take root, thus stabilising itself permanently. As a result, the structure has a permanent and fixed position (Figure 8). Textile structures in which plants are integrated can be oriented both horizontally and vertically, and they can, for example, be suspended in space. Light is an important factor for growth in such a scenario, as is space, and a vertically oriented structure mediates how much light is absorbed, filtered, and allowed to pass through.

Figure 9: The interaction between plants and a textile in a horizontal orientation, in relation to the density of the construction of the latter.

Loose construction
Densely filled substrate

Figure 10: The interaction between plants and a textile in a vertical orientation, in relation to the density of the construction of the latter.

Loose construction
Densely filled substrate
The interior of a textile envelope is referred to in this thesis as ‘below ground’, and features climatic conditions (the textile climate). The exterior is termed ‘above ground’ and is also determined by climatic conditions (the microclimate), including what is behind, in front of, under, and above the textile (Figure 12). The introduced materials, e.g. cotton padding, coconut tablets, or soil, not only provide substrate for the plants but ‘upholster’ the envelopes, adding weight to the overall structure. The relations between moisture and density and weight of the substrate determine the behaviour of the textile-plant structure when it is folded or draped.

These examples show that designers can influence the aesthetic interplay of textiles, biology, and the environment and its parameters by making design decisions in relation to the textile, plants, and climatic conditions. Textile designers can choose textile materials based on their properties and colours, select weave structures, and determine positions and orientations in space. Seeds, as a dynamic material for textile design, can be chosen in relation to e.g. shape, size, colour, type of germination, and the shape of the leaf of the mature plant. Climatic conditions and the textile climate closely relate to both perspectives, and enable responsive transformations – if the colours of a sprout and the cloth blend or contrast, if the sprout manages to permeate the weave structure, if exposed roots remain fresh or turn brown and shrivel, and so on. These variables determine the interactions that take place between the growing plant and the places where the weft and warp intersect, as well as between above ground and below ground and between the textile-plant mediator and space in relation to climates.

The graphs presented on the previous page exemplify the explorations conducted regarding contrasting weave structures, e.g. plain weave and basket weave, to support or restrict the development of seeds. Figure 9 represents the interaction between sprouts and weave structures. Loose structures on the face and rear of a textile allow roots, stems, and leaves to permeate the weave, whereas a dense structure on the face in combination with epigeally germinating seeds supresses permeation and therefore plant growth. The combination of weave structure and seed type thus influences and directs growth in certain areas or directions. Roots, however, are less influenced by textile barriers due to their sharp tip and forceful growth. The growth of roots may be directed by e.g. gravity and the availability of moisture, as is illustrated in Figure 10.

Figure 11 depicts empty, densely filled, and loosely filled envelopes. The amount and quality of substrate determine not only the textile climate (relating to e.g. the amount of moisture that can be taken up and stored) but the weight, light levels in the structure, and how seeds interact with the textile. An envelope into which soil has been densely packed is more difficult for the roots to permeate; however, a loosely filled envelope might make it impossible for the sprouts to permeate the weave construction as they unfold their embryonic leaves between the substrate and the envelope (see example I.05 on p. 148 of this thesis). Sprouts generally have to permeate the ground and break through its surface in order to access what lies above. In this context, the surface was the textile structure, and so this, along with the substrate density and type of germination, determined whether permeation occurred.

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Textile Climates

The triggering of the germination processes of seeds requires certain climatic conditions. The climate that emerges within the envelope of a textile structure when it is filled with substrate and watered is referred to as a ‘textile climate’. As seasonal textiles are based on a certain textile climate, the graph in Figure 13 was used to describe the state of an example in relation to time and a beneficial climate. Here, the absence or presence of moisture is the major variable. ‘Dormant state’ describes conditions in which moisture is absent; ‘transformative state’ describes states in which moisture is present and transformation takes place. States between dormant and transformative (to the left) occur when some moisture has been added, and states between transformative and dormant (to the right) occur when the supply of moisture is terminated, leading to dormancy or the death of plants as a form of preservation of a certain state of growth, e.g. leaves prior to flowering or flowers.

Figure 13: A slider that can be used to design or describe the state of development of a textile structure with integrated plants.

Construction

A textile climate emerged through the insertion of substrate into the textile envelopes and the addition of moisture. The textile created a spatial division between the space enclosed by the envelope and that outside of it. This spatial separation represented the division between below ground and above ground, and consequently the division between roots and shoots, and their processes: shoots search for light above ground and roots search for water and nutrients below ground. However, whereas the space above ground is almost limitless, the space below (inside the textile) is not. As plants maintain a balance between the spaces that they occupy above and below ground, the space below ground that a plant has access to, i.e. moisture and nutrients, determines its development.
In a horizontal orientation, a textile has an upwards-facing side (the face) and a downwards-facing side (the rear). The face is usually exposed to light, which is absorbed or reflected by the textile structure, the elements that it contains (e.g. substrate), and the surface on which it is placed. A seedling in a horizontally oriented textile envelope is consequently phototropic. The microclimate on the rear of the textile is warm and moist. The roots, which are gravitropic, usually grow downwards and outwards from the envelope in search of a dark, moist, and warm environment. Hydrotropism, thermotropism, and chemotropism thus more strongly affect the roots below ground on the face and above ground at the rear.

Seeds can be located in different areas within a textile envelope, with one or many per envelope. When a textile is horizontally orientated, the seeds can be placed vertically in the substrate by expanding the textile envelope, and can be located in the top and close to the face in order to ensure maximum space for the downward-growing root and a minimum distance for the upwards-growing stems and leaves. Alternatively, the seeds can be placed at the bottom and close to the rear to allow roots to appear and impede the penetration of the face by the stems and embryonic leaves. They can also be placed equidistantly between these two points in order to observe the temporal differences in root and shoot development. On the horizontal axis they can be located in the corners of a textile envelope to accentuate their presence or in the centre to ensure that the maximum amount of substrate is available to the growing plant, as the expansion of the envelope creates the most space in the centre (Figure 15).
**Vertical Orientation**

Vertical orientation was also explored in the examples. Here, there is more below-ground space for plants due to the growth of roots downwards, and seeds can be placed differently within the structure, as is shown in Figure 16. When seeds are situated in the top part of a textile envelope the entire lower section is available for the roots to expand in; if the seeds are placed in the lower part of the envelope it is more likely that the roots will appear above ground. Other important factors for the appearance of roots include the size of the envelopes in relation to the plant growth pattern and time.

A vertical structure can direct the plants towards light or keep them in shade. The textile climate is crucial here with regard to e.g. the level of moisture and the temperature, as the evaporation of water and overheating of the substrate can overly stress plants. Vertical orientation, in comparison to horizontal, is space-saving and easy to make adjustments to with regard to e.g. areas of direct sunlight during the day for sun-loving plants. The flexibility and mobility of a vertical textile means that the textile-plant structure can be positioned flexibly and adjusted to the plants’ needs (Figure 17). As humidity is affected by gravity and thus moves downwards, it remains for longer in a vertical structure (see example I.10, p.172 in this thesis), and so more plants could be watered from above and be organised in relation to their needs, with e.g. drought-loving plants at the top and marsh plants at the bottom. Vertical orientation therefore favours the development of plants (biological perspective), while horizontal orientation favour textile expressions (textile perspective).
Seasonal Textiles

When stages of the life cycles of plants, e.g. germination, growth, and decay, are added to the life cycle of a textile, another relation to time is added. Seasonal textiles are created when textile climates meet textile permeability, spatial climates, and spatial permeability, as when the early-spring sun warms a greenhouse or a textile envelope in which seeds are placed is watered by rain and the seeds swell and germinate. A textile structure that has sprouted the green tips of seeds is therefore a seasonal textile, representing the spring indoors.

Construction

Figure 18 shows two paths that can be taken when designing the interactions and expressions of textiles and plants. During the experimental phase it was used to describe and categorise the examples with regard to either the textile perspective or biological perspective. This facilitated analysis, and the drawing of conclusions regarding important parameters when designing textiles in which both perspectives are relevant.

The term ‘textile perspective’ involves not only the variables relating to textiles, e.g. material and structure, but to the aim of the outcome – whether the textile structure is designed from a textile point of view, i.e. in order to create expressions that expand upon standard textile expressions through e.g. fringes of roots. Similarly, the term ‘biological perspective’ invokes not only the variables of the plant, e.g. the size and shape of the seed, but also the objective of the textile structure, namely whether it was designed to suit the needs of the chosen plant by e.g. providing substrate and nutrients for the entirety of the life cycle of the plant. Designing a textile from a textile perspective means enhancing or adding textile expressions that are created by plants. Therefore, the density of seeds in a textile...
envelope has to be increased in order to create a dense area of growth. However, this increased density can mean that there is a lack of space and nutrients for the plants to develop past their sprouting stage. By choosing a dense weave structure on the face and a loose structure at the rear of a textile envelope, along with a horizontal seed position and epigeally germinating seeds, the growth of roots is emphasised and the permeation of the face by sprouts prevented (see example I.03, p. 138 of this thesis). The roots expand the texture of the textile envelope, strengthening the textile expression and creating an aesthetic blend due to the fact that roots and threads share certain similarities (see example I.03, p. 138 of this thesis). From a textile perspective a horizontal orientation is beneficial as sprouts and roots would grow at a 90° angle due to gravitropism, and thus create dense coverage. This coverage would also be the equal result of climatic conditions, the textile climate, and microclimates. This focus on the textile expressions of plants can be seen as a harvesting of expressions, e.g. a green fur-like texture on a red piece of cloth.

From a biological perspective, a textile envelope contains far fewer seeds, meaning that the plants have the space and conditions that they need to develop up to a certain point, e.g. maturity or the flowering stage. From this perspective, a vertical orientation of the structure (or its use as a template to which an additional substrate is provided), is beneficial. The vertical structure provides more vertical space for substrate, and moisture for the roots to grow towards and absorb. Plant maintenance can be motivated by the aim of harvesting plant elements, e.g. sprouts, leaves, flowers, and seeds, or microclimatic benefits, e.g. cleaner air, scents, and increased humidity.

As both perspectives are temporal, harvesting demands selective timing, i.e. the needed resources (e.g. maintenance, time, nutrients, space) are made available to the structure until the desired expression has been achieved, and that the time of harvesting should be carefully selected.

Surface Expression

The examples were also categorised in terms of whether they presented contrasted or blended aesthetics using the graph in Figure 21 to describe the aesthetic relationships between biological and textile materials. How these are influenced by the colour and thickness of biological materials, e.g. stems and roots, and textile materials, e.g. yarns, is shown in Figure 22. The two seedlings in the horizontally oriented textile envelope show how hierarchical layering results in one aesthetic blend and one aesthetic contrast. An aesthetic blend can be created by e.g. choosing similar colours for the textile and biological materials, such as green yarns and seeds from which a green seedling will sprout. An aesthetic contrast can be created by e.g. choosing red
yarns and green plants, or green yarns and plants with red roots. The colours of the structure, particularly that of the textile envelope, are important, as these determine the expressions of the two sides of the textile and how they alternate. In a vertical orientation, however, the background construction, where both warps connect, also matters as it provides support to the upwards-growing plant. Aesthetic harmony is achieved when an expression neither blends nor contrasts, and both material categories fuse to create a new, hybrid expression (see example I.10, p. 173 in this thesis). As biological materials are temporal materials, their expressional changes over time are of particular importance as e.g. colours can change as the plant develops.

**Figure 22:** The expressional perspectives in relation to colour and the spatial orientation of the textile structures and the plants.

**Figure 23:** An illustration of how a plant and a textile can be influenced by environmental conditions (e.g. sunlight) over time in different ways, e.g. fading colours, growth, and decay.

**Figure 24:** A model that joins the textile perspective with the biological/horticultural perspective to describe the life cycle of a textile that accommodates plants. Three life spans are presented, exemplifying several possible scenarios. The dashed line is a structure that is used as a normal interior textile, and so is viewed from a textile perspective. After an intervention, e.g. watering, the integrated seeds germinate and the structure transforms, meaning that the biological perspective is now in focus. The plant, e.g. mint, can be harvested and eaten. Another intervention, e.g. the initiation of a drought, leads to another inactive phase and the preservation of the dried expression. This dried expression can be enjoyed, which constitutes harvesting from a textile perspective, or the dried leaves can be harvested to e.g. prepare an infusion.

**Life Span**

The developmental stages of plants relate to the seasons, and are defined in their blueprint; when optimal growing conditions are sensed by the seed, the plant’s metabolic machinery works hard to efficiently use the time available. This temporality of expression does not fit with the current focus on longevity and immutability in interior textiles. Consequently, a temporal perspective was suggested for interior textiles and spaces. While the temporal nature of biological and textile expressions differs with the seasons and other environmental influences - for example, plants constantly change shape in response to sunlight - and the colours of textiles gradually fade over time as a result of sunlight (Figure 23), aesthetic blends and contrasts are temporal in nature and can follow one another. Textile temporality thus merges the natural and the artificial using time, and seasonality is added to the expressions of textile structures that accommodate plant life.
The interventions that trigger an activation or deactivation are therefore actions of selective timing and are directed from a textile perspective (e.g., the harvesting of a textile’s expression resulting from biological growth) or from a biological perspective (e.g., the harvesting of edible flowers). The textile and biological materials and the length and nature of the seasons determine the quality of the transformation and the life span of the structure. The division of plants into annuals, biennials, and perennials could be used in the design of structures to assist in choosing textile and biological materials in relation to a specific life span—an inbuilt expiration date, so to speak. A textile expression that is the result of biological growth, e.g., a curtain with a brown furry texture, requires a dense coverage of plants with a restricted growth span that is determined by the plant itself or its environment, the textile climate, and the microclimate. Moreover, this must take place on a textile that can accommodate the plants for the duration of their growth period. After deactivation, the brown furry curtain arrives at its desired expression and can be used in the interior as an interior textile until it is no longer needed, at which point it can be left to decompose. In this scenario, the textile materials have a longer life span than the biological materials.

Due to the short life span of grass, the structure described in the previous paragraph could be understood to be annual as it has one temporal dimension. With a template for growth in which biological materials are exchanged and the textile structure accommodates plants during several growing seasons, however, the structure could be seen to be biennial or perennial. Here, the textile materials need to be more resilient to degradation as the textile-plant structure is active and occupied for a longer period of time (or several periods of time with a break between each). In a textile-plant structure featuring a substrate for growth (e.g., a structure for precultivating strawberry plants to be planted outdoors later), the growing season of the strawberry plants exceeds the textile’s life span: even though the plant is a perennial, the structure has one temporal dimension and can therefore be understood to be annual. The same structure that is lacking a substrate for growth but accommodates a strawberry plant indoors can be seen as perennial, on the basis that the plant will grow, fruit, flower, and form offshoots, and so has several dimensions. As a result, the textile will have to be adjusted or expanded to accommodate the offshoots.

Different time spans/periods, e.g., dormancy and transformation, can be seen as seasons, and the interventions as their triggers. As a transformation can affect the germination, development, or decomposition phases, it covers time periods of different length, meaning that the seasons of seasonal textiles also have different lengths. These do not necessarily follow outdoor seasons as interior microclimates are different from their outdoor counterparts, and can easily be changed.
1. SUGGESTING WAYS OF LIVING BETWEEN THE INSIDE AND THE OUTSIDE

*On Textile Farming* proposes a biological and horticultural perspective on designing spaces in which the interior is seen as an ecosystem in which biotic and abiotic components meet and thrive, in close connection with the interior and exterior environment. The growth of plants is thus invited into the context of textile interior design, opening up for reconsiderations of spatial design with regard to the conditions in which plants thrive. These strategies involved several challenges and opportunities, such as envisioning and designing microclimates to invite and enable seasonal expressions and conditions, and envisioning and designing new spatial interactions by considering various actors, e.g. plants, people, spaces, textiles, and microclimates.
Spaces as Mediators

Ludwig et al. argue that engagement in baubotanical structures means that “the ecosystem of plants is now playing a major role in the contextuality of architecture” (2012: 86), and so propose that a horticultural perspective be added to the design of spaces. On Textile Farming invites plant growth into the context of interior textile design, opening up for a reconsideration of spatial design with regard to the conditions in which plants thrive in spaces with e.g. seasons, natural light, rain, insects, animals, and microorganisms.

The first slider in Figure 25 illustrates the degree to which a space or structure can be considered to be permeable to environmental influences such as wind, light, and organisms (e.g. insects and people). Permeability is a fundamental concept when considering a spatial dimension, and invites climates and therefore seasons into spatial design. Spatial permeability involves designing the exchange of aesthetics, conditions, and climates between the outside and the inside. and is therefore a similar concept to textile permeability. However, while the latter relates to the capacity of a textile to provide opportunities for plants to interact, the former is the capacity of a space to provide diverse opportunities for all inhabitants, i.e. people, plants, and textiles, to interact and exchange with one another and the outside. Spatial permeability therefore describes relationships between time, function, and space. As plants need access to natural light, water, wind, and pollinators, outside conditions can be invited into the interior or plants can be moved outside occasionally, e.g. to meet pollinators, or permanently, e.g. to mature. Therefore, spaces need to offer permeable structures, e.g. floors that can be opened to let in cold air or that are designed so as to allow curtains to connect to the ground through roots, or walls to guide and filter rain or...
host and guide insects for pest control or pollination. This spatial permeability can be supported by textile structures due to their flexibility and mobility in terms of both position and orientation, as well as through their permeability in hosting and guiding transformations. For example, a vertical textile structure can insulate windows against the exterior during winter or summer while filtering rain to plants, which can be harvested or dried and stored inside in winter. Multifunctionality and connectivity are thus key factors for both textile permeability and spatial permeability. As ‘seasonal textiles’ logically lead to ‘seasonal interiors’, the two concepts are connected.

The second slider in Figure 25 represents the degree to which a space or structure relates to or is independent of seasons. However, an independent structure in this context does not mean that a separation from natural life cycles takes place; instead, these could be prolonged or brought inside through e.g. a composting unit, which is independent of the seasons because it is placed inside. These seasonal interiors introduce temporal expressions and experiences, which predominate over permanent expressions and experiences in interior spaces and so expand on spatial design aesthetics and design processes. Designers need to consider and design expressions of growth and decay, for example by increasing three-dimensionality through plant matter or introducing changes in colour or weight. Changing olfactory dimensions and aural impressions is also part of spatial design aesthetics and processes. Seasonal living involves designing and using spaces in relation to outdoor seasons and their effects on the interior, in which temporal expressions predominate over permanent expressions. Seasonal living demands a different relationship with time as the seasons determine periods of transformation through e.g. growth and decay, and therefore influence the aesthetics and level of care required by the interior and its inhabitants. A spatial designer can design in order to prolong and mirror the external seasons in the interior, or create additional or alternative seasons through the creation and intervention of microclimates. An abundance of smells, foods, and colourful expressions of autumnal plants can be achieved inside as well, in addition to the interactions related to them, e.g. drying herbs and flowers and harvesting beets. Through spatial design other types of interactions and expressions can introduce alternative or additional seasons, e.g. by opening the space to invite pollinators to meet a flowering curtain. Therefore, both new expressions and new human experiences enter the space, and have to be designed and guided.

The third slider in Figure 25 represents the level of mobility of a structure. The focus of spatial design should be ensuring that a space provides opportunities for plant mobility and access for the elements. The mobility of plants through their organisation within textile structures is an important alternative to the use of pots and rigid structures, as plants are dynamic and flexible within spatial settings in terms of their positions, orientation, and thus interactions. A harmony between ‘mobile’ and ‘static’ results in flexibility - a static space that is permeable and flexible as a result of its structure. This promotes spatial adaptations, which can be temporary or permanent, e.g. a floor turning into a workstation for two weeks or a vegetable box for a year.
Spatial Permeability

Spatial permeability is a concept that proposes opening up interior spaces with regard to environmental conditions by mediating natural expressions and experiences. In order for this to take place, spaces need to exhibit a certain permeability through e.g. openings to the outside such as windows, doors, openable floors, and interior systems that imitate exterior processes such as composting. In this way, resources and seasonal expressions, e.g. water and the smell of summer rain, are accessible in the interior and can also be created in the interior, and interior conditions such as a more stable climate are available to exterior organisms such as plants. Open boundaries and suitable materials are necessary to facilitate the exchange of e.g. water in order to nourish plants and invite wind and pollinators into the home. When designing a space in which plants that need pollination grow, access for pollinators is required, and so the space must be permeable to them. Cohabitation includes certain challenges; water can damage parts of the interior, and the spaces that insects do and do not have access to need to be communicated, as do entrances and exits. Time is an important factor, as are selective invitations and repudiations, just as with the concept of textile permeability (although in this context it is seen from a spatial perspective).

This perspective consequently changes the design of spaces, from finished results to open frameworks in which alternative ways of living can be set up, prototyped, and tinkered with. In this context, textiles can support spatial permeability through their own permeability, as is discussed above. With regard to spatial permeability there is the aspect of different climatic conditions and zones, as the outside and inside mix when a space is open.

The graph in Figure 26 is identical to that presented in the section on textile permeability. Both concepts are connected as the woven and situational examples were evaluated in relation to their level of openness in general and with regard to interactions in particular. A high level of textile permeability means that seeds and substrate are easily integrated, plants easily interact with textiles, and the textile and spatial climates reach an equilibrium more quickly. A high level of spatial permeability means that there are fewer boundaries between inside and outside spaces, and that indoor and outdoor microclimates, expressions, and experiences can blend and interact more quickly. Spatial permeability thus influences spatial climates and enables seasonal interiors.

Figure 27 shows the spatial setup used in the context of this work; the large rectangle represents the house on wheels from above, with its ground floor marked in grey, two lofts in light grey, storage in dark grey, and windows, doors, and openings indicated with dashed lines. The smaller rectangle that extends the house is the greenhouse; its openable floor is marked in dark grey, and features windows located on the walls facing the outside, a translucent roof, and an opening facing the main door of the house. Here there are two distinct microclimates; the exterior, which is determined by the seasons and weather, and the interior, where the microclimate is controlled by building strategies and energy systems, e.g. insulation and a heating system. The intermediary space is therefore a mix of both the interior and exterior microclimates. The textile climate is the smallest microclimate, and exists inside the structure that mediates plant growth; thus, the two perspectives (the textile and the interior) are connected. These interrelationships are the focus of On Textile Farming, and what bring together designing textiles and ways of living.
Spatial Climate

Figure 29 shows three microclimatic zones: the outdoor microclimate, the intermediary microclimate in the greenhouse, and the indoor microclimate. The microclimates indoors and outdoors determine the intermediary microclimate, which is located between the two, opening up for a seasonal use of spaces. In winter, the greenhouse benefits from the heating of the interior and the intermediary microclimate is less harsh as it is protected from snow, rain, and wind. In spring, it absorbs the warm sun from outdoors, causing the growing season to begin slightly earlier and warming the interior space due to the fact that the latter is better insulated and so does not warm up as quickly as the greenhouse. In the summer it is too hot in the greenhouse, and so the floor can be opened to let in air; in addition, the skylight indoors can be opened to create an airflow through the greenhouse that cools the space with a stack/chimney effect.

There are climatic differences, however, between each of the zones due to the fact that e.g. heat rises. Consequently, there are different temperature levels between the floor and the ceiling, opening up for using these climatic differences for the vertical cultivation of plants. The textile climate and the spatial climate are therefore connected, and can influence one another. A textile envelope positioned at the top of a vertical structure has a drier and warmer textile climate than one positioned lower due to the fact that heat rises and humidity moves downwards within the textile climate. Another climatic factor is sunlight entering through windows. Here, textile structures could create two zones by dividing a space horizontally, exposing sun-loving plants to the window and providing shade to those plants that are sensitive to direct sunlight (Figure 30).

Figure 28 is a graph that has been used to describe whether design examples are mobile or static. Here, elements that are part of the spatial structure are defined as being static, while temporary examples that can be moved are considered to be mobile.
Position and Orientation
As textile structures with integrated plants can change position and orientation, they make use of different spatial climates both vertically and horizontally. Figure 30 shows a structure that was vertically connected to the outdoor microclimate and made use of gravity. Water on the roof was led into the structure, which was suspended in the greenhouse and reached down through the open floor. The water inside the textile flowed down into the ground as a result of gravity. Here, the outdoor space was connected to both the greenhouse and the outdoors, and so two climate zones were vertically connected through a resource being guided through the structure. Figure 31 illustrates the different spatial climatic zones that are created by the influences of direct sunlight, greenhouse and vertical textile.

Figure 31: Different climatic zones through radiation, the glasshouse effect, and light and shadow.
Above and Below Ground

Above- and below-ground areas in textile envelopes can be connected to spatial climates and interior spaces in general, as their characteristics are the presence and absence of light and different temperatures and levels of humidity. Below-ground conditions occurred within the house, as is shown in Figure 32, as a result of the presence of an evaporative cooler for food storage, a worm farm, a bokashi fermenter for processing food waste, and a storage space for water. The below-ground spaces in the greenhouse included a soil bed and the below-ground envelopes of textile structures that integrated plants.

Above-ground spaces were exposed to light and therefore changing temperatures, whereas the below-ground spaces were more resilient to changes. The climate-controlled inside space was relatively stable and warm as it was usually maintained at approximately 20°C for the comfort of inhabitants. As the greenhouse lay between the indoors and the outdoors and was shielded with glass windows, the microclimate here was influenced by but not wholly dependent on outdoor conditions, such that it was less cold in winter due to protection from wind and snow. The sun had the greatest effect on the climatic conditions in the greenhouse, and warmed the space quickly. Outdoors, the most stable climatic zone is below ground. The deeper below ground, the more stable the temperature.

Changes in outdoor climates take place slowly; for example, the sun slowly heats soil, which stores thermal energy and slowly cools as temperatures decrease. The qualities of the below-ground areas were beneficial mainly for storage of e.g. fresh water, root vegetables, fruits, and other edible plants.
Seasonal Interiors

Seasonal textiles add temporary expressions to interior spaces, and thus enable seasonal interiors. The seasons introduced by seasonal interiors differ from those of the outdoors, or define other seasons that emerge through expressions, experiences, and practices that are repeated in a certain way: The flowering of pea plants in spring, the smell of flowering calendula in summer, the harvesting of spinach leaves at the end of winter, a certain pattern of light and shadow in the interior, or the need of plants for pollination mark the seasons.

The graph in Figure 33 was used to describe the level of temporality and seasonal dependency of the situations described in the ‘Ways of Living’ chapter. Seasonal situations occur under certain conditions and are temporary; they are usually sensitive to changes in the space, e.g. temperature, humidity, the length of the day, and intensity of direct sunlight. Independent situations are more stable in themselves, exhibiting less sensitivity to changes, and can therefore be of a more permanent nature. Figure 34 represents a potential life cycle of a textile structure with integrated plants used first as a spatial separator indoors, then filled with soil and substrate and moved to the greenhouse, where it transforms as a result of precultivation. With the arrival of beneficial weather conditions the structure is moved outside, and continues to thrive. After harvesting, it is taken down and left to biodegrade. During its life cycle, the structure thus connects three climate zones through changes in its position. Seasonal interiors are enabled by both concepts described in the following chapters: spatial climates and spatial permeability. The latter enables an exchange to take place between the inside and outside, e.g. wind, rain and insects can be given access, whereas the former direct the foundations of seasonal interiors and expressions inside, e.g. by imitating spring indoors during winter outdoors in order to precultivate plants for later outdoor planting.
The two chapters that follow – ‘Textiles as Plant Mediators’ and ‘Ways of Living’ – describe the examples and illustrate the conceptual framework which both derived from the experimental work that was carried out. The chapters can be distinguished through the two design perspectives - the textile and the interior. Both perspectives are represented in the structure of this thesis and consequently guide the way in which the examples are presented, following the conceptual framework that On Textile Farming presents:

1. Designing dynamic textile expressions by integrating plant growth
2. Suggesting ways of living between the inside and the outside
TEXTILES AS PLANT MEDIATORS

Figure 36: A textile envelope blending with the colours of the branching stalks of a nasturtium plant.
BETWEEN HORTICULTURE AND INTERIOR DESIGN

In order to make seeds blend with the expressions of textiles and textile techniques, they have to be brought into contact with textiles. ‘Transforming Textile Expressions by using Plants to Integrate Growth, Wilderness and Decay into Textile Structures for Interior’ (Keune, 2017) and the Licentiate Thesis ‘On Textile Farming: Seeds as a Material for Textile Design’ (Keune, 2018) describe the integration of seeds in textile structures such as tubes, yarns, and non-woven, crocheted, hand-woven, and Jacquard-woven envelopes. The examples involved integrating dormant seeds in textile structures, and their activation and resulting stages of transformation were studied over time. Both the sprouts that grow from seeds and certain seeds themselves are edible. ‘Al Dente Textiles. Notes on Edible Textiles as Economic and Ecological Intermediality’ (Heinzel et al. 2017) presents edible textiles as an alternative, hybrid medium. Expressions of decay as a part of the life cycle of a plant are discussed in both the Licentiate Thesis and the article ‘Co-designing with plants: Degrading as an overlooked potential for interior aesthetics based on textile structures’ (Keune, 2017). Double-weave structures used to accommodate seeds and substrate are discussed in ‘Growing textile hybrid structures: Using plants for constant/dynamic textile transformation, an approach towards Biophilic Urbanism on the scale of the interior’ (Keune, 2017). Here, a range of striped and circular patterns were used to weave black and white envelopes on a Jacquard loom at AB Ludvig Svensson. Using textiles as envelopes for plants in the context of the interior and sustainability alongside textile design and architecture students is discussed in ‘Earthy textiles: Experiences from a joint teaching encounter between textile design and architecture’ (Femenias et al, 2017). This chapter presents the next iteration of double-weave structures, to which colour was added in order to explore the potentials of seeds as materials for textile design. The findings which derived from there opened up for the concept of spatial design.
Setup

The explorations described in this chapter focused on industrially woven double cloth with individually placed envelopes in geometrical shapes, e.g. circles, squares, and stripes. Figure 37 shows the designs of the rectangular envelopes. The left part of each image shows the face and the right side the rear of the fabric. Each colour represents a different weave construction and therefore explore a different mix of colours, resulting from the different ways in which weave construction and coloured weft and warp threads interlace. The brown and violet areas show where the black and white warps interlaced. The warp material was black and white (1:1), with a 32/2 mix of wool (85%) and polyamide (15%), and consisted of 4096 threads at a density of 27 threads per cm, giving a width of 150 cm. The machine and warp used are usually utilized to produce an upholstery collection called ‘ACCESSOIRE’. Circles, squares, stripes, and cheques were explored in relation to dense and loose pocket-weave structures, described on the following pages. A loose binding is a weave structure in which the warp and weft threads are interwoven in such a way that they can be easily separated, and is characterised by floats and fewer binding points, e.g. basket weave and aida cloth. Dense bindings are weave structures with a greater number of binding points, creating a dense and stable grid of interlaced threads that cannot be easily permeated. The looser a structure the greater its permeability and thus the easier it was for the substrate and seeds to be inserted and interact with the weave construction. Figure 38 shows the pattern of five circular envelopes, spread over the entire width of the warp. The upper row represents the face of the textile and its weave structure and the lower the rear. The circles (Figure 38), squares (Figure...
The four patterns in Figure 38 illustrate two and three adjacent envelopes in order to investigate modularity. Here, the space and substrate available to the plant were modified over time, and the textiles were able to accommodate two different plants that were either beneficial to each other or exhibited contrasting expressions in relation to size, colour, and direction of growth.

Figure 40 shows a textile design that was used to explore different stripe diameters and spacings. As these connected spaces vertically, gravity played a major role, as it does in plant development and the movement of moisture. Cheques in Figure 41 created vertical and horizontal connections, as well as connections between the stripes that they were constructed from. These crossing points enabled connections in all directions. The structure/construction that connected both warps is marked in brown and violet in Figures 37-41.

The black and white warps, along with the weft (which was made using materials of multiple colours) were a mixture of wool (85%) and polyamide (15%). The materiality of the textile structure itself was not a focus when conducting the experiments. The materiality of the warps and weft materials, however, are of major importance and need further investigation in relation to developing a system that enabled plants to grow successfully in textiles in terms of whether the structure absorbed or repelled water, was biodegradable, and resisted environmental influences over time.

37), and stripes (Figure 40) were of different sizes in order to explore how the size and shape of textile envelopes affected the integration and transformation of plants. This was examined from two perspectives: supporting plant growth (the biological perspective), with just one seed integrated, and investigating plants as materials that support textile expressions (the textile perspective), with a number of seeds inserted. The experiments thus focused on the interplay between the permeability of weave structures and colours, the shapes of envelopes, and the shapes and colours of growing plants.

The separate envelopes made maintenance more difficult, and so the experiments and examples did not focus on developing a system to support plants successfully growing in textiles; rather, the focus was on how plants and textile structures interact, and the concepts and principles for designing with seeds that could be drawn from this. The findings then led to propositions for textile design practice and how a biological perspective on textile design can lead to changes in spatial design.
Figure 40: Face (top) and rear (bottom) of the striped design.

Figure 41: Face (top) and rear (bottom) of the check design.
Figure 42: The image shows the pattern of a textile envelope with plain weave on one side and satin on the other (DWPS).

Double-Weave Plain Satin (DWPS)

Figure 43: Face and rear of the design.

Figure 44: A three-piece textile envelope with plain weave on one side and satin on the other (DWPS).

Figure 42 shows a plain- and satin-weave pattern. As a dense weave construction, plain weave is very strong and hard-wearing, making it suitable for e.g. upholstery fabrics. Satin weave is characterised by floating weft yarns and an irregular structure. It is more flexible and has better draping characteristics than plain weave, which makes it suitable for e.g. fashion or decorative fabrics. The woven pockets visible in Figure 44 were constructed using two dense weave structures (Figure 42), which were chosen in order to investigate whether certain plants, e.g. grass and legumes, and their components, e.g. stems, leaves, and roots, are able to permeate the pockets and how they interact with the structure. The structure that was used is referred to hereafter as a ‘double-weave plain satin’ (DWPS). In order to explore textile design variations in terms of colour, the pattern was rolled in the warp or weft to exchange the warps or switch the places of the face and rear. Figure 44 shows the face of a double-woven fabric with a bullseye pattern; it features a red and blue weft binding with a black warp in satin weave in the central circle and outer ring, and a blue and green weft binding in plain weave with white warp in the middle ring.
Figure 45 shows the pattern of a woven structure with plain weave and basket weave, referred to hereafter as ‘double-weave plain basket’ (DWPB). A basket weave is a variation on a plain weave in which groups of warp and weft threads are interlaced, resulting in a chequered appearance and a soft and loose textile. The weave structure is relatively compact but, due to the grouping of the threads, these can be easily separated from one another. The woven pockets shown in Figure 47 consequently exhibit a dense, loose, and permeable weave structure. The separated warp and weft threads on the face of the inner circle that are bound using the basket weave technique by the black warp reveal the underlying plain weave with white warp and red and blue weft threads. The loose basket weave allowed alterations to the structure to be undertaken, and enabled the envelope to be filled with substrate and seeds. The textile invited the growing plants to interact with it by allowing more light and moisture to enter, and by providing space in which to grow as a result of the interlacing threads, expanding the expression outside of the textile envelope. Dense structures such as plain or satin weaves prevented or reduced interactions between textiles and plants, creating a stable envelope. The examples with combinations of loose (and therefore open) constructions and dense (and therefore closed) ones were intended to guide growth and explore different plants with regard to e.g. types of germination.
Figure 49 shows the pattern of a twill weave and an aida weave (mock leno weave), referred to hereafter as ‘double-weave twill aida’ (DWTA). Twill weave is characterised by a pattern of diagonal parallel ribs, achieved using floats across the warp yarns in a progression of interlacings to the right or left. The fewer the interlacings the more freely yarns can move, making the cloth not only softer and more pliable but more permeable. Aida (mock leno) weave is created by tightly binding together several warp and weft threads with one or more floats, creating a lattice-like transparency and thus a relatively open weave. As the warp yarns are not twisted around the weft yarns (as they are in a leno weave), the threads can be displaced with relative ease, resulting in a highly permeable structure. The weave construction shown in Figure 49 featured a loose face and rear, and was used to explore the integration and interaction of plants and substrate. Figure 48 shows a design featuring a bullseye pattern of envelopes. Twill was visible on the face of all three, and aida was visible on their rear. Through an exchange in weft colours and warps a variety in surface expression was achieved, even though the same bindings were used.
Integrating Plant Growth in Textile Structures

This section presents a method for integrating seeds and soil in the unfilled envelopes of double-weave structures. As a result, the piece of cloth becomes a textile envelope that can be used to grow plants.

The pocket-weave structures, which were created using alternating dense and loose constructions, allowed the integration of seeds and substrate. The threads of the loose structures, e.g. aida, twill and basket weave, were possible to move, so as to create a hole without damaging the fabric (Figures 51, 53). Seeds and substrate, e.g. soil or cotton padding, were inserted by creating an opening by moving aside the warp and weft using the tip of a wooden bobbin used in hand-weaving (Figure 55). Figure 56 shows the opening, through which is visible a dense binding at the rear; the filled envelope containing a nasturtium seed is shown in Figure 53, and the closed envelope in Figure 57. Having been filled with substrate, the closed structure was slightly thicker and softer than the unfilled envelopes, and so the weave structure was slightly distorted (Figure 57).

Figure 51 shows a mid-sized circular envelope containing cotton padding and a small seed in its centre. The differences between the sizes of seeds and envelopes were examined, although in many cases several seeds were inserted in order to explore higher growth densities with regard to the surface expression.
Figure 58: The channels of a suspended pocket-weave were filled with seeds and soil using a funnel and a screw-driver.

Larger envelopes were filled using a funnel consisting of an adapted plastic water bottle, which facilitated the insertion of loose substrate, e.g. soil or perlite, and seeds. Rabbit droppings, which were a resource that was freely available outdoors and does not have downsides such as a bad odour or wet texture, were inserted as fertiliser. Figure 58 shows a textile structure with vertical stripes; a hole was created in this and the funnel was inserted so as to fill the envelope with substrate and seeds, which were stuffed into the channels using a screwdriver. A larger channel diameter meant reduced friction, facilitating the distribution of the substrate throughout the length of the channel with the assistance of gravity and movement. Figure 61 shows the connection between the water bottle and the open weave of a large circular envelope. In order to create as much space as possible for the substrate to be distributed in, the funnel was located close to the edge of the textile rather than in its middle. Insertion was much easier in this case due to the lack of friction in the envelope.
I.01 A Mixture of Seeds in a Large Envelope

Figures 63 and 64 show the face of an envelope that was filled with soil; the rear is shown in Figure 62. The large circle was woven using DWTA. The soil deformed the fabric, added weight, and created a contrast in terms of both physical dimensions and colour (the envelope in relation to the rest of the structure), characterising the expression as a ‘contrast’ with regard to the third slider in Figure 73. The stuffed fabric was possible to shape rather than drape, and responded to pressure by altering the vertical and horizontal space below ground that was within the textile envelope. The insertion of a number of different seeds in a large envelope created a textile with several different life spans (in terms of e.g. germination rates) and contrasting expressions (e.g. colour contrasts between plants and the structure).
The process of transformation that was triggered by the damp soil was carried out when the textile was oriented vertically, meaning that there was more vertical space available for root development than if the textile had been in a horizontal orientation. Figure 66 shows the white stems and embryonic leaves growing upwards, against gravity and towards light. The loose weave structure provided enough resistance to envelop the damp soil, and enough permeability for the above-ground parts of the plants to pass through, which is why the expression was characterised as ‘permeable’ on the fourth slider in Figure 73. The white and green sprouts created an aesthetic contrast to the black warp and red and blue weft threads on the face of the envelope (Figure 69). The small seeds were positioned throughout the envelope. Although there was a large quantity of substrate for the roots to develop in, they quickly reached the bottom of the envelope and permeated the weave (Figure 66). Due to the rapid evaporation of moisture, the sprouts withered and collapsed against the textile due to gravity and faded in colour (Figure 67).

Figure 69: The first type of seeds germinated and their sprouts interacted with the twill weave construction.
After the sprouts withered (probably due to a lack of water) another different sprout appeared at the very top of the circular envelope (Figure 68). The different time periods and requirements for germination and growth opened up for temporal expressions that were shaped by the appearance of one kind of plant after another. The different states shown in the photographs are compared to one another and to time in the first slider in Figure 73.

As the face of the textile faced the light (with the rear in shadow), most of the sprouts appeared on the face. Figures 70 and 71 show the sprouts that appeared on the rear. The white stems of the three sprouts in Figure 71 and the white root in Figure 72 blended with the white warp threads due to the colours and thicknesses being near-identical. The different seeds introduced different time spans with regard to the biological perspective of the structure, and were able to grow simultaneously, one after another, or briefly offset. As seeds often have different triggers for their activation, e.g. frost or a constant warm temperature, the envelope can be seen as a storage place in which the plants grew in response to beneficial conditions. As the plants shared one envelope, they could be selected based on whether they were beneficial for the development of one another, or based on different life spans and germination triggers.

In Figure 69 it is difficult to ascertain whether the structure can be characterised as constituting a biological perspective or a textile perspective, as the sprouts had sufficient space and substrate at that time but not for their future development. Their number and distribution across the surface of the envelope also suggested that they were a decorative pattern that temporarily expanded the expression of the textile, which is why a neutral perspective was chosen to characterise the example (see Figure 69 in particular) using the second slider in Figure 73.
TEXTILES AS PLANT MEDIATORS

1.02 A Horizontally Oriented Bullseye Pattern

This example consisted of a bullseye pattern of circular envelopes; a handful of radish seeds was placed in the densely filled central envelope, and the textile was oriented horizontally. The cloth was positioned with the dense weave structure at the top; the loose weave was at the rear, and watered. After four days, red roots emerged from the weave structure and unfolded at the rear of the envelope (Figure 74), while the face was unchanged. In order to help the sprouts permeate the weave structure, small holes were created by separating the warp and the weft, and one sprout appeared (Figures 77 and 78). Consequently, the rear was characterised as ‘permeable’ and the face was characterised as ‘impermeable’.

A bowl of soil was placed underneath the structure to provide a suitable microclimate for the roots to develop in. The red roots and particles of soil created an aesthetic contrast in the area in which the white warp intersected the green and blue weft and an aesthetic blend in relation to the middle ring, where the black warp interwove with a light-blue and rose-coloured weft. Viewed from above, the red stem on the face created an aesthetic contrast with the weave structure it grew out from (black warp with light-blue and rose-coloured weft), whereas the green leaves blended with the green and blue weft of the middle ring. A characterisation between ‘blend’ and ‘harmony’ (slider three in Figure 81) was thus chosen.

From the side (Figure 77) it was possible to consider the orientation of the sprout, which was diagonal, likely in response to the direction of a source of light. Due to the additional access to moist soil, the life span of the plant was prolonged; moreover, its access to water was improved (as moisture evaporates quickly from textiles). Conversely, the colours of the sprout blended with those of the face of the envelope such that the sprout was barely visible. However, the rear of the envelope developed a layer of mould, which caused the death of the plant; it collapsed on the weave’s surface. The expressions of degradation on both sides created an aesthetic blend of textile and bi-
This example shows that a dense weave construction can prevent some sprouts from permeating its surface, and that the growth of roots can take place in the opposite direction to gravity when the microclimate below a horizontally placed structure is beneficial. In this way, the growth of roots can be emphasised over the growth of sprouts – or, in other words, it is possible to add only the expressions of roots, which are similar to threads, to the overall expression of the textile. The growth of sprouts can be guided by creating a hole in the structure through which they can grow. The example also shows a life cycle that was shortened by mould, although this augmented the expression by creating an aesthetic blend of textile and biological components on both the face and rear.

The roots that appeared at the bottom of the textile exemplify the phenomenon of gravitropism, and revealed that circular modules in a horizontal position can function as a template for growth, rather than a substrate, and that the pattern functions well from a textile perspective but does not provide a beneficial environment in which plants are able to develop over a long period of time. By integrating a larger number of seeds, a coverage of plant growth was achieved. The sprouts were able to permeate the loose weave structure, expanding the dimensions of the envelope in relation to the above-ground microclimate with regard to e.g. light. By using a dense weave structure, the growth of the sprouts was impeded or prevented, while the growth of roots was supported by providing a beneficial microclimate outside the envelope, where they took root and absorbed nutrients and moisture.
1.03 A Vertically Oriented Bullseye Pattern

This example consisted of a bullseye pattern of three circular envelopes; a brokkoli seed was integrated in the densely filled central envelope, and the textile was oriented vertically.

Figure 82 shows the young seedling that permeated the relatively dense DWPS weave structure at the top of the rear; it grew upwards, against gravity, and thus was in line with the vertical orientation of the fabric. The length of the stem was equal to the diameter of the circle that it grew in. The middle ring and the white stem were in harmony due to the white warp binding and light-blue and mint-green weft. In front of the outer ring, the stem created an aesthetic contrast with the black warp and blue and red weft. The two dark green embryonic leaves were in harmony with their background, and neither blended nor contrasted. Consequently, a characterisation determined by 'harmony' was chosen on the third slider in Figure 86.

When designing with plants, the surface that will form the background for the plant has to be considered, particularly when working with a vertical textile orientation. The fact that the plant looked healthy suggests that it found a beneficial climate within the textile filled with soil. However, it attempted to expand its root system downwards, and permeated the bottom of the circular envelope (Figures 82 and 84). The above-ground microclimate was not beneficial to the development of the roots, and so they withered. The size of the envelope however provided an adaptable supply of nutrients and space for the root system to expand and absorb moisture. The textile supported the growth of the plant for a limited amount of time which is why a characterisation between a 'textile perspective' and a 'biological perspective' was chosen for the second slider in Figure 86. The fact that the roots appeared above ground (outside the protective envelope) indicates that the plant needed additional space and support mainly downwards. Roots could therefore serve as an indicator of the internal relationship between the textile and the plant.

Despite the vertical orientation of the cloth, which provided more space for the root system, the roots appeared above ground, at the bottom of the envelope. Here, the circular pattern with three adjacent envelopes facilitated the insertion of...
soil into the undersides of the outer, increasing the quantity of substrate available to the plant in a downwards direction. Figure 84 shows the subtle three-dimensionality of the central circle, and the roots poking out, one of which reached all the way from the innermost ring to the outermost, passing over the middle one. As the roots grew downwards, only the inner and lower part of the outermost ring was filled with substrate in order to explore whether the roots, once above ground, would permeate the structure again in order to return below ground in search of nutrients and moisture. However, the plant died before this could be tested. A characterisation towards ‘impermeable’ was chosen for the fourth slider in Figure 86 due to the dense plain and satin weave constructions. However, the sprout managed to permeate this construction. Figure 85 also reveals the different densities of substrate in the envelopes, which also affected the transmission of light. The double weave had a degree of translucency, while the areas filled with substrate were opaque. Affecting lighting and thus climatic conditions using a vertical textile structure and substrate would complement a weave construction in certain areas. However, a characterisation towards a ‘biological perspective’ was

**Figure 84:** Close-up of the roots permeating the bottom of the central envelope.

**Figure 85:** A front view with backlighting reveals the different levels of translucency.
chosen as it was possible to increase the amount of substrate and due to the fact that only one plant was integrated in the bullseye structure.

This example illustrates two states; the original textile envelope in Figure 87, and the manipulated one in which a plant grew in Figures 82, 84, and 85. A dormant state and a transformative state are therefore represented, as shown in the first slider in Figure 86. As the plant did not continue to grow, this point was seen as the final with regard to the transformation of the example.

The example showed that the bullseye pattern did not constitute an efficient use of space when plants were accommodated in the central circle: as the roots generally developed in a downwards direction, the rest of the space was unused. When a textile-plant structure is in a horizontal orientation, roots tend to grow downwards rather than horizontally, even when there is more soil to take root in in the latter direction. Accommodating a plant in the topmost part of the outermost ring of the bullseye would make better use of the existing space. In the design of a textile, however, it is important that the choice of plant for integration with the textile takes into consideration the fact that plants blend and contrast in ways that change over time.
I.04 A Large Circular Envelope in a Vertical Orientation for Accommodating Lacinato Kale

This example consisted of a large envelope filled with a handful of lacinato kale seeds and soil, located in the centre of a vertically oriented envelope.

Figure 88 shows a small lacinato kale plant in an envelope. A hole was created in the DWPB material in order to ascertain whether any transformations had occurred within the textile envelope, as no external evidence for this had appeared over the course of several weeks. The hole revealed the stem and leaves of a lacinato kale sprout, hiding in the textile and thriving in the textile climate. The lack of sunlight caused the yellow colouration of the leaves. Figure 89 shows the transformation, which was revealed by cutting away one side of the envelope. As no roots permeated the bottom of the envelope, the sprouts had sufficient space and nutrients available; however, the cutting of the cloth brought an early end to the experiment. In the first slider in Figure 92, the example is consequently characterised as being ‘transformative’ with regard to its expression as its lifecycle had ended, even though the plant’s development was not concluded and the resources within the envelope had not yet been taken up. This in turn led to the example being characterised as having a ‘biological perspective’.

Although the weave construction was relatively loose, the seedlings did not interact with the interlacing threads and thus remained below ground. However, a characterisation towards ‘permeable’ was chosen in order to underline the permeability of the weave construction. Due to the size of the envelope, the expansion of the substrate displaced it to the sides and did not fill the available space. The small gap between the soil and the textile construction caused the sprouts to unfold too early, meaning that they did not have the necessary force to push through the construction. The size of the envelope in relation to the amount of substrate consequently determined how the seedlings interacted with the cloth, e.g. whether they unfolded their leaves within or outside the envelope, and below or above ground.

As the kale did not grow out from the inside of the envelope, no change in expression was visible from the outside and thus there was no blend or contrast. Consequently, the third slider in Figure 92 was left out. Figure 91 shows the sprouts when they had been removed, with a network of roots in soil. The stems were curving and white.
due to their long journey through the soil, and bent in their upper sections where they had grown against the textile. Several tiny, light-green folded leaves were visible at the end of the bent stems. The roots had a good amount of substrate and space to expand in. The envelope therefore supported a longer plant life span, and can thus be seen as promoting a biological perspective rather than enhancing textile expressions.

This example shows that the placement of the seed and type of germination are more important than the density of the weave, and determine the ways in which the two interact. An open weave (in this case a basket weave) can suppress the growth of a plant if the seed is placed deep in the envelope and has a thick, less pointed stem.

Figure 91: Removing the plants from the envelope revealed their structural development.
I.05 A Nasturtium Plant in a Large Circular Envelope

Figure 93 shows a double weave with a circular envelope enclosing soil and a nasturtium plant. Nasturtium plants climb and creep, and are juicy and annual or perennial herbaceous plants. They can be used for medicinal purposes, and are suitable for consumption: young leaves can be used as a seasoning ingredient for salads, and the flowers are edible ornaments. The leaves are very sensitive to light, and orient themselves towards it. When light is not available, their deep green fades within a few days. The nasturtium that was planted in the textile envelope was a creeping species.

Its stem had a colour gradient from rose-coloured to light green, blending with the rose and yellow tones of the textile structure (Figure 95). Due to the similar colouring and contrast in the thicknesses of the plant stem and yarn, a characterisation near to ‘harmony’, towards ‘contrast’, was chosen. In a vertical position, the plant collapsed downwards as it was accustomed to creeping rather than climbing. Considering its development and the size of the envelope, the example was categorised as having reached its transformative peak. To prevent the plant being damaged, the main branch was stitched to the textile to keep it in place.

Plant support is usually performed using metal or plastic clamps and sticks. A textile framework for developing plants, however, is a more flexible way of guiding and supporting them. Due to the permeable surface, the stitches were possible to place anywhere, and climbing species are able to easily attach themselves to such structures. Here, textile permeability enabled manual manipulation of the fabric by both people and plants. Due to this, a characterisation towards ‘permeable’ was chosen, which along with the size of the envelope led to the selection of ‘neutral’ as a perspective in the second slider of Figure 96.
I.06 The Manual Extension of a Small Envelope

This example shows that an envelope can be added or extended manually by e.g. crocheting an additional envelope on top of it. Figure 97 shows an already-filled central envelope in a vertical orientation, along with a sprout that managed to permeate its DWPS construction. An envelope was crocheted on top of this using the adjacent basket weave construction of the outer ring to provide more substrate and space for the sprout to develop. A crochet hook was used to permeate the face of the envelope with a large woolen yarn (Figure 98), and the envelope was filled with potting soil (Figure 99). A characterisation towards ‘permeable’ was chosen, although permeability decreased as a result of the use of a bouclé yarn in the weft. As the envelope contained just one plant and enabled its expansion, a characterisation towards a ‘biological perspective’ was chosen; it was concluded that the textile-plant structure had a harmonious expression and a state that tended towards ‘transformative’ (Figure 101). The craft-based approach opened up for manual customisation that went beyond industrial production, and allowed the textile to be permeated not only by plants but also by people. In addition, together with the previous example it emphasised the potentials of permeable textile structures in relation to accommodating plant growth.

Figure 100: Face and rear of the design.

Figures 97-99: The envelope before, during, and after the extension (from left to right and top to bottom).

Figure 101: Four sliders showing the characteristics of the expressions of structures, and their positions within a life cycle.
I.07 A Circle with an Adjacent Ring in a Vertical Orientation for the Integration of a Borage Plant

This example involved the planting of a borage plant in a circular envelope that was densely filled with soil, and surrounded by a soil-filled ring.

Figure 102 shows the woven double cloth in a stitching frame, which was used to stabilise the textile vertically. Both of the envelopes were filled with soil, and the open-weave construction DWTA was used with a white warp in the centre and a black warp in the ring adjacent to the face. The fourth slider in Figure 107 represents the high level of permeability.

A pre-grown borage plant was planted in the central envelope. The change from horizontal to vertical orientation resulted in a downwards orientation of the plant, but over the course of two weeks it developed new leaves and reoriented itself upwards. As the small, soil-containing envelope could not support the borage for long, a number of roots permeated the bottom of the central and adjacent envelopes. As a result of this possibility of expansion, a characterisation towards a ‘biological perspective’ was chosen. Figure 102 shows the original unaltered fabric and therefore a dormant state, while the other figures show a transformative state close to a peak – the state before the development of the plant stagnated and transitioned towards dormancy.

Figure 104: The borage plant, freshly inserted and oriented vertically, hung downwards.

Figure 105: After several days, the plant reoriented itself and grew new leaves.
The circle, in which the white warp was intertwined with a rose-coloured and yellow weft, shared similarities with the curves of the leaves and the colours of the young plant, which exhibited gradients from white and rose to light green. The ring, where the black warp intersected the yellow-brown and red-brown weft, created an aesthetic contrast. The dimensions of the plant almost exceeded the dimensions of the textile, and the size and shape of the above-ground parts increased the aesthetic contrast between the textile and biological components. The roots, which crossed from one envelope to the next on both the face and rear, blended well with the white, rose, and yellow expression of the aida weave on the face of the circle and the twill on the rear of the ring. An aesthetic contrast was formed by the twill and the aida binding and the black warp and dark-red and orange-brown weft. Consequently a characterisation towards 'blend' was chosen for Figure 106, and a characterisation towards 'contrast' for Figures 104 and 105.

In order to increase the available growing area, the borage made use of the adjacent ring and its substrate; however, only a small part of the available space was used, as the roots oriented themselves downwards and so spread in one direction rather than many.

The circular design only made efficient use of 20% of the available space as the seed was planted such that the plant grew at a 45° angle to the surface of the textile. In order to create a textile habitat that was possible to permeate over time, the textile design had to meet the needs of plants, by e.g. providing vertical space below the plant. However, as textiles are highly flexible systems that can be easily altered and extended, the environment was possible to improve and the position of the seed could be changed by e.g. positioning seeds in the top of an envelope or inserting several plants in different positions.
Figure 108 shows a transformation towards a transformative peak in chronological order, as illustrated by the first slider in Figure 110. Figure 108 shows how the embryonic rocket leaf unfolded in front of the intertwined warps, creating a complementary contrast, contrast, and grew upwards. With increasing growth, one sprout died and grass appeared. The rocket sprout became too heavy, and so collapsed onto the textile envelope that was filled with soil, blending with the white, grey, and green threads. The grass plants covered the upper side of the envelope on both the face (Figures 111-112) and rear (Figure 113). Due to their narrow width, upwards orientation, and intense green colour, they blended with the white warp binding due to its grey and green shades and the background at the rear (Figure 108). The plants created a harmony with the background on the face due to the green threads, which interwove with the rose-coloured and red weft, and the thickness of the grass leaves, which were similar in thickness to the threads. While the grass generally grew straight upwards, and was only impeded in this by the weight of the sprayed water (Figure 111), the rocket sprout leaned downwards, against the envelope, spreading its leaves to absorb sunlight. Whether the textile and biological expressions blended or contrasted thus depended on the position and physiology of the plants, and their development over time. Due to the balance between sufficient space, substrate, and coverage of growth that needed to be maintained, a neutral perspective was chosen to characterise the example. The colours of the structure on which the plant was placed, developed on, and viewed with regard to determined whether an aesthetic blend, harmony, or contrast was created. Figures 108 and 114 were characterised as falling between ‘harmony’ and ‘contrast’, whereas Figures 112 and 113 were placed between ‘blend’ and ‘harmony’ on the third slider in Figure 110.

The textile climate and envelope suited the root system, which was shown by the fact that the roots did not appear above ground. Thus, one could conclude that there was sufficient substrate, nutrients, and moisture available, and that an imbalance in these is possible to observe not only by the state of the plant but based on whether and where roots leave the below-ground area. Consequently, seeds can be used as materials for design not only to create biological expressions when they are fresh and textile expressions when they are dry, but to function as indicators of the internal relationship between a textile and a plant.

I.08 A Mixture of Seeds in a Small Rectangular Envelope

Figure 108 shows the early development of grass and rocket in a square-shaped, vertically oriented textile envelope.

A leaf being pushed through the loose basket weave structure on the face by the embryonic stem, blending with the white warp threads, is visible in Figure 108. The basket weave exhibited a higher level of permeability than the plain weave on the rear; however, the grass that germinated after the development of the rocket sprouts easily permeated the weave construction at the rear, which is why a characterisation towards ‘permeable’ was chosen.
Figure 110: Four sliders showing the characteristics of the expressions of structures, and their positions within a life cycle.

Figures 111-114: Two types of plants in relation to the square shaped textile envelope and its face (Figures 111, 112, and 114) and rear (Figure 113).
I.09 A Pea Plant in a Vertical Channel

This example involved the planting of a pea plant in a channel filled with soil, and explored an interaction between a climbing plant and an open-weave construction.

Figure 117 shows tendrils attached to the aida weave construction, leading to a characterisation towards a biological perspective. Figure 118 shows an attempt to insert more substrate due to the fact that the first quantity sank in the envelope, leaving the plant with too little in which to grow. The width of the channel, however, made this process difficult, and furthermore resulted in relatively quick evaporation of moisture, increasing the level of stress on the plants during their development and Figure 115 shows the plant, and thus the example as a whole, at its transformative peak. Designing towards a biological perspective consequently didn’t result in a favourable growing condition for the pea plants.

The bright green plant in front of the white-brown background textile and black and blue channels formed an aesthetic contrast, resulting in a characterisation towards ‘contrast’ being chosen in the third slider in Figure 119.

This example shows that textile permeability must consider the support of plants in both vertical and horizontal orientations, as the above ground area anchors and stabilises the plant against forces such as wind and rain. In addition, climbing plants need vertical support when attaching their tendrils. However, as the plants could be planted above one
another, they could also use other peas or plants to build a temporal vertical space of dense growth. With the approaching winter the plants died, as they are annuals. They could either be left as support for the next growing season, or cut off in order to reveal the textile structure again. In this way the textile structure is revealed and covered with the seasons and expressions of growth and decay alternate or exist simultaneously.

**Figure 119:** Four sliders showing the characteristics of the expressions of structures, and their positions within a life cycle.
I.10 Carrots Stored in Vertical Channels

This example explored the storing of carrots in soil-filled channels in a vertically oriented textile.

Harvesting, preserving, and storing vegetables are typical late-summer and autumnal activities. At this time, potatoes, carrots, and beets – to name just a few – are ready to be harvested but, if they are not immediately consumed, are better left in the soil or stored unwashed in a substrate of sand, wood shavings, or soil in a dark and moist environment with a cool, stable temperature. Figure 120 shows an attempt to store carrots in vertically striped envelopes filled with soil and imagine how they could be grown in these.

Figure 120 shows a vertically striped structure, with a channel every second stripe and a different weave colour combination every 15 cm. The channels were bound with a basket weave on the face and plain weave on the rear (DWPB). The basket weave was loose enough to create a hole in which a carrot could be inserted, but the narrow diameter of the channels impeded this endeavour, leading to a neutral characterisation between ‘permeable’ and ‘impermeable’.

The colours of the carrot roots blended with the weft material, while the bright green stems created an aesthetic contrast. This example is most fruitfully viewed from a biological perspective, as there was little interaction between the plants and the textile structure. Holes in the basket weave were created in order to insert and remove the roots and to store them below ground, surrounded by soil and moisture to keep them fresh. The width of the channels, however, meant relatively dense growing conditions for the carrots, which was not optimal.

Figure 121: Face and rear of the design.

Figure 120: Carrots were stored in striped textile envelopes which were filled with soil.
Carrots are biennial plants; in the first year they develop their typical taproot, and in the second they flower. The taproot can be harvested within just three months, while the stems and leaves are also edible but not as popular as the roots. A great deal of sunshine and deep, well-drained, and loose, sandy, or loamy soil provide the best environment for carrots to thrive in, and they benefit from companion plants such as radishes, lettuce, rosemary, and sage.

As carrots do not need rich soil but good drainage and a deep substrate, a vertically striped cloth was deemed to be suitable to accommodate them. As they require much sunlight during their growth, the structure could be used to shade an interior space while simultaneously providing sun to the growing carrots, and in winter be moved to a warmer place. This meant that carrots could be grown and stored vertically in soil, without taking up horizontal space. Growing carrots in such a structure saves space and organises the plants neatly and vertically in the striped envelopes. These caused the taproots to have straight, long forms, and provided enough depth for full development. The vertical drainage allowed for efficient use of water, and the form of the textile meant that it was obvious when the time had come to harvest the carrots, as the textile structure expanded and became rigid, shaped by the roots.
I.11 Transformation of a Vertical Structure Between the Inside and the Outside

This example explored four kinds of sprouts in the soil-filled channels of a vertically oriented textile.

Figure 125 shows a vertical textile, approximately four metres in length, suspended in the opening of the greenhouse with one side facing the interior and the other the exterior. Four different kinds of seed – barley grass, radish, grass, and rocket – were inserted into the unfilled channels, which were woven with DWTA. The black warp with a grey and green-blue weft was woven into a twill to create an open structure on the face of the channels; the white warp was woven with light grey and light blue to create an aida structure. Both the face and rear therefore had a high level of permeability.
Figure 127 shows the textile positioned with the dark side facing the outside, exposed to the elements. The lower part of the structure was filled with soil and seeds, adding to the weight of the textile-plant structure, creating a straight drape, and preventing the structure from moving in anything but high winds. Figure 129 shows the transformation of the striped structure, which was maintained primarily by the rain and watered artificially only during dry periods. The moisture, however, evaporated quickly from the thin channels.

Four kinds of sprout are visible; a radish to the left, barley grass in the centre, and grass (and a random sprout) to the right. While only two radish and barley grass sprouts were visible, the grass coverage was dense. The plants created contrasting aesthetics due to their colours. The grass, however, created a harmony with the textile structure due to its dense surface and fine blades, which is why the example was characterised as being harmonious in the third slider of Figure 139. Figure 128 is a close-up of the two barley sprouts; the substrate is visible as a result of the uneven filling of the narrow channels.

Figure 130 shows rocket sprouts permeating the twill weave structure on the face, creating an aesthetic contrast. Figure 131 shows the other side of the cloth; rocket sprouts permeated the aida weave structure, which was woven with a white warp and light grey and light blue weft.
When viewed closely the colours seemed to contrast, but from a distance they distorted the grid structure of the textile but lost their contrast (Figure 132). Figure 133 shows the grass covering part of the aida weave, again creating a surface that blended well with the expressions of the weave structure.

Figures 135-138 show expressions of growth and decay; Figures 135-136 show the grass surface while it was growing, in a fresh state, while Figures 137-138 show the same area after the structure had dried out and the grass had shrivelled and thinned, losing its saturation and upright orientation and bending, folding, and becoming relatively rigid. The first slider in Figure 139 reflects the chronological order of the images, and their position on the timeline with regard to the example’s development.
TEXTILES AS PLANT MEDIATORS

Due to the changes in the colour and thickness of the grass, it blended with the textile expression. Figure 134 shows the greater density of growth towards the bottom of the channel, which was caused by the tendency of moisture to collect in the lower parts of the envelope as a result of gravity, causing a gradient of grass growth. This example achieved a harmony between both the biological and textile perspectives since the plants can be seen to have enhanced textile expressions on the textile structure; at the same time, the textile structure provided enough space and nutrients for the plants to develop.

Growth occurred on both sides of the structure due to the access to light on both sides. It also explored the different levels of textile climates, and their influences on the expressions of a structure. Expressions of growth and decay enhanced the design and created contrasts and blends.

Figures 135-136: The same surface with fresh and withering grass.

Figures 137-138: The same surface with fresh and withering grass.
Figure 139: Four sliders showing the characteristics of the expressions of structures, and their positions within a life cycle.

Figure 134: A stripe with a surface of withering grass in a vertical gradient.
I.12 Strawberries in a Chequered Structure Outside

This example involved planting strawberries in a soil-filled chequered structure woven with all three (basket, twill, and atlas) weave structures, which was suspended on the outside of the greenhouse to provide shade inside over the summer.

Figures 140 and 141 show the woven structure outside the greenhouse façade. The channels were partially filled with soil, adding weight to the structure and thus making it less affected by the wind. By creating holes in the three weaves, the plants were planted in the channels, which therefore possessed high levels of permeability. The plants blended with the green background structure, but more generally disturbed the aesthetics of the textile-plant structure due to their irregular and three-dimensional patterns of leaves, which contrasted with the right angles and white and green colouring of the cheques. The example was thus categorised towards ‘contrast’ in the third slider in Figure 142.
As strawberries develop best when exposed to a great deal of sunlight and the greenhouse needed shade, this arrangement was expected to bring mutual benefit. However, the plants did not survive for very long, likely due to either a lack of moisture or the unusual (vertical instead of horizontal) orientation. However, as the textile structure provided a framework for the plants to expand and connect with one another above ground and below, the textile-plant structure was characterised towards a ‘biological perspective’.

On the one hand, the chequered pattern offered a great deal of potential as it enabled vertical and horizontal connections, facilitating e.g. continuous watering from above and the establishing of roots in the below-ground area of the envelopes. On the other hand, this example showed that one of the biggest issues in using textiles as mediators for plants is the number of parameters that must be factored in. Moreover, the rapid evaporation of water meant that watering had to be conducted very regularly in order to ensure the healthy development of the plants.

Figures 140-141 show the structure with strawberries at its ‘transformative’ peak right before they withered due to too much stress in the textile structure.

Figure 126: Face and rear of the design.
WAYS OF LIVING

Figure 143: The house in which the examples were placed and experienced.
II.01 Adaptative Changes to the Greenhouse

This example explored adaptative changes made to the greenhouse over the course of two years.

Figure 142 shows the greenhouse, which was built over the course of the summer and autumn of 2018. As it was intended to accommodate experimentation with textiles and plants, it features a high, translucent roof, shelves, curtain rods both inside and outside, a gutter to collect rainwater, a glass façade on three sides, and an opening on the fourth that allows it to be connected to the front or terrace doors of the Tiny House on Wheels. This example focused on the wooden floor of the greenhouse, which can be partially opened and was adapted to different uses over time. Figure 143 shows an opening in the floor during the construction of the greenhouse. On the side opposite the entrance, the entire floor can be opened by removing the floor panels. When the greenhouse was finished, the floor was closed in order to embrace the entire space (approximately nine square metres) and explore the vertical and horizontal orientation of hand weaves in the space (Figure 144). This setting was independent of the seasons.

In order to prepare the weaves that were explored in the first part of the experimental work, a temporary workstation was set up by removing several of the floorboards. These were piled and a sewing machine was placed on top, with the pedal resting on the grass under the greenhouse so that it was possible to sit on the wooden floor with one’s feet in the grass while using the sewing machine (Figure 145). This setup

Figure 142: The image shows the process of setting up the greenhouse interior.

Figure 143: The greenhouse floor, which can be opened on one side.

Figure 144: The finished greenhouse with windows, a closed floor, and textiles on display.
was both temporary and seasonal, as the greenhouse was quite cold during the winter, early spring, and late autumn. The best time was late spring, when it was not too hot. Working in such a way, with one’s feet in the grass, was a very comfortable experience that blended the inside and the outside, and contrasted with ordinary spaces in which machines are used (which are generally indoor, protected environments and equipped with tables and chairs).

Small samples were filled with substrate and seeds, suspended above another opening in the floor, and watered from above so that excess water simply dripped onto the grass. The suspended samples were very vulnerable to extreme temperatures and dry spells, and thus were temporal and seasonal objects. The combination of water, textiles, and soil resulted in dust and puddles in the greenhouse, but this was not an issue and so could be embraced. Excess soil could simply be brushed through the opening in the floor, and puddles dried out over time.

When the samples were complete, a wooden frame was placed in the middle of the opening in the floor in order to install a vegetable box containing compost, hay, and potting soil. This was intended to allow a variety of plants to grow and be connected to the ground soil, providing access for microorganisms and worms. This also allowed the growing season to be extended to the winter and spring as the bed was protected from rain, snow, and wind. In summer, the openable floor also allowed cooling air to enter, and in winter it was closed to prevent this. In spite of several limitations and with the taking of several measures, the box was relatively independent of the weather and seasons, but exhibited temporal and seasonal expressions in the form of seasonal vegetables and their life cycles and expressions of growth, maturity, and decay. Over time, the vegetable box accommodated a mixture of
vegetables: Jerusalem artichokes supported a row of peas, which together provided shade for e.g. chards and spinach (Figure 149).

This permeability of the wooden floor allowed a range of spatial adjustments to be enacted and improvisation to take place, creating a balance between mobile and static characteristics (see the third slider in Figure 152). The permeable floor was static in nature, but highly flexible in the way it could be changed and used. It also supported expressions and experiences that were of a seasonal and thus temporal nature, allowing unique, repeating, and independent ones.

In the future, the plant box could be extended to accommodate more plants and to include a composting unit at its centre, inspired by the keyhole principle (Insteading, 2016). Another possibility would be to install a small water-storage barrel, fed by the gutter, on the same side of the greenhouse to ensure easy access to water and explore how this would affect both the spatial qualities and experiences of non-human visitors.
II.02 Seasonal Living Indoors

This example explored seasonal living indoors, using windows, doors, and textiles as openings to the outside, creating a transition between the Tiny House on Wheels and the greenhouse.

Figure 153 shows the rectangular window that covered most of the wall above the storage box, and therefore extended the entire height of the bedroom and almost the entire length of the bed. The outside was thus a major part of the bedroom experience (Figures 154 and 155). The weather and the seasons directly affected lighting conditions, and wind, rain, and hail could be heard and observed through the window whether closed or open. The window faced the parking area and forest road; this is the only access point for the property, and so anyone leaving or approaching could be observed. This was also the rabbits’ favourite place in the morning and evening (Figure 153), and deer occasionally passed by. When the sliding window was fully open, it could be used as a desk while enjoying either shade during the day or the evening sun, along with the view and the fresh air (Figure 156). In winter, the window was generally closed during the day and open slightly at night, allowing one to enjoy the fresh air. The seasonal changes that occurred outside were possible to observe on a daily basis due to the sleeping position next to the window, and the first and last views of a day were always of the outside. Consequently, the window was a mediator between the inside and the outside that could be directed through the acts of
opening and closing. In winter, the smell of snow and the feeling of cold snowflakes on the skin was experienced while under a warm blanket. The window thus provided a degree of permeability with regard to the interior space, i.e. the bedroom, and offered access to seasonal expressions and experiences. In itself it was independent of the seasons and static as it was part of the building (see the first and second sliders in Figure 172).

Above the bedroom was another window – a square skylight that could be opened to allow access to the rooftop terrace. In winter this was sometimes covered by a blanket of snow and thus generally closed; it was also the highest point, and thus warmest, part of the house. In summer, however, when the greenhouse was too warm, an airflow could be established by opening the front door and the skylight. Cold air entered through the openings in the floor, and hot air rose throughout the building, as well as out of the open window (a ‘chimney’ effect). This airflow connected the outside to the interior, the inside, and the outside again, and brought fresh air and the smell of summer into the house.

The quantity of light that came in through the window, greenhouse, and skylight exceeded that which came from the windows set in the walls. During rain, the sound of drops against the window filled the house, creating an awareness of the weather outside. The window provided access to the rooftop terrace, extending the living space by an area equal to the floor space of the Tiny House on Wheels, and allowing the property as a whole to be observed. The window and terrace were thus static structures that provided...
Figure 161-162: The greenhouse facade with a close-up on a transforming textile, Summer 2018.
very seasonal experiences, which were possible to mediate with regard to the degree of openness. This spatial permeability influenced and mediated the intermixing of microclimates, and invited exterior expressions and experiences into the house (Keune, 2019). The example was categorised using the numbers three to five in the sliders in Figure 172.

Figures 161-162 show the greenhouse and the two large examples presented in the Examples I.08 and I.10. Both pieces covered the opening of the greenhouse, which would later be covered by the entrance to the house. The flexible openings allowed the wind, animals (e.g. mice), and insects (e.g. lacewings) to enter and use the greenhouse for purposes such as hibernation (Keune, 2019). Ants entered in search of food and shelter, bumblebees and other pollinators were attracted by the flowers, and a rabbit caused some chaos when it jumped into the vegetable box in order to eat the cucumber plant. Figure 163 shows a caterpillar that was found on one of the textiles in a state of pupation. The sticky silk of the cocoon was partly coloured with the thin blue and red wool fibres of the textile, giving the two-dimensional piece a third dimension. After the moth or butterfly emerged its house of fibres was left empty on the cloth, telling a story about one of the textile’s previous experiences.
In Autumn 2018, hundreds of lacewings took over the greenhouse to hibernate there. They hid in the folds of the vertical textile-plant structures, as well as in and on top of the piles of folded fabrics (Figure 164). They occasionally entered the house, attracted to the bedroom light, and often flew around the bed. One night, I observed one walking on the bedsheet as I was trying to sleep. The experience with the lacewings continued beyond autumn and winter; their way of flying caught my attention whenever I saw one outside after their hibernation period was over. In spring, one even walked across my computer while I was working on the rooftop terrace (Figure 165). The textiles seemed to attract such encounters with other species, and their seasonal behaviour was promoted by the flexibility of the space and the ways in which it can be used differently over the course of different seasons. More experiences are documented in 'Living in a Prototype: A Research Diary' (Keune, 2019).

Figure 161 shows the greenhouse interior in Summer 2018, before the Tiny House on Wheels had been attached to it. Textiles were suspended inside and outside, with large ones at the top and small samples on the shelves and at the bottom. Figures 162-163 show the greenhouse connected to the Tiny House on Wheels, in particular the different usage in winter (Figure 162) and late spring (Figure 163).

The house promoted an acknowledging and observation of the seasons and seasonal behaviour. It was not only the windows that promoted seasonal usage: In winter, the greenhouse served as a larger entrance and storage area that was protected from the wind, rain, and snow, and was slightly warmer than the outside. Figure 161 shows the entrance when closed, with a large woollen carpet (which was used to insulate the floor and walk on) visible. Figure 163 shows the space in late spring, with the doors open in order to use the warm greenhouse atmosphere to heat up the indoors space, let in light, and set up a temporary workspace for the early afternoon. Plants started to grow and slowly take over the space, and a branch that was installed later was used as a wardrobe and climbing structure by a miniature kiwi plant.
WAYS OF LIVING

Figure 166: The greenhouse interior, Summer 2018. Textile-plant structures were placed vertically and horizontally, inside and outside.

Figure 167: The greenhouse interior, Winter 2018-2019.

Figure 169 shows a bumblebee in the greenhouse in Summer 2019, and Figure 170 a butterfly on a nasturtium on a windowsill in the house. The spatial experiences, expressions, and usage were thus shaped by its permeability and the seasons, could occur once or repeatedly, and take place over the course of a moment or several weeks. The objects shown in Figures 167 and 168 were therefore characterised towards ‘permeable’ and ‘seasonal’ and between ‘mobile’ and ‘static’ in the sliders in Figure 172, as they were not very mobile in the sense that the greenhouse cannot be moved easily (it was built to be moved, but this requires a large amount of effort) but can easily be adjusted and used differently.

Figure 168: The greenhouse interior, Summer 2019.

Figure 164: The greenhouse interior, Summer 2018. Textile-plant structures were placed vertically and horizontally, inside and outside.
Figure 169: A bumblebee pollinating a bean plant in the greenhouse, Summer 2019.

Figure 170: A butterfly laying eggs on a nasturtium plant in the house, Summer 2019.
WAYS OF LIVING

Figure 172: Three sliders showing the characteristics of the expressions of structures, and their positions within the house.
II.03 Material Cycles

This example explored and compared multifunctional systems and principles which transform energy into a different form and therefore open up for circular thinking: a worm farm, bokashi fermentation, a gas stove, a wood stove, and expressions of decay in textile structures.

Figure 173 shows the inside of the worm farm, which was an indoor vermicomposting system consisting of a clay pot for plants and its saucer (Figure 175). The pot was partially filled with soil, onto which the worms were placed. Finely chopped food leftovers were added, and the saucer was used as a lid to prevent evaporation and stop flies from entering or escaping. Three legs supported the pot, revealing the small whole in its bottom where soil and excess liquid drained into a small jar. This was then used as fertiliser (Figure 174). Water and leftovers were added once or twice a week to provide food and moisture for the worms. In winter, the farm was placed inside so that the worms would not freeze. As the nutrients were used to grow vegetables, the farm explored a circular way of dealing with food waste. It also extended the season for vermiculture, as worms die at temperatures below 4°C and usually retreat into the earth in response to low temperatures. An indoor worm farm thus facilitated experiences with a foundational natural process – the decomposition of organic matter into something useful to other organisms – and invited worms into the home. Unlike other composters, the object was possible to move and therefore positioned according to the climatic conditions it needed and the available spatial possibilities, changing with the seasons. Figure 176 shows a bokashi fermenter, a method by which microorganisms and dried granules are added.
to organic material, e.g. food leftovers, in a container, which are then pressed and sealed for two to three weeks. The fermented scraps are then buried in the soil, where they decompose. While worms and other organisms cause the decomposition of organic material, microorganisms ferment it, retaining nitrogen and much of the CO2 (Merfield, 2012). Through bokashi fermentation, another natural process was integrated into everyday life indoors through the processing of food scraps. The fermentation cycle took place over the course of two to three weeks, and was thus temporary but repeating. The placement of the fermenter varied but was mostly positioned under the kitchen counter.

Figure 177 shows the dry toilet, where solid and liquid waste were collected separately. The liquid could be used as fertiliser once diluted, while the solid was mixed with sawdust to bind liquids and trap odours, then composted (Figure 178). In this way, no drinking water was polluted and the solid waste could be turned into compost (Jenkins, 2019). The dry toilet was mobile, and together with the composting and fermenting methods explored a circular and local way of dealing with organic matter and viewing it as a resource, rather than a waste product. This connects to the ways in which textile plant structures could be dealt with over time, e.g. first as templates and later as substrates for growth, degrading as plants grow (Keune, 2017; 2018). Expressions of degradation are illustrated in the following images. Figure 179 shows a close-up of the face of the weave construction of a textile envelope, and Figure 180 shows the rear; this was filled with soil and exposed to outside conditions for an entire year by being suspended on the outside of the greenhouse. The combination of soil and textile led to changes in colour, and partial gradient stains. Figures 181-183 show parts of the same sample...
in which the textile construction tore, revealing a mixture of soil and perlite in the teardrop-shaped envelopes. The textile material and construction allowed environmental parameters to create alterations, and was thus characterised as ‘permeable’ in the first slider in Figure 187. The expressions of degradation – changes in colour, shape, and weave construction – made visible the effects of time and other environmental parameters, which were therefore characterised as ‘seasonal’ in the second slider in Figure 187. As the structure could be easily moved to another position, it was characterised as being mobile. The structure opens up for explorations of textile transformations and the transience of natural materials with regard to the textile design process. The contents of the envelopes, e.g. soil, seeds, and plants, could be released after a certain amount of time in order to change place, access a different environment through e.g. contact with the ground and local microorganisms, or provide more space for the roots to expand in. The structure could also completely collapse onto the ground and provide nutrients for insects, plants, and microorganisms (although this should, of course, be made of materials that do not harm the environment in any way).

Figure 184 shows the wood stove. It was used to heat the house in winter, and for drying, cooking, and baking. In the future, it could be expanded using e.g. an attached and water-led copper coil to support the water heater or a thermoelectric generator (Bloom & Boehnlein, 2015). As wood stoves are generally used primarily in winter, it was a seasonal and static system with a certain level of permeability, since it could be extended and used for many purposes.

Figure 185 shows the gas stove, which was installed on the kitchen counter and used to cook during the
summer and (briefly in the) winter. The wood and
gas stoves complemented each other quite well, and
both possessed the potential for further improve-
ment and complexity. Since, like the wood stove, it
had a fixed position in the house, the gas stove was
categorised as ‘static’ in the third slider in Figure 187.
Its permeability was considered to be in balance as it
could be altered in order to make use of excess energy,
e.g. kitchen waste. In the future, the gas bottle could
be replaced by a small biogas system that produces
methane gas using e.g. kitchen scraps. Such anaero-
bic systems require specific temperatures, and so are
more suitable for use during summer, which is when
the gas stove was needed most. Figure 186 shows the
gas bottle under the house (to the left) and the grey
water canister (to the right). The grey water that
was collected could be filtered by a slow sand filter, a
wastewater treatment pond, or a similar system, then
be used again or directed to the plants in the green-
house. The entire house was thus planned based on
the principles of multifunctionality and permaculture;
it is open to adjustment in many ways and therefore
has a high level of permeability and allows systems to
be tinkered with in order to create material cycles in
which textiles can be integrated, gradually taking on
tasks usually performed by static and rigid structures
such as the previously shown ones.
A BUILDING’S GARDENER: TOWARDS AN INTERIOR ECOSYSTEM

Rahm argues that nature has always been excluded from interiors and that, as that untouched nature no longer exists and the whole world – including external environments and their climates – have been altered by human activity, we could create interior spaces that are more natural than the exterior by reformulating the specific conditions so as to create natural milieus inside buildings (Clément et al. 2006; Scuderi, 2014). One of Rahm’s proposals is to work with physical differences in the ways in which temperature is distributed in space by creating vertical ways of living that harness different heat zones, layers, and lighting conditions: “It’s not to design solid shape and form, it’s to design climate.”(Scuderi, 2014). Lally supports this view, and proposes pockets of energy as a new method of organising spaces and activities (Lally, 2014).

In relation to this On Textile Farming proposes a framework for designing textiles by integrating plant growth. As plants maintain close contact with other species, such as bacteria and insects, ways of living are suggested that invite exterior and seasonal expressions and experiences, e.g. a fresh breeze and the smell of rain, into everyday life. The framework for designing with plants relates to Grüntuch-Ernst’s call for “architectural strategies that activate the potential of plant material in the design process”, which is expressed by the term “hortitecture” (2018). By proposing a framework for how to design with plants in relation to textiles and interiors, On Textile Farming aimed to improve our understanding of the design potentials of plants and thus support the textile perspective of hortitecture by suggesting a complementary perspective to that in which rigid approaches to the organisation of plants and systems in relation to space are central. Textiles as plant mediators can be moved and move with the wind, suspended or spread out, expanded and extended, placed evenly or folded, and facilitate or inhibit e.g. the ingress of wind, water, and light.
The framework acknowledges the complexity of accommodating plant growth in textiles, and the many details that designers have to consider. As Nieto states:

"When we design with plants, we consider that they are going to change and try to foresee what might happen with the change. So it is not something that we can just let happen, you have to think in advance about how you want to control it. We must have a concept that works together with plants, but the architectural solution underneath must be determined and strong." (Nieto, quoted in Grüntuch-Ernst, 2018: 36)

Designing with plants introduces a "horticultural way of design thinking and acting" (Ludwig et al., 2012: 86) into the design process. This implies that e.g. seasonality, the life cycles of plants, the natural microbiome, symbioses with other species, conditions, and plants' ways of germinating and growing, become part of the textile and interior design process. Loenhart points out that an understanding of architecture is fundamentally changed when plants, as living beings, are introduced, and concludes that designing climates through plants is an architectural issue that can be approached based on their interactions (Grüntuch-Ernst, 2018). This strongly relates to the central tenet of On Textile Farming, which involved designing textiles and interiors with plants. Here, too, designing climates and microclimates becomes a matter of textile and interior design, which is also approached in relation to their interactions. In addition, a major question that is asked by Grüntuch-Ernst relates to how to generate and maintain a composition that foregrounds the living nature of plants. On Textile Farming tries to partially answer this by exploring design parameters in relation to textiles. Designing a textile system that provides the natural conditions for plants – imitating the soil, one could say – is a matter for further research to be carried out by biologists, textile designers, and textile engineers. Many processes that take place below ground are still not fully understood, and their relationships with above-ground processes have not yet been investigated as the two are traditionally explored separately (Bardgett & Wardle, 2010). Above- and below-ground interactions in the context of On Textile Farming are mediated by textile structures with loose or dense weave structures. As textiles provide a mobile, flexible, and permeable structure, they function as templates for exploring processes of growth, as they can be placed in different spaces, oriented vertically, horizontally, or anywhere in between, and easily altered by e.g. inserting more substrate into the envelope or extending it through fixtures to guide growth. The transience or permanence of textile structures and materials can be explored in relation to the transience and circular metabolic system of plants. Textiles can be explored with regard to their capacity to absorb and deliver moisture and nutrients to plants through their structure construction of fibres and weaves.

In horticulture, textiles are used to create beneficial microclimates by managing the light levels and consequently temperatures of spaces. Rather than the textiles establishing a conducive interior climate, they could create a beneficial textile climate – one that better meets the needs of plants by ensuring optimal conditions both above and below ground. Rather than textiles shielding plants from a distance, then, the latter are accommodated within, and their ecosystems are supported by, the former. Such a system can also accommodate beneficial bacteria and insects as a result of the use of pheromones and visual patterns, which attract them and the predators of pests (non-beneficial visitors). This perspective drastically challenges the current ideal of the interior as a clean and well-organised space in which the climate is determined in the same way as the behaviour of the inhabitant and the use of spaces and their furniture are, and could make interior spaces habitable for all. The concepts of textile climates and spatial climates are inspired by these propositions, which relate to architectural design and the utilisation of existing climates and establishing of new ones.

The concept of textile climates in relation to the CS department at Svensson opens up for a range of textile developments, in which a beneficial ecosystem is integrated and invited rather than microorganisms and insects being excluded in general. Through the IT department at Svensson, a biological perspective challenges the field, providing impetus to rethink the interior and the functions of textiles in them.
The examples presented in this thesis open up for various improvements and further iterations. In order for further development to occur, textile materials, structures, and designs and patterns should be investigated further.

Material choices could be based on two categories: transient materials and durable ones. Durable materials could accommodate perennial plants or undergo multiple plant integrations as frameworks or templates for growth. Such materials must be able to support plants for several years, and therefore need to be not only durable but expandable, and provide plants with water and nutrients. The textile structure could thus be connected to the systems of a building, and be supplied with rainwater or nutrient-rich liquids from e.g. a fish pond or aquarium. Such an aquaponic structure could be designed as a static part of a building, and be placed inside or outside. With the former, the structure could add substrate in the form of decomposing leaves, and mosses and lichen would populate its surface. The use of durable textile materials in combination with plants has been explored by FloraRobotica. Over the course of the project, a bio-hybrid system was developed in which a symbiotic relationship between plants and robots was explored in order to produce living, adaptive structures and grow building components. Braided structures with plastic strips served as temporary scaffolding, guiding growth in pre-programmed shapes supported by watering and stimuli, which triggered plants’ different tropisms (Hamann et al., 2015; Wahby et al., 2018). The concept of textile permeability could add an additional perspective to the guiding of the growth of plants, and a structure that not only guides but integrates plants and their substrate would allow different vertical levels to be worked with from the beginning. Ludwig et al. took this approach by vertically arranging trees in buckets containing soil. The trees grew together over time using the root system of the lowest tree, which was rooted in the soil, making the other root systems and their buckets obsolete (2012).

As the plant scaffolds in both projects were more or less temporary and made of durable materials, they didn’t merge with the plants aesthetics. Permeable materials with defined life spans could facilitate this, and add temporal expressions to the developing structures. Therefore, materials that fit into the nutrient cycle of nature have two advantages: they resemble plants and merge with them aesthetically, and have defined life spans, at the end of which they biodegrade and turn into another form of substrate and nutrients for the plants.
Temporary textiles can be reinforced in order to function as stable and supportive structures. In Small scale robotic manufacturing for large scale buildings, Chaltiel uses a temporary lightweight form made of different textiles, e.g. jersey and jute, to apply layers of mixtures of clay and fibres in order to create earthen, monolithic shells. The clay is applied in varying thicknesses, sometimes leaving openings, using drone-based spraying technology (Šamec et al., 2019). It would be interesting to integrate plant growth in such a structure in order to create e.g. additional surface topologies and seasonal and temporal aesthetic changes, and to provide reinforcement through root systems and guide growth based on the principles of textile permeability. This could involve suppressing the growth of sprouts, or supporting root development in order to harness the tensile strength of roots. When integrating plants into textiles, the reactions of textile materials to humidity is an important factor due to the fact that the textile structure will be in contact with moist substrate and needs to be watered. As the samples were woven using a wool-polyamide mix their surfaces were hydrophobic, impeding the ingress of water from the outside in the form of rain, mist, or a watering can, but absorbing water vapour in large quantities without feeling damp and facilitating evaporation faster than e.g. cotton. This led to a constant lack of water for the plants, as the textiles were water-repellent and the moisture quickly evaporated. Large amounts of soil that were continually moistened ensured the well-being of the plants, but sped up the processes of decomposition that weakened the fabric. Cellulosic fibres are known for their capillary forces, and are able to absorb and transfer liquids; similarly, cotton fibres exhibit increased strength in moist conditions. A mixture of natural materials could therefore be utilised to create a structure with areas that react differently to moisture; for example, one area repels moisture while another absorbs and transports it, creating climatic pockets and surface areas with different properties.

The envelopes themselves also had different areas with specific requirements, as those on the top needed to be permeable – in order for the plants to emerge – and absorbent, while those on the bottom needed to store water and prevent substrate and water from dripping or spilling out. The differing life spans of materials could also be used so that the different parts of a structure decompose at different points in time, changing the aesthetics of the structure in intentional ways. Consequently, both plants and textiles would change their expressions over time and have specific life spans. In this scenario, the temporality of both material categories enables them to react to the same environmental influences and merge and become one. This would mean that textile structures that incorporate plants become seasonal textiles that are e.g. taken outside after precultivation has been completed or the growing season has come to an end, functioning as vegetable beds in which the textiles gradually biodegrade as the plants mature or degrade and spread their seeds.

The role of the textile construction is explored at length in the ‘Examples’ chapter; they are responsible for containing the substrate and interacting with the plants by enabling or suppressing growth. Further work could focus on the areas described in the preceding paragraphs, and support the repelling, absorption, transportation, and storage of water and nutrients. The interplay between climbing plants and textile structures could also be further investigated.

The roles of colours were explored in relation to whether those of textile structures and plants blend, contrast, or harmonise. As plants and insects, pests, and their predators react to light and colours, the role of colours and patterns in relation to plant health, pest prevention, and the attraction of beneficial animals is likely worthy of further exploration. Spatial permeability in particular should be investigated in relation to how to invite beneficial animals and keep out pests, and how to safely guide beneficial animals into and out of indoor spaces without them being harmed or people being disturbed.

The roles of people, insects, and microorganisms in relation to the maintenance of textiles with integrated plants should also be researched further. Microbiomes are a key factor in the health and activity of plants (Berendsen et al., 2012), and have gained considerable attention in recent years (Lebeis et al., 2012; Bulgarelli et al., 2013; Turner et al., 2013). They are, however, relatively underrepresented in studies of horticultural practices. As microbes can be used to change the colour of textiles or support certain plants with e.g. nutrients, it would be interesting to investigate how they could inhabit textile structures through biocolonisation, which could be achieved using bacterial dye, coating, or spraying prior to or after the integration of substrate and plants. The roles of insects have been previously discussed: They randomly interacted with the experiments and hibernated in the folds of textiles, pupating or walking on and inspecting their surfaces. Designing textiles for insects is an intriguing concept, particularly with regard to how attracting and repelling them might be achieved, and how to guide them towards or away from textile structures and their spaces.
connected to others within their group but separated from those in other groups. Figure 188 shows patterns based on circles and Figure 190 shows patterns based on teardrop shapes, which could be used to explore hierarchical layering and selective timing in textile-plant structures. Circular patterns made from concentric rings could accommodate a seed or small seedling at the top; by adding substrate to the next ring through a loose weave structure, the plant could be provided with more space in which to take root and more nutrients to absorb (Figures 188-189). This approach would improve drought resilience due to the larger quantity of soil for absorbing and storing water. Consequently, hierarchical layering could be used to control the amount of substrate and its composition and influence the development of plants as regards when nutrients and moisture are provided, allowing growth to be restricted or promoted. As the resources that a plant is provided determine, amongst other factors, the duration of the development period, a modular circular pattern is a way of guiding growth. The difference between the circular and teardrop-shaped pattern is the space that is available to the root system: the former suits root systems that exhibit more shallow, horizontal expansion, while the latter primarily promotes vertical (downwards) expansion. However, the separated envelopes require the roots to penetrate the weave structure in order to leave one envelope and enter the next, meaning that plants with a taproot system cannot be accommodated.

The role of the people living with the structures is active, as they need to install, set up, maintain, and eventually move them. It would be interesting to investigate the kinds of interaction that emerge between all actors, and how they can be guided by the ways textile structures are designed and prepared. A range of speculative scenarios was presented in the Licentiate Thesis, wherein actions are proposed and textiles’ changing spatial roles over time are discussed in relation to the development of plants (Keune, 2018).

The roles of textile design and patterns have been explored in relation to basic geometrical shapes, such as stripes, cheques, circles, and squares. Circular patterns create distinct shapes and clear boundaries. They could therefore be used to accommodate a single plant or small groups of plants in ‘islands’,
Figure 189 illustrates the concept of selective timing in relation to a vertically oriented circular envelope. Here, a module consists of three envelopes in a bullseye pattern. Substrate and seeds can be inserted into the upper parts of the envelopes (the lighter grey areas in the gradient), and plants can permeate the structure. The envelopes could all be filled at the same time (Figure 189a), or at different times in order to restrict or guide growth. In addition, contact between the plants could be promoted or restricted. Figure 189a shows three plants that are connected by their root systems, which are located in the upper part of the envelope and therefore have a large quantity of substrate to take root in below. Figure 189b shows two plants, and explores the root development of the plant at the top by leaving the central envelope empty. In Figure 189c, the middle ring is empty in order to separate the two inserted plants, although the envelope could be filled later to provide more substrate and nutrients and enable contact between the two plants. The density of the weave construction at the bottom (the darker grey areas) is intended to prevent substrate from falling out and ensure that moisture is retained; here, the choice of material is of particular importance.

Figure 190 shows a pattern with adjacent triangles as a way of exploring the idea of ‘companion planting’ in textile-plant structures. Substrate could be inserted through the loose sections of the upper part of the textile, and seeds could be placed at the top in order to make use of the vertical space available and ensure that sprouts are able to permeate the structure. The triangles would be possible to separate from one another (which would mean that the plants would have to work harder in order for their roots to mingle) or could create one larger envelope. However, circular patterns containing a large quantity of substrate add a great deal of weight to a structure that is unevenly distributed vertically; thus, circular designs are not the best option. Due to their vertical orientation and thus even distribution on a vertical structure, stripes are more suitable. However, some factors have to be accounted for.

The channels that were explored in the ‘Textiles as Plant Mediators’ chapter were too narrow for the substrate to fit in, and so in the future the optimum width for insertion and the spatial needs of developing plants should be considered in relation to the stage at which harvesting is intended to be carried out. As is illustrated in Example 1.06, p 152 and Example 1.07, p 154 textiles can be easily extended using e.g. crocheted applications. However, envelopes can be attached to textile structures
to increase the space available for plants or accommodate companion plants at a later point. The vertical stripes and continuous grid used in the example ‘Strawberries in a Chequered Structure Outside’ provided space for the roots to expand and meet one another, facilitating the exchange of resources.

Figure 191 shows a pattern of vertical channels as a way of exploring vertical companion planting in textile-plant structures. The stripes accommodated a group of plants which, due to their close proximity, were beneficial to one another. The root systems of multiple plants in one channel can mingle or exchange nutrients below ground, while the plants in the next channel row can benefit from above-ground interactions, e.g. attracting the predators of pest insects and repelling pests through essential oils. Through the microclimate and vertical orientation of the structure, the temperature at the top may differ from that of the bottom. Different textile climate zones can also be achieved when water is applied from above and travels downwards due to gravity. In this scenario, plants that are sensitive to drought conditions should be placed close to the bottom.

Figure 192 shows a pattern with cheques; this was used to explore companion planting in textile-plant structures as well. The overlapping striped envelopes created restricted connections, and were filled with substrate all at once or separately, over a period of time. Water was introduced using the vertical channels and the moisture slowly moved downwards, thus reaching all of the plants. Plants are generally connected horizontally, as was achieved using the horizontal channels, but the vertical orientation of the textile-plant structure allowed them to be connected vertically as well. Through the vertical orientation and continuous vertical channels, the textile climate was different to that of other parts of the structure. In the uppermost vertical stripes, water was added and slowly moved downwards, temporarily collecting at the bottom of the structure. The drainage depended on the position of the textile-plant structure, i.e. whether it was suspended or resting on a surface. The driest part of the structure was the horizontal channel at the top, while the dampest areas were the lower parts as the water had more time to be absorbed there. The textile structure with cheques thus facilitated the creation of different textile climates in the same structure. Accordingly, plants should be chosen and placed within the structure with the desired textile climate in mind. The potentials of vertical and horizontal above and below ground connections as well as the climatic differences in relation to plant growth, communication and symbiosis need further investigation.

Textiles, as a flexible medium, can thus provide a flexible environment that can adapt itself, or be adapted by a plant or a person, to a plant’s changing needs. A textile could be constructed in such a way that it provides climbing support for pea plants and a bacteria called Rhizobia, which the pea plants form a symbiotic relationship with due to the fact that it can fix nitrogen gas from the atmosphere, turning it into a more readily useful form of nitrogen which benefits the plants. The textile could also expand over time to provide more space for root development. By enclosing the substrate, pest ingress can be prevented, and the textile plant mediator can be moved easily, including on its own axis in order to change the plants’ direction of growth from vertical to horizontal. Furthermore, it would be interesting to explore to what extent below-ground actions could be facilitated by the part of the textile there, and how this could be supported by textile materials and structures in which multiple and complex interactions arise by dynamic assemblies of abiotic and biotic actors.
RESEARCHING WAYS OF LIVING

Living with Diversity

At first glance, the examples described in the ‘Ways of Living’ chapter may seem to have little to do with textiles; however, they explore a spatial approach to seasonality, namely seasonal spaces and interiors. This is a spatial form of textile permeability and relates to microclimates both inside and outside. Figure 177 shows how the concepts relate to one another.

Spatial permeability was explored by connecting the space to the outside using textile materials, windows, doors, a greenhouse, and an openable floor. These architectural elements initially divided, then selectively connected and merged, spaces, providing information regarding human relationships and relations with the outside. McCarter dedicated The Space Within: Interior Experience as the Origin of Architecture to these inside/outside relationships, and how architects engage with them. He examines how, from the late 1800s to today, architects perceive the differences and connections between interior and exterior spaces, and how these are incorporated into design processes. The final chapter, ‘Interior Experience of the Exterior Environment’, presents the views of e.g. van Eyk, who argues that all inhabited spaces, including urban squares, must be understood to be interior spaces. Similarly, Wright claims that modern architecture marks the end of the separation between the inside and the outside, and that the presence of nature should be an integral part of everyday life and interior experiences. Conversely, Leatherbarrow argues that the separation between the inside and the outside was not eliminated by modern architecture, and that instead the spaces between them were enlarged:

This makes it possible for people to live both inside and outside their houses, and also in the in-between areas, the transitions between ‘inside’ and ‘outside’ [...] the building’s margins were designed to transform an entirely palpable ambient quality into its desired opposite: warm air was cooled in summer, in the winter the reverse. Likewise were both glare and darkness moderated. The walls of the building were instruments of intertwining, according to which rooms and [exterior] fields could supply what each other lacked, like the sort of fabric that allows your skin to breathe while keeping it warm. (quoted in McCarter, 2016:140)

Here, Leatherbarrow refers to the functional qualities of textiles and skin to curate and mediate between elements, causing some to pass through and others to be repelled. He uses this example in order to describe the performance of the architec-
on so that the second loft could be used as an office, and the sliding window could be used as a desk to transform the loft into a seating area. One of the large windowsills on the ground floor could also be used in a similar manner. The garden, greenhouse, and rooftop were explored in similar ways. The showerhead could be attached to all of the water outlets in order to rinse vegetables in the kitchen or wash oneself, both outside and in other interior spaces than the bathroom. Even the showertub could be moved to another place. All of the technical appliances had more than one function, and could be altered or upgraded with relatively little effort in order to be improved or connected to another system. Spatial permeability thus involves creating an open framework, instead of permanently furnishing a space following certain standards. In this way, diversity in terms of living practices is allowed and supported by the spatial setting.

The openness of the space, which mediated between the inside and the outside, was represented by the greenhouse, the rooftop window, the swinging windows, the vegetable bed, the openable floor of the greenhouse, and the plants within. Consequently, seasonal usage, experiences, and expressions entered the interior, resulting in seasonal interiors. In winter, the greenhouse was used as an extended and roofed entry space, in spring to occasionally heat the house, and in both spring and summer to cultivate vegetables and as an extended living room. Bees, butterflies, lice, ants, and a hornet paid a visit during the summer, while lacewings entered the greenhouse in the autumn to hibernate, and occasionally found their way inside. Some mice found a cozy place and some food during the winter. The wood stove was used for heating, cooking, baking, and drying during the winter; in summer, the gas stove was used for cooking. The rooftop terrace was a pleasant place on dry and warm days; on rainy ones, the sound of rain was amplified in the greenhouse, and the translucent roof provided optimal lighting that was amplified in the interior. Expressions of the outside consequently also appeared inside. The natural stone bathroom floor created the sensation of walking barefoot on a riverbank, while the branches in the kitchen and bathroom introduced bark and lichens into the interior. The worm farm made vermicomposting possible throughout the year, and facilitated experience of microbi-al processes through the production of liquid fertiliser and hummus for plants. Bees and wasps that flew past the ventilation slot could sometimes be heard throughout the house.

In relation to this, Le Corbusier argues that:

> I perceive that the project we are designing is neither alone nor isolated; that the air around it constitutes other surfaces, other grounds, other ceilings [...] A pro-ject is not made of itself: its surroundings exist. The surroundings envelope me in their totality as a room [...] the outside is always an inside. (quoted in McCarter, 2016:142)

Spatial permeability could thus be used as a foundational principle with regard to how spaces are thought of, designed, built, and explored in relation to their surroundings, as the concept situates the ‘boundary condition’ at the centre of the design process.

The Tiny House on Wheels offered various opportunities to live inside, outside, or between the two, and for continuous readjustment by e.g. moving the bed to the ground floor, the second loft, the rooftop terrace, the greenhouse, or outside into the garden. In addition, the hammock that could be placed inside the house was possible to sleep in. The same was true for the working space. A ladder could be sat or stood...
DISCUSSION

The differences between the spatial climates in terms of e.g. temperature were not limited to the differences between the inside, the greenhouse, and the outside; Example II.03 illustrates other more or less temporal and mobile systems, e.g. evaporational cooling, which replaced the electrical fridge under the kitchen counter. It is the coolest place in summer aside from the bathroom floor. The hottest place is under the roof-top window when closed. The temperature difference between the top and bottom of the house is approximately 5°C due to warm air rising, and so the two lofts are always warmer. As the storage space is well insulated, dark, and stores 100 litres of cold well water, a quite stable temperature was maintained in both summer and winter. The greenhouse was the space with the highest temperature fluctuations as it was not insulated and had a glass façade, and was always warmer than the outside. In the winter it was colder than the inside, and during the summer it was warmer. There were also large temperature differences between the vegetable bed under the greenhouse and the highest shelf, which was at a height of three metres. This inclusion and consideration of local conditions in the planning of the Tiny House on Wheels also extended to the outside: The walls of the house with the most windows faced east and south so as to let in as much light as possible. In summer, a large maple tree provided shade at midday, although in winter, with the leaves having fallen, this was not the case.

Petersilie is clearly designed for observation, exploration, and experience, rather than comfort, automation, and hiding the impact of one’s everyday living practices. Moreover, it is based on past experiences and imagination regarding the future – thoughts of independence and a desire to take responsibility for one’s own impact on the environment. My personal experiences showed that the knowledge and the freedom that I gained were far more significant than the change in habits I had to make, and I felt that these changes were empowering, instead of restrictive.

The three examples that explored spatial permeability opened up many possibilities with regard to the use of textiles. They not only made spaces more flexible, permeable, and able to incorporate seasonal experiences, but connected available resources and integrate them into material cycles through the assistance of environmental conditions. A vertically suspended structure in which plants are incorporated could thus collect rainwater from the outside roof while filtering the water through the

Figure 192: The conceptual design of the Biogas curtain.
textile fabric, the plants, and their substrate. Another metabolic mechanism in textiles could be a textile biogas system, along the lines of a vertical biodigester made from textile materials – a ‘biodigestive curtain’. Such a curtain could feature a range of smaller biodigesters, such that the gas tanks and digester tanks are not excessively large, but can be arranged next to one another across the curtain (Figure 192). Waste would be introduced using a small feeder tube into the digester bubble at the bottom of the curtain. Through its weight, the tanks would consequently stabilise and weight down the curtain. During the fermentation process, the liquid that could be used as fertiliser would run out at the bottom and be collected or led into the ground, while the methane gas would rise through a tube filled with steel wool in order to separate the sulphur from the gas. The curved tubes would prevent moisture entering the gas balloons. When gas reaches the balloon in the upper part of the curtain, it would expand and create a certain pressure that could be used to provide a gas flow for a stove. The size of the gas balloon would thus provide information regarding the amount of gas available and the status and function of the biodigesters. By feeding them with different mixtures, one could examine which of the digesters works best. Producing and harvesting gas from such a ‘biodigestive curtain’ would thus demand a certain amount of dedication and observation over time.

Designing and Researching with Time in Mind

Time is considered very differently in relation to plants, to textiles, and to architecture. In biology, time is the second key aspect of growth; there is no defined final state as the very principle of biology is cyclic, and instead there is the strive for maturity so as to ensure procreation (Imhof & Gruber, 2016). In textiles and architecture, every action is concentrated on the rapid completion of the structure – the end of the fabrication or building process, and the start of functionality. For the last few centuries, ideal forms of architecture have been independent of time and processes of decomposition, and the same can be said of interior textiles and interiors in general. Decker emphasises the use of performative materials to overcome this (2016), and explorations with biomaterials have introduced degrees of temporality. Plants, however, incorporate manifold potentials that exceed the production of bio-fabricated materials using temporary microbiomes. Examples of such cultivated materials are discussed by Hebel and Heisel (2017), and include bacterial dye (Chieza & Ward, 2015) and Ludwig’s “living plant construction” (Ludwig et al., 2012: 83), which grows over time, changes with the seasons, is never finished, and never repeats the same expression. On Textile Farming aimed to relate the potentials of plants to textile expressions and interiors by breaking down their elements in order to understand them and their processes, all in order to be able to design with them. Designing and building with “time in mind” (Franck, 2016: 8) and embracing this fourth dimension of design processes (Decker, 2016) consequently becomes a major part of not only the process of designing or fabricating, but of usage and living practices. Goffi writes of “unfinished fabrics of time” in relation to architecture, which are coated with history and offer a basic texture for imagining futures and offering continuity and succession (Goffi, 2016: 24). Just as some objects are affected by external conditions and expressed by seasons, activities, and transformative materials, the textiles in which plants are embedded and the spaces that they inhabit show their transformative presence through time-based changes, wherein “time is local and embedded in the moment” (Taylor, 2016: 49). One of the preconditions of living organisms is metabolic activity, which is an exchange of substantial amounts of matter and energy – and again, a cyclic process – that requires careful coordination between supply and discharge, system and environment (Gruber, 2016). By living in a prototypical environment and gradually introducing systems that support a certain level of metabolic activity to everyday life (food, water), the interior is imagined as an ecosystem in which there is no waste and energy is recycled.
In the context of this research, many circumstances have contributed: the employment at Svensson led to me putting aside research into textiles and electronics and instead considering plant seeds to be biological microchips on which the entire blueprint of a plant is stored, and that is constantly examining and responding to its environment. In addition, the agenda of exploring more sustainable future ways of living was fuelled by the escalating climate crisis and limited housing options in Sweden's cities, along with problems with growing crops in universities and corporate offices. This led to the construction of an environment for self-determined research and life, involving the renunciation of ordinary living standards. This was enriching rather than limiting, and opened up for an unending wealth of ideas regarding how to live a life full of experiences with using less resources and technologies, e.g. refrigerate food without a refrigerator and how, over time, all systems could be linked to one another.

Rethinking Comfort

Many future scenarios used to develop anything from products to homes and cities emphasise the use of technology. They bring smart concepts to the fore, turning living environments into hyper-efficient spaces in which experiences are as seamless and automatic as possible and energy cycles and climatic conditions are systematically and automatically optimised. A popular scenario is the autonomous optimisation of indoor climates using air-conditioning systems, which are intended to efficiently manage indoor climates without independent ventilation, e.g. opening a window or terrace door or the adjustment of radiators. However, temperature is perceived differently by everyone and cannot be standardised, leading to personal interventions that can disturb the system or destroy its positive benefits by e.g. opening a window or installing a mobile heater, decreasing an employee's work performance. On the one hand, resources are supposedly optimally used, in this probable future scenario, and distributed and equipment no longer bought (used but not consumed), and our way of life is more effectively regulated automatically, without our intervention. On the other hand, the possibility of self-determination is restricted, and diversity in terms of differences decreases. Unified solutions can thus have a dampening effect on self-responsibility, and restrict personal involvement and interventions. People in this scenario may believe that they do enough (for sustainability) by supporting such systems, and that one can afford to maintain today's Western standard of living and continue with one's lifestyle by simply optimising existing systems. This, however, presupposes that certain unified solutions exist that suit the needs of everyone, and furthermore that a system exists that is the most sustainable for a given location and context. The idea of unified systems, moreover, imply that we will depend ever more on services involving large-scale cooperation, through which we will lose our connection to the objects that serve us in our everyday lives, as these hide the mechanisms of their functions and do not require maintenance or allow adjustments to be made. With this unification of standards and systems, we lose the variety of alternative possibilities—and, more importantly, alternative perspectives. Such systems also enhance the division between interior and exterior environments (Hensel, 2012) through their hermetic approach to technical climatisation, as well as through the standardisation and homogenisation of interior environments. Therefore, as Hensel argues:

...it is necessary to reduce the total amount of climatised interior relative to the allowed footprint of a building for the sake of an extended threshold approach that enables a more heterogeneous space with half-climate and more exposed areas, as well as to share these partially with other species. (Hensel, 2012: 228)

Sharing a part of my living space temporarily with mice and lacewings was certainly a challenge, but drew attention to how houses are generally cut off from these experiences and how important it is to find a way of coexisting by e.g. providing spaces for these creatures to occupy. As bees and lacewing populations are already adapted to artificial housing solutions that are temporarily inhabited to varying degrees (e.g. beehives, attics), spaces or suitable surfaces could be designed and provided within domestic housing.

Papanek argues that design has turned into the most powerful tool with which people shape tools, environments, society, and themselves, and accuses designers of being jointly responsible for almost all of our environmental mistakes through “bad design or by default” (1971). He argues that it is the responsibility of designers to factor in social and moral considerations before the design process even begins, and that they carry an important role due to their training, which stresses the importance of “speak[ing] the language of many disciplines” (Ibid.). Papanek is not the only critic of design practice, however; based on Borgmann's philosophy of technology, Fallman argues that the concept of ‘good’ design in relation to technology has to be
Current standards for building and furnishing houses provide little diversity or ways of changing or experimenting with implemented systems. Hagbert and Femenías argue that housing design today is determined by market forces, such that sustainability is defined by the ideals driving those forces rather than being based on knowledge of actual practices (2015), and design can play an important role in creating structures that can decrease usage of resources (Hagbert, 2014), such as low-energy structures that can change and shape routines and habits (Shove & Walker, 2010; Scott et al. 2012). Braide asserts that an oppositional development has taken place; on the one hand there is the interest of inhabitants to change and adapt their homes based on their changing preferences and needs, and on the other there is the increasing standardisation and resulting reduction in diversity and possibilities to adapt and change things (Femenias et al., 2016).

A common prediction is that the proportion of the world’s population that lives in urban environments will continue to increase. Most of the homes in which these people will live are currently being built, or will be built in the near future. Manzini and Jégou (2014) argue that if these spaces are to function differently and be more flexible, sustainable, and resilient, urban planning, architecture, energy systems, and interiors must be re-thought. In ‘Sustainable Everyday’, they suggest scenarios and proposals that were developed to address the challenge of sustainability in urban contexts. Here, the risk of making seemingly naive suggestions is acknowledged, and the motivation is to promote positive choices rather than disastrous events. Furthermore, Manzini and Jégou are of the opinion that “we are all designers of our own lives – and so of our own future”, and so call for more “possible scenarios for living strategies”. From this perspective,

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\text{design activity that leads to sustainability is not a one-sided, unitary project based on a single way of seeing things. Instead, it is a complex social learning process, a vast intertwining of initiatives in which we proceed through partial successes, errors and unforeseen effects, learning by experience. (Ibid.; 14)}
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This perspective on design and sustainability demands a greater diversity of living strategies than what is available at present. It also requires a social movement that is empowered to explore forms of living and take the risks that come with such a project.
In ‘Design for Existential Crisis’, Light et al. present a list of qualities that can be employed in design work, and acknowledge and respond to the approaching existential crisis. They suggest that we design for noticing – to acknowledge and embrace the rhythms of life and death around us so as to be in contact with natural processes. Here, the concept of seasonal interiors aims to open up interior spaces towards the outside by inviting seasonal expressions and experiences. Enabling this suggests that interiors become open frameworks in which the inside and outside merge, and their use is a fluid and continuous improvisation. Van Eyck argues that all spaces that are made by people, both inside and outside, must be understood to be interior spaces, including rooms, streets, and urban squares, and offers an interesting perspective that is similar to one that arose while living in Petersilie, albeit in a rural context: “We are in the most important room of the house: the garden […] Architecture that lasts […] provides maximal engagement of its environment and maximal enrichment of experience for its inhabitants.” (McCarter, 2016: 134). Van Eyck criticises the ‘sealing’ of interiors (through e.g. uniform mechanical heating and cooling), which denies inhabitants sensory engagement with exterior environments. There is little to no engagement with the climate and natural contexts, e.g. solar orientation, the shade of a tree, gusts of wind, the smell of rain, and the sounds of insects and native birds. Light et al. also suggest designing for more gratitude and adequacy in relation to resources, positing that contact with and personal responsibility towards local resources such as drinking water and issues such as waste (e.g. grey water) are of major importance (2017).

There were several reasons this research became autobiographical in nature. In order to develop alternative perspectives on ways of living more sustainably and decrease the use of resources needed on a day-to-day basis, a personal viewpoint had to be explored by investigating a ‘sufficiency-based lifestyle’ (Kropfeld, 2019), how much of a reduction was comfortable, inspiring, and felt to be an increase in quality of life. Furthermore, the environment in which the research took place provided a foundation. This research argues that a normal working place – often just a desk in a temporary space – is not suitable for such an endeavour, particularly if the basis of the work is practice-based research through art and design. It was this conclusion that led to my investment in my own, external environment, in which opening times, behavioural rules, and existing systems have no influence. The decision to base myself in a rural area was made due to the absence of spatial restrictions and rules to comply with: I was able to immediately follow an idea, without having to apply for permission first, comply with opening times, or deal with spatial matters.

The possibilities for observation and discovery were unlimited, and it was possible to spend the whole day outside, observing and obtaining inspiration from the subtle but vibrant surrounding life. There were also few distractions that could interfere with creative processes. As a result, it made sense to explore living and being in nature in order to begin to imagine how one could do the same in urban spaces.

The perspective taken in this research aims to provide a more holistic understanding of relationships, and acknowledges the equal role of all involved parties – the autobiographical researcher, the design experiments (artefacts), and the environment in which they interacted with one another. In doing so, the perspective “supports ways of understanding and designing that take place after, with and beyond the design work at project time” (Giaccardi, 2016: 378). This implies that the environment in which the researcher is immersed effects both artefacts and the researcher. Desjardins and Wakkary support this by writing about the intimate relationships that were constructed between the maker/user/researcher and a van that was slowly converted into a campervan (2016). They describe both the prototype and people living in and using it as changing over time, explaining this reciprocal shaping using the idea of a ‘reflective conversation’, first posited by Schön. Designing and transforming the van was undertaken while maintaining a balance between achieving physical comfort and being challenged by living in such a reconfigured space (Desjardins & Wakkary, 2016). In the research presented in this thesis, the artefacts, researcher, and environment were considered to be equally important, and their connections were explored through autobiographical design. Consequently, the design examples presented in this thesis are the result of actions carried out by all involved parties, including the researcher, the materials of the artefact, the environment, and possibly animals and insects. The design examples thus provide insights into the agency and interconnectivity of living things (intentions, reactions, developments over time in changing environments) in relation to their surroundings and sustaining factors (human management and the natural environment). Csikszentmihályi argues that the process of cultivation generates a strong bond between the cultivator (the researcher or the manipulator/user) and the cultivated (the artefact). Thus, we value living things differently than inanimate objects (Csikszentmihályi & Halton, 1981: 173). A researcher who not only designs but cultivates designs consequently has a more intimate perspective, and a better ability to generate new knowledge.
Tiny Houses as a Platform for Researching Sustainable Forms of Living

With the depression that affected the United States in 2008 and a growing number of people unable to afford accommodation, interest in the Tiny House architectural and social movement grew exponentially. The desire to live in a more simple and ecologically friendly way reached Europe more recently, and resulted in a number of self-built projects and small companies specialising in the building of Tiny Houses (Tiny Houses, n.d.; Vagabond Haven, n.d.). Tiny Houses on Wheels that can be moved via road are very popular. This movement brings with it many architectural, social, and systemic challenges. However, building a mobile home requires consideration of the building and road-traffic regulations, as transporting and ‘parking’ them is not particularly easy. As they are not considered to be real estate, it is not possible to obtain a property loan with a favourable interest rate, which makes the financial aspect of owning a Tiny House on Wheels challenging. Living in a Tiny House on Wheels is not necessarily more sustainable than the alternatives, as they are e.g. exposed to the weather in every direction. An apartment is, in fact, much more energy-efficient than a Tiny House on Wheels, as e.g. heating systems and washing machines can be shared with other residents. Tiny Houses on Wheels are not necessarily a simpler form of living, either, as there are many examples on the market that are similar in standard and equipment to normal houses – they are simply smaller and more mobile. In urban environments they are exposed to their surroundings, e.g. noises and curious people. As they suggest mobility, independence, and affordability, they are not a solution to a growing population and the lack of housing in big cities. However, a Tiny House on Wheels allows many norms that define common residential buildings to be changed or disregarded entirely, e.g. fridges, washing machines, and furniture, and even some that are mandatory, e.g. a water toilet or conventional sewage system. Purposely removing this framework from existing buildings would result in a feeling of restriction and loss of comfort. Starting from scratch within existing regulations regarding e.g. dimensions and weight, however, enables everything to be questioned and creativity to be boosted in order to find alternative solutions and start with as little as possible, with the opportunity to improve over time. This is what makes Tiny Houses, whether on wheels or not, interesting instruments for researching more sustainable forms of living. Examples of this include the Bauhaus Campus exhibition held in Berlin between Spring 2017 and Spring 2018. An experimental Tiny House village on the grounds of the Bauhaus-Archiv in Berlin became a place for open education and discourse relating to e.g. democracy, sustainability, and design, and hosted the Tiny House University (tinyU), a Berlin-based non-profit association founded by the German architect Van Bo Le-Mentzel in 2016. The village was a temporary hub in which a range of initiatives and projects were showcased and developed, e.g. Tiny100, the Projektcafé Grundeinkommen, The House of Rights, the New Work Studio, and The Holy Foods House (Bauhaus Campus, 2017). All of the buildings addressed contemporary societal challenges with regard to affordable housing, mobility, refugees, democracy, food, education, sustainability, and ways of working. The village was also the temporary home of the Green Tiny House, which was built as part of a research project on a self-sufficient grey-water treatment system in order to strengthen autonomy using universal systems. This was created in order to empower individuals to develop their own systems, and to provide access to a filter system that had been built into the wall of the Green Tiny House (House of Tiny Systems, 2019) in a way that revealed its principles and processes from inside and outside.

Living with Petersilie resulted in a more autonomous way of life with regard to standards and systems, and a more symbiotic life with regard to building connections with plants, insects, animals, and the weather. After one year of living with Petersilie and four years of research, however, it feels like the journey has only just begun, and the experience has awakened the desire to continue living in and working with Petersilie on research projects. Moreover, I wish to root the Tiny House on Wheels in one place in order to create stronger bonds with soil and plants by engaging with natural cycles and regenerative practices, and to further investigate the potentials of textiles and textile design in relation to this. A special interest is the potentials of textile-inspired architectural surfaces for insects, in order to gradually invite more ‘outside’ perspectives, expressions, and experiences into designing, building, and dwelling practices.
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The publication presents reflections on a two-day workshop on textile interactions, in which the group members and authors of the paper focused on edible materials in textiles, e.g. popcorn and coffee beans in tubular knits as materials for hand weaving. The experiments were based on the methods of insertion and activation of the On Textile Farming research project, and were used to investigate and reflect on edible textiles as a new, hybrid form of media by relating them to examples from contemporary art and design.
and provides an overview on related examples in contemporary art and design practices to investigate edible textiles as a new hybrid form of media. Our reflections relate to the present debates on new materialism and economy of attention, by questioning the concepts of ‘medium specificity’. Both ‘new materialism’ and ‘economy of attention’ are forms of critical interventions. New materialism addresses human and non–human agencies in an attempt to reconfigure nature / culture, body / thought, concrete / abstract dichotomies. The ‘economy of attention’ is an expression used by theoreticians like Herbert Simon (1971) and Bernard Stiegler (2010) to speak about new forms of attention management in contexts of information overproduction.

The debate on the specificity of the media was launched in the 18th century when the industrial forms of production started to impose themselves. The medium specificity debate guided most of the modernist enterprises that were trying to accommodate the role of arts in the industrial schema. Therefore, the focus on the ‘aesthetic efficiency’ of artistic production hints an economic concern (Heinzel, 2014).

The multifaceted aspects we encountered open up for a discussion on how media is defined, suggesting intermedia is not only a condition for alternative forms of expressions, but also the mark of a new paradigm that exceeds the modern industrial affordances schemas. Supported also by STS studies’ conclusions on the nature of relationship between materiality and sociality (Law, 2008), our research points towards possible design strategies of material intervention.

Intermedia has to be understood here as the coming together, in a unified manner, of different already established forms of media. ‘Edible textiles’ are seen as textile structures that contain or are made of materials that can be consumed by living beings such as humans, animals or microorganisms. Consequently those structures relate to ‘food art’ and biodesign, proposing new opportunities for textile artists and designers to explore new expressions by developing new materials, design methods, aesthetics and forms of interactions.

Experiments on textile interactions: edible textiles

During a two–day workshop on textile interactions conducted by Delia Dumitrescu and Hanna Landin in the frame of ArcinTex Conference which took place between April 11–15, 2016, at the Swedish School of Textiles in Borås, there was a general interest in the work–in–progress materials
Commercially available tubular knitted materials from cotton, wool and synthetics were used as a basic material, and thus we focused on creating hybrid textiles, a combination of textile materials and edible/biological materials. The collected edible and biological materials to fill the basic textile materials with were cornflakes, corn, coffee beans, hazelnuts, pasta, coconut fiber tablets and boiled eggs. These materials were filled into the tubular material by using a straw and/or manual pressure to bring and spread them across the length of the tubes (fig. 3). The result was a series of different threads that could be used further, i.e. in hand weaving.

By using plain weave, the produced threads were used as weft material on an ARM–loom in a hand–weaving process, partially supported by using common yarns (fig. 4). Later on, the samples were activated to generate ideas for textile interactions and transformations, based on the potential of the edible materials used in the thread–production (fig. 5). Important design parameters were: filled materials, diameter and density of the knitted material, the weaving material in warp and weft. Fundamental for the overall expression were the edible/biological materials in terms of size, pliability, and consistence or to initiate processes of plant–growth (fig. 1).
Experiments

In the following section, three experiments are described more in detail: corn, coffee beans and pasta. The experiments varied according to the type of filled elements we used.

Fabrics with corn

For the fabrics filled with corn, a spray can filled with water, a heat gun and a microwave has been used (fig. 6). Due to the heat required for the popping of the corn, the textile can start to burn quickly. This can be avoided by using flame retardant materials or by careful observation and cooling breaks for the fabric in between the heating phase. As the corn stores the heat, those cooling phases don’t disturb the process of popping too much. The popped corn adds more variation to the textile structure such as an additional color, an opposing consistence through the light, crisp but fluffy popcorns that consequently enhance the texture and that add three-dimensionality and odor to the structure (fig. 7). The popcorn can be picked from the textile surface or the floor if it popped out, and can be eaten. By activating the corn with water, the corns start germinating within one or two days. The small sprouts fight itself through the knitted structure. Here the overall expression and dimensions of the weave itself stay the same and are only affected by the germinating seed and its further growth.

Figure 6 The production line with corn. Copyright: Svenja Keune and Juste Peciulyte.
Fabrics with coffee beans

The weave with tubular inserted coffee beans was soaked in hot water for a couple of minutes. Observed was a slight change in the color of the water and the weave, it turned brownish. The strong odor of the roasted beans stayed the same (fig. 8) and consequently opens up for uses in interiors where smells need to be neutralized or that would profit from the smell in other forms.

Figure 7 Weaving with corn. Copyright: Tincuta Heinzel.

Figure 8 Weaving with coffee beans. Copyright: Tincuta Heinzel.

Figure 9 Weaving with pasta. Copyright: Svenja Keune.

Figure 10 Pasta soaked in cold water over night. Copyright: Svenja Keune.
Weaving with pasta

The weave with pasta has been partly soaked in cold water over night and in hot water for a couple of minutes. Observed was a change of colour and consistency. Under pressure the soft pasta squeezed through the tubular knit. The overall expression changed towards a flat, textured surface that became rigid through drying (fig. 9 and fig. 10). This experiment with a distinct passive, as well as active structure, opens up for using edible materials to achieve certain transformations or material properties such as flat or three-dimensional, soft or rigid, pliable or stiff.

Examples of edible textiles

At the end of these experiments the concept of ‘edible textiles’ imposed itself. Therefore we decided to investigate some other examples of existing edible textiles.

Camilla Wordie ‘textile based’ approaches

The Scandinavian artist Camilla Wordie works at the intersection of textiles and food, defining herself as a food stylist. She translates different textures of food into textile structures or produces textile structures by using different kinds of foods. The Wearing Rice is Nice project (fig. 11) was inspired by rice textures.

Figure 11  Camilla Wordie, ‘Wearing Rice is Nice’ (2013). Copyright: Camilla Wordie.

The installation Am I chocolate or not? (fig. 12) consists of a tabletop made from chocolate to enhance the common experience of ‘crumbly’ and ‘dusty’ chocolate powder. Parts of the table can be eaten or react to forms of use, such as traces of melted chocolate caused by warm plates.

Figure 12  Camilla Wordie, ‘Am I Chocolate or Not?’ (2013). Copyright: Camilla Wordie.

De Culinaire Werplaats (Eric Meursing and Marjolein Wintjes) – you are what you eat. Copyright: Marjolein Wintjes for De Culinaire Werkplaats Amsterdam.

De Culinaire Werplaats ‘you are what you eat’: ‘politically conscious approaches’

Eric Meursing and Marjolein Wintjes (fig. 13) produce edible pastry wrappers made out of dehydrated fruits, vegetables and herbs in their design studio/restaurant. They created a collection named ‘taste the unwearables’, aiming to raise the awareness towards natural and organic food, but also to debate about the ephemeral nature of fashion. In contrast to Wordie’s experiments with food, Meursing and Wintjes collection encourages the consumption of the textile. They also follow a more holistic
The described experiments that are condensed under ‘Al dente textiles’ question the possibility of edible textiles as medium. It is also to notice that if it is to keep us in the recurrent understanding of media as form of communication, then neither textiles, nor food are conventional forms of communication. They do not really use codified information inscripted on a material support for straightforward interpretation. They are rather forms of expression. Both in the case of textiles and food, the opposition between support and content is a fragile one. Therefore, one of the questions we have to address is through which means textiles and food become expressive and what do they mediate?

Textiles and food as medium

The described experiments that are condensed under ‘Al dente textiles’ question the possibility of edible textiles as medium. It is also to notice that if it is to keep us in the recurrent understanding of media as form of communication, then neither textiles, nor food are conventional forms of communication. They do not really use codified information inscripted on a material support for straightforward interpretation. They are rather forms of expression. Both in the case of textiles and food, the opposition between support and content is a fragile one. Therefore, one of the questions we have to address is through which means textiles and food become expressive and what do they mediate?

Textiles as medium

One of the key persons in the definition of textiles as a medium was the Bauhaus artist and designer Anni Albers. In her book On Weaving (Albers, 1974), Anni Albers defined fabrics in terms of construction (Heinzel, 2012). The specificity of the textiles would reside, from her perspective, on the way the threads are brought together to form a fabric. That it is also why, the main channel of appropriation of a fabric is the texture, which is generally

Aniela Hoitink: growing textiles (MycoTex)

In order to investigate and to develop new methods for textile and fashion production, Aniela Hoitink, a Dutch fashion designer and researcher, developed a dress from mycelium, a living material which forms fruit bodies in forms of mushrooms and which she uses as a material for design. Usually grown on solid substrates such as wood, the mycelium here was grown in a liquid environment to manufacture thin textile–like layers. The pieces, shaped by their petri dishes they were grown in, were then merged to form a dress. The mycelium reacts to environmental conditions, degrades and can be repaired by natural processes. The dress mediates imaginations on future forms of manufacturing, aesthetics and materiality of textiles and clothes (fig. 14).

Figure 14 Aniela Hoitink, ‘Mycotex’ (2016). Copyright: Aniela Hoitink.
Al Dente Textiles. Notes on Edible Textiles as Economical and Ecological Intermediality

given by the threads’ properties and aspects, as well as by the way they fold. Different from other mediums of artistic expression, like painting, for example, the qualities of the fabrics are not to be appropriated only through vision, but also by touch.

Often used for sound insulation and, more recently, synthetically produced, the textiles display qualities like sound absorbance or impermeability which not only are defined in relation to an physical environment, but are also pushing forward the relationship between the natural and the artificial properties of the fibers. In a way, the new physical properties of textiles are translating the technical advancement of their sites of production. The transformation of textiles in interfaces (Heinzel, 2012) it is even more obvious in the case of electronic and smart textiles. The augmented capacities of textiles materials and their controlled performances are all supporting this perspective.

The use of fabrics can result in textiles artifacts, like cloth or furnishing, which at their turn can become a medium, as Marshall McLuhan see them. For him cloths are our second skin and therefore a body extension. And, as he describes in Understanding Media (McLuhan, 1964), the cloth has a double role: 1) to offer a thermo-regulatory mechanism to the body and 2) to socially define the individuals (the difference between cloth, costume and style, for example, it is to be taken into account). Fashion in this sense participates to the definition of the social distinction through cloths.

Food as medium

When it comes to food, we can delimit between cooking and eating. Both have rich aspects to consider: from the products that are cooked, to the way they are acquired, the hygienic conditions of cooking, the use of condiments, specific traditions of cooking, to the accessibility and variety of food and the cultures of food consumption. Like cloth, as a basic need, food is consumed /used on daily basis. But then, like in the case of cloths, we can also delimit between common food and special occasions food or ritual food. The discrepancies between different geographical regions, between social classes, are also not to be neglected. Such interpretations cannot take place out of the context in which they are performed. Their form of expression is related to their ‘affordance’ (Gibson, 1979; Lievrouw, 2014) in terms of functions, relations and repertoires of uses culturally and socially sanctioned. It is in this note that we should also interpret our approach to textile and food waste.

Notes on media

The idea of bringing together two media like textiles and food, forces us to acknowledge the existence of two distinct media. This fact pushes us to define them and to find what are their specificities. The preliminary tests and the examples we have studied served to question the aspects to consider while generating new intermedia forms. Still, the whole picture would not be complete, if these speculations are not placed in a larger historical perspective. Tracing back the ways in which arts and design have defined the media specificity, will help us to understand the strategies design had used in order to make relevant interventions into the socially constructed nature of materiality (Law and Mol, 1985).

Media specificity theory

The debate on media (medium) specificity it is not a new one. It can be traced back to 18th century when Gotthold Lessing opposed Charles Batteaux on how to approach the arts. If Charles Batteaux (2015) was suggesting that the rules of art should follow the classic principles of imitation of nature and, therefore, all arts should be treated in the same way, Gotthold Lessing opposed him by arguing that ‘an artwork, in order to be successful, needs to adhere to the specific stylistic properties of its own medium.’ In Lessing’s perspective, as derived from Laocoon (Lessing, 1836), some arts are more likely to express better certain ideas than others. The poetry, for example, was to be used to depict actions, while painting was fitting better to represent moments.

In this way, the specific stylistic properties of the medium are to be understood as ways to achieve a maximum aesthetic effect by using the medium's most common properties. In other words it was about how to reach an ‘aesthetic efficiency’ of the artistic product by mastering the limitation of the materials and by studying the fastest way to reach an aesthetic impact. The scope of each artistic discipline would be in this sense to develop their own methodologies, to delimit their own areas of competence.

The quest for the specificity of the medium was at the core of most modernist theories, being them art (Greenberg) or craft/design (Bauhaus) related. Bauhaus school’s workshops, for example, followed the principles of media specificity and were organised based on the used materials following Bauhaus Manifesto’s lines in which it was stated that art cannot be taught, there are only the techniques that can be taught. It was only through technical competences that pertinent and critical interventions were
understood as aesthetic ‘efficiency’ (Heinzel, 2014). Going along the industrial serial production, the medium specificity’s role was to ensure that the aesthetic dimension, the sensitive appropriation of the objects, was universally functional, facilitating in this way the social insertion of industrial production. Modernist claims of not being a style and of being un–historical, it is to be understood also in this key. This aesthetic efficiency was later to be acquired by studying the perceptive abilities of the users (aesthetics and psychology), ergonomics, measurements’ standardization and/or observation of their life style (anthropology).

Still, already in Annie Albers’ writings, we will found references to the synthetically produced fibers and their enriched properties. Today, through the development of nano–technologies we can speak even of materials as machines (Bensaude–Vincent, 2010), where the molecules are about to be active agents in the environment. At the same time the development of 3D printed manufacturing and the debates on alternative fabrication models (like fab labs, or robotized production, for example) are promising to revolutionize the industrial mass production model. Not only we have today a new understanding of the matter, which is not in terms of materials, but in terms of functions (Bensaude–Vincent, 2010), but we can also see initiatives that are looking to allow us to customize our mass production and subsequently, to have less of waste. Therefore a new understanding of the media is making its way.

An economic lecture of the media finds nowadays it’s way through what it is generally called the ‘economy of attention’. Unlike the modernist perspective, which was trying to accommodate the role of arts into an industrial society, the ‘economy of attention’ concept nowadays evolves into a context of overproduction of objects and data. Such research into a society dominated by scarcity of attention (Festre and Garrouste, 2015; Stiegl, 2010), becomes a key factor in various decision–making contexts, including arts and design.

Through ‘media ecology’ concept, some media theorists like Matthew Fuller (2007) or Jussi Parikka (2012) bring us to consider not only the mediatic aspects, but also to the environment in which this media perform. Jussi Parikka goes to the extend of saying that the new materialism is a media theory, one that should consider the technological specificity, the materialities of media cultures and the materialities of their relations and sensations, the transformations of the media and their residues.

**Critics of media specificity theory**

But media specificity theory counter–arguments are also to be heard. One of them is formulated by Noel Carroll (1985) who criticizes precisely the aesthetic media efficiency being based on the physical structure of the medium and not on the telos (the content) of the artwork. Would an aesthetically non–efficient artwork be less valuable? Also, the difficulty to identify the raw materials of a medium (the materials or rather the time, the space of the work?), as well as the difficulty to assign the aesthetic effect a work of art should engage (especially in the case of performatif arts), are for him sufficient arguments to reject the theory of media specificity. Another aspect he brings into the discussion is that of the provisional uses of a medium, which explains the evolution of the medium, the medium’s permanent reinventions. Last but not least, the injunction between ‘differentiation’ and ‘excellence requirements’ as present into media specificity theory is just a path towards the sacrifice of excellence in art and the reference to a judgemental position. Still, as he himself acknowledges, a certain medium specific use has pedagogical usefulness and can support future repositions.

**Medium and matter**

One of the issues to consider when it comes to medium specificity theory is related to the materiality of devices. Very often the materiality of the medium extends towards the technical means employed in its transformation, in a sort of technological determinism (Suchman, 2014). Still when it comes to the concept of medium, we can notice that there are two different perspectives in its definition (Heinzel, 2012). One is materialist and technologic determined, the other one is phenomenological and anthropological based.

We will find a materialist perspective in the writings of French anthropologist André Leroi–Gourhan, for example. In *L’Homme et la matière* (1943), Leroi–Gourhan proposes the concept of ‘technical tendencies’ by which he understands the universal (non–historical and non–contextual) technical dynamics that operate beyond the technical facts (concretisation of different technical tendencies in certain contexts). To support his research he used different states of the matter as tool of characterization of
technical tendencies. For him, the materials are conditioning the way we develop our tools and we use them. Given the determinism between the matter and the tools, there is a certain neutrality of the medium. The limits of technology will reside in the resistance and the limits matter induces.

The second approach is one that takes into consideration the effect certain technologies have upon the human psyche. The technology in this case is nothing else than the extension of our body and of our senses. It is the case of Marshal McLuhan’s theory of media. What McLuhan understands by media, are the ‘extensions of the man’, in other words the technological extensions of our senses. This is why the technologies are redefining our existence. And the syntagma ‘the medium is the message’ proves it. If there is a message to send, then this message lies in the change of scale, rhythm, or pattern the new media produces (McLuhan, 1964).

We encounter here two different approaches. While in the case of Leroi–Gourhan the medium is material and exterior to the person that interferes with it, being related to the act of ‘making’ (in other words, to ‘techne’), in the case of McLuhan, the medium is ‘aesthesis’, less related to the materials’ aspects, as to the sensorial and psychological phenomena that have an impact on the related person.

Still, as we could see earlier, the artists and designers role was never assigned to one or another of the theories. Media specificity theory asserts in fact that, being into an operational position, artists and designers have to know well enough their tools to better support their mediation interventions.

**Final remarks: edible textiles as intermedia**

Edible textiles pushed us to question the notion of intermedia.

Our experiments have shown that there are new potentialities and forms of expression for both textiles and food when brought together. Combining the two media allow new forms of interaction and transform the structures of two mediums as well.

As illustrated by the experiments, the intersection of two mediums always addresses, in a way or another, the two media specificity’s efficiency. They are doing so via formal, discursive or technical interventions. Imitating the stylistic expressions of one medium was used mainly to attire the attention to one or another medium’s oversaturated, mainstream forms of expression and its uses. On the other hand, as in the case of *Orange Fibers* and *Mycotex Dress*, the interventions invites to new forms of production, even to new forms of economy (1984), for example, sketched some possible intervention towards a ‘poetic economy’. The aim was to go from the ‘work as toil’ toward the ‘work as play’. Ironically addressing the world of art under economic auspices, Filioù will place under the concept of ‘The Principle of Equivalence’ three categories: ‘well made’, ‘bad made’, ‘not made’. If the ‘bad made’ is about failure and experimentations in art, the ‘not made’ is about the possibility of non-production, as de-construction of the theory of values applied to arts.

Probably the best way to answer to the question related to what kind of media the edible textiles are, we should ask ourselves: Would you wear your food? Would you eat your cloths? And for sure, there would be not only one answer. The materials hold potentials for active and adaptive properties, they could be used as food source, to neutralize smells, to reinforce textile structures in order to adapt to or to create certain forms. By using biodegradable materials only, the materiality of clothing or interior textiles would promote alternative ways of living and interacting, especially in terms of afterlife or circular design scenarios.

Our experiments were looking at textiles’ new potentialities when combined with edible materials. The edibility of textiles is also to be seen in todays’ context of frequent synthetic interventions on the matter and the development of new tools of fabrication. The examples of edible textiles we have given, balanced between critical and ecological interventions. But finally there are the terms of systemic affordances that we have to clarify before any attempts to start or to analyze any edible textiles interventions.

**Al Dente Textiles. Notes on Edible Textiles as Economical and Ecological Intermediality**

**TINCUTA HEINZEL, SVENJA KEUNE, SARAH WALKER, JUSTE PECIULYTE**

ecologically aware. In this sense media specificity it is to be read as a predominant form of mediatic affordance.

Often defined as a crossing border between traditional and contemporary media, between different art activities, intermedia has been most of the time perceived not as an accumulation of two media, but as collision, as exchange and transformation (Youngblood, 1970). The question, of course is to know what does it change and transform.

Intermediality was of high interest for the Fluxus movement’s artists (Higgins and Higgins, 2001) who use it to express their anti–mechanistic critic of society and production of objects. Critical against categories and classification, Fluxus’ intermedia actions were about to produce a space of dialogue, of aesthetically rewarding possibilities. Such a position attacks precisely the economic perspective of media specificity. In reaction to media specificity as form of marketization, the French Fluxus artist Robert Filioù (1984), for example, sketched some possible intervention towards a ‘poetic economy’. The aim was to go from the ‘work as toil’ toward the ‘work as play’. Ironically addressing the world of art under economic auspices, Filioù will place under the concept of ‘The Principle of Equivalence’ three categories: ‘well made’, ‘bad made’, ‘not made’. If the ‘bad made’ is about failure and experimentations in art, the ‘not made’ is about the possibility of non-production, as de-construction of the theory of values applied to arts.

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References


Websites

The publication presents experiments in which seeds were used to explore the transformative potential of growth in textile structures. Seeds were thus introduced to the textile design field as active materials. The methods and processes through which seeds were integrated into textile materials are discussed, as are their further processing into textile structures using textile techniques such as knitting, crocheting, and hand weaving. Photographs were used to capture, analyse, and reflect the dynamic expressions of developing plants. The publication proposes an alternative life cycle for interior textiles, opened up for by the biological perspective of plants.
The emergence of biodesign, as a new field in design, opens up the design process for new methods, techniques and materials, consequently these new possibilities offer special potential for the textile design practice i.e. integrating living systems into textile structures. The purpose of this work is to develop an understanding on dynamic and active expressions through using bio-based materials in textile design processes.

Major placeholders are exploring new forms of plant organization, and challenging existing concepts of living with plants, focusing on surface aesthetics. By practice-based design research, the experimental design explorations will illustrate the expressiveness of growth, wilderness and decay, using moisture, light and heat as design materials. This pictorial shows seven sets of experiments that explore dynamic transformations of bio-based materials such as seeds and plants in interaction with textile materials and techniques like weaving, knitting and crochet. Consequently, the experiments illustrate potentialities in a design space where plants are placed as living materials for new processes and dynamic expressions. Subsequently, these materials open up the discussion on alternative aesthetics when designing interior textiles and designing spatial scenarios with them. The integration of living systems and dynamic expressions, especially towards growth, wilderness and decay, rises new issues i.e. their integration, maintenance, application and interaction.

The transformative character of textiles by traditional techniques has been expanded through the development of smart materials (Worbin, 2010; Dumitrescu et al, 2014; Talman, 2015), therefore the functionality of textiles shift from static and passive towards dynamic and active expressions (Schülke, 2014). Thus, the materials potential for change becomes more essential than its visual appearance (Hibbert, 2001).

**Abstract**

Transforming textile expressions by using plants to integrate growth, wilderness and decay into textile structures for interior

**Keywords**

biodesign; dynamic expressions; textile transformation; living with plants; indoor greenery

**Introduction**

The transformative character of textiles by traditional techniques has been expanded through the development of smart materials (Worbin, 2010; Dumitrescu et al, 2014; Talman, 2015), therefore the functionality of textiles shift from static and passive towards dynamic and active expressions (Schülke, 2014). Thus, the materials potential for change becomes more essential than its visual appearance (Hibbert, 2001).
Biodesign as an emerging field has opened new materials and methods for designing textiles and envisioning contexts of applications. As Paola Antonelli states: “Biodesign harnesses living materials (...) and embodies the dream of organic design: watching objects grow and (...) letting nature, the best among all engineers and architects, run its course” (Myers, 2014). An example of living materials in textile structures is the project BioLogic, developed by the Tangible Media Group at MIT Media Lab. It presents a textile surface using living bacteria that react to body temperature and moisture with contraction and expansion (Yao et al., 2015). Exemplary for a collaborative design process it the “Bacterial Ink” research project by Chiara and Ward. They are developing a closed-loop manufacturing system for textile dyeing and printing by using bio-pigments, produced by living bacteria (Chiara and Ward, 2015). Their collaborative research project Faber Futures aims to establish a new craft discipline through the concourse of design practice and synthetic biology. They investigate processes of co-design with living technology by manipulating textiles through folding and creasing, and introducing bacteria to create deliberate patterns. An example of responsive architecture, based on material behavior, is the project Hygroscope – Meterosensitive...
Morphology. The wooden materials silent changes of movement are a result of its hygroscopic behavior and anisotropic characteristics (Myers, 2014). Scherer is fascinated by dynamics of below-ground plant parts. She is studying and manipulating root systems and uses underground templates to shape the growth of roots into a textile-like structure (Scherer, 2015).

However, more research in the textile design field is needed to develop new methods to design dynamic and active expressions by transformation over time through using bio-based materials in textile design processes and on the scale of the interior.

This research started out with material experiments using seeds and plants to explore potentials of expressional changes in textile structures, thus the natural parameters of plant life, from growth to decay, were explored. These parameters are activated by levels of moisture, light and heat; their change lead to processes of germinating, rooting, swelling, drying, shrinking, color-changing.

The research explores different methods to integrate plants, the following method generated the first category of experiments. A textile hybrid material consists of a biological material, i.e. seeds, plants, soil and a textile material, i.e. cellulose based yarns. The seeds are inserted into the textile material, here a tubular knitted material, to produce a system that can contain and carry the seeds for later usage within textile production processes, thus, this textile-seed hybrid material can be used to produce a two-dimensional or three-dimensional hybrid textile by weaving, knitting and crochet. Color, material of the used textile material, diameter, construction, the inserted biological material (size, shape, color, surface) and its distance in between one another are important design variables. Smaller seeds such as grass seeds could be integrated on a material-level within the spinning process for example. For scaling up the experiments, bigger tubular knits (Set 7-8) and crochet-works (Set 5-6) have been filled with soil and seeds or plants.

The graph shown in the beginning of this pictorial illustrates the order of the examples, from hybrid material to hybrid structure, from Set 1 - Set 7 and concludes in forms of human management.
Set 4 shows a wool–corn material crochet into an organic form. The woolen tubular knit was chosen due to its material qualities and the fine construction that highlights the corn. Activated by regular watering, the outgrowth of roots positioned, stabilized and enlarged the object towards the ground and sides. The up-reaching sprouts transformed its soft expression, form, color, size and materiality.

Set 5 shows a textile container crochet from wool and a cotton–corn material, forming a ring around the soil containing object. Regular watering into the object started the growing. White and red roots grew underneath and inwards. Stopping the watering initiated the drying process which transformed the material again, changed color, pliability and direction of the leaves, their sound and the objects weight.

Set 6 shows a tubular knit from Polyester, filled with soil and grass seeds. The textile materials was chosen due to its color, the grass due to its potential to cover an entire surface. The outgrowing grass covers the up-facing parts of the structure like a fur. Its density increased, the expression transformed from subtle to more expressive, from glossy, bright green and straight to fuzzy, dark green and distorted due to the initiated drying process.

Set 7 shows a tubular knit from Polyester, filled with soil and planted with lettuce. As in Set 6, the tube was expanded and shaped by the contained soil and manipulation. Through a hole in the structure the lettuce could be planted and the structure watered. The neon–yellow color of the knit was dampened by the soil that penetrated the construction. The vertical, three-dimensional structure can be altered, reshaped, expanded, and repositioned easily, due to the flexible construction of the knit. The structures main transformation is expressed by the withering lettuce–leaves, hanging down, nestling to the structures form and downwards. The leaves first strong and upwards but pliable, turned weak and adapted a textile–like character, by its folding, wrinkling, hanging leaves. Their color, bleached by the drying process, matched up with the color of the structure.
The use of knitting, weaving and crochet, as illustrated in this pictorial, offer different qualities to embedding seeds and plants and to provide a growing matrix or to disrupt the expressions of the constructions. Knitting was used to explore flexible, more spatial and threedimensional constructions. The density and the position of the knot influence the outgrowth of the germinating seeds. The material affects the water distribution and the reaction to moisture, heat and light. Crochet was used to explore free-formed threedimensional shapes that resemble with common plant containers but differ by using the textile-seed material to form the soil-containing structure. Hand-weaving was used to explore the transformation of twodimensional constructions. When using corn, the form of the activation makes a significant difference, as well as the position of the cloth.

By embedding the potential of growth into textile structures, the interaction of cloth and plants evokes. The illustrated examples indicate various transformations, expanding and altering textile expressions by adding organic disturbances to former complete forms, structures or textures. Set 1, 2 and 6 illustrate disruptions of the construction of the cloth whereas Set 5 - 7 provide a living matrix for growing plants, by using soil as a substrate. Set 4 exemplifies a threedimensional transformation of a textile object and Set 5 displays a complete biological lifecycle from growth to decay. Consequently the transformations can vary in their diffusion and density and are mostly unique and irreversible. In contrast to the project Hygroscope, the proposed hybrid textile material system is aligned, based on textile techniques, constructions and applications. The difference to the project Bacterial Ink is the production that doesn’t require special environments such as a laboratory and sterile conditions. Another difference are the two general states: passive and active. Whereas the wooden materials hygroscopic behaviour and anisotropic static and dynamic expression, the activation of the hybrid textile material system starts a process, comparable to a chain reaction that is not reversible and increasingly erratic as the complexity of the material system expands and the scale increases.

Consequently the presented examples provide perspectives on textile structures for interior that can be edible - degradable, passive - active, promote a symbiotic relationship between human and plant through the textile and a biological lifecycle. Especially the integration of seeds open up potentials for using unactivated structures on the scale of the body or in interior settings. Thus, not only the stable and passive structures challenge new forms of interaction, the activation becomes an open field for exploring interactions as well, using moisture, light and heat as design materials. The parameters of life, from growth to decay, open up for interactions regarding maintenance, i.e. watering, cutting, harvesting...
and regarding i.e. eating, manipulating, arranging.

This research illustrates potentialities in a design space where the living material is placed as dynamic material for new processes and expressions; a potential design space where the dynamic and transformative materiality give textile design a bio-based dimension in the design process. Thus, biological materials such as plants and seeds in particular, are used as natural smart materials used to develop new textile materials and expressions. Subsequently, these materials open up the discussion on alternative aesthetics in interior spaces when designing textiles and spatial scenarios. Expressions of wilderness and decay challenge the limits of conventional textile and interior design and promote a discussion about future forms of living with plants that ranges from textile design to indoor gardening.

The further practical work will consist of experiments and scenarios that concentrate on the interaction of plant and textile construction, suggest different forms of human management and promote an extended lifecycle that results into a biocene by focusing on pure cellulose-based fibers. The potentials of industrial weaving for plant-containing structures will be explored by using pocket-weave constructions. Therefore sprouts will be used, as they grow fast, demand little, come in different shapes and colors and can be trimmed, harvested and eaten.

Conclusion

As pictured, textile materials, techniques and constructions will be of foundational use to interweave interior living and plant organization in a hybrid environment that is managed by humans. To create alternative expressions of static and dynamic qualities, “Farming Textiles” proposes biological materials such as plants and seeds in particular, as natural smart material for using in textile design processes to develop new textile materials. These materials open up for a new range of interactions, since human management is part of their maintenance and transformation. These forms of interactions and conditions redefine what is understood as behaviour and prevailing states indoors, the present definition of interior is challenged and open for discussion. “Farming Textiles”, as an artistic research program, is not directed to develop functional solutions, it aims to propose future perspectives in forms of living with a hybrid of interior textiles and a diversity of local plants. Seasons and lifecycles are usually not expressed in interiors, especially Subnatures and processes of degradation are not considered as experiences of beauty and enjoyment, they are expressions of evanescence and imperfectionism. They are often seen as threatening, uncomfortable and a disturbance of a pleasant atmosphere. As a side-effect of “Farming Textiles” materials and processes, interactions and transformations, a range of Subnatures such as mud, dust, puddles and insects can occur and challenge the understanding of a comfortable space. Thus, they force a confrontation with the prevailing relationships to the environment.

References


This publication presents an experiment in which a textile containing seeds was crocheted into a shape that was filled with soil. This structure was documented in its various stages, in which it initially served as a textile envelope and the seeds were decorative material, then became an envelope filled with soil that was watered, triggering the sprouting and development of the seeds, turning them into a dynamic material. An initiated drought caused the object to wither, and a later reactivation led to the development of further sprouts and young plants. Thus, the biological perspective that the seeds added was explored, with a focus on the additional stages of transformation and the aesthetic potential of degradation in relation to textile expressions and interiors.
Co–designing with plants. Degrading as an overlooked potential for interior aesthetics based on textile structures

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Abstract: This research explores the dynamic qualities of plant degradation in textile structures for interior and aims to develop alternative aesthetics, interactions, life–cycles and applications for living with plants by referring to outdoor expressions and experiences. A series of material explorations illustrates the potential of corn seeds in textile indoor applications, focusing on aesthetics and material properties of degradation to create an interplay of texture, structure, form and color. The hybrid textiles refer to Blaisse view on curtains as fluid atmospheres and second skin, challenging the static nature of architecture and reinforcing the dialogue between landscape and interior. Bringing aesthetics of decay into interior spaces not only challenges the nature of materials, it also invites to rethink the aesthetic and cultural bias towards natural processes in interior scenarios.

Keywords: Interior Textiles, Degradation, Biodesign, Co–design, Seeds

1. Introduction

New concepts of living attempt to break the separation of human and nature through urban development, proposing new models of hybrid housing and urban gardening, where human management and food production intersect (Doron, 2005; Bohn, 2005).

New forms of textile development and manufacturing comprise concepts of design for disassembly, where the afterlife of products is part of the design process and materials are recycled or biodegraded into organic matter and composted as biological nutrients. Compostable materials and clothing are of growing interest and are brought to market (Freitag, 2015; Lenzing, 2017). The materials open up for new methods, aesthetics and interactions to manage the aesthetics and the afterlife of compostable products.

Within Biodesign, a wide range of biological processes is used in design and manufacturing, such as growing mycelium, bacterial cellulose or using bacteria as a living system in co–design processes for actuating textile surfaces or textile dyeing (Tabellini, 2015; Lee et. al., 2007; Yao et.al., 2015; Chieza and Ward, 2015).
This research explores the dynamic qualities of corn seeds in textile structures by integrating them within textile structural techniques such as crocheting. The growing process is initiated by watering, the activation. The research project aims to redefine how we live with plants in interior scenarios and how we design adaptive and responsive textile structures.

2. Method

The object shown in the poster explores the potential of a textile envelope with embedded corn that is a container for soil at the same time. Corn seeds were introduced into a tubular knitted material made from cotton and polyester, forming a rim on the outside of the crocheted object from wool. The experiment was conducted to explore the container in passive and active phases and across its life-cycles.

2.1 Activation and Transformation

Regular watering of the object started the growing. The corn-envelope developed germ/coleoptiles after two days of water supply. The coleoptiles grew straight upwards. The radicals and the seminal roots, white and red, grew towards and gathered at the bottom. Within a couple of days, green leaves grew, unfolded and determined the general expression, which is described as a form of wilderness in the present context.

To activate the process of decay, the water supply was cut, initiating the drying process which transformed the textile envelope again. First collapsing through the increasing softness of the stems, they turned brown and stiff, with an inclination to crumbness, thus the sounds and the objects weight changed as well. The predominant presence of the corn-plants are balanced by the transformation of the seeds with the textile construction will be explored further as well as the seed organization within other textile structural techniques such as pocket weaves, using specific materials for managing watering and nutrition.

2.2 Afterlife

To explore the potential for reactivation the dried object was planted into a glass bowl with Perlite substrate, watered and covered. Whereas the lower envelope degraded and developed white mold, some corn seeds germinated and started to grow. The white layer of mold connected the crocheted structure and the dried leaves, creating a soft, airy and white translucent covering, reminiscent of a textile padding or insect web.

2. Result

The example as shown in the poster demonstrates the conceptual framework for manufacturing an alternative textile plant container and explores the aesthetic potential of seeds as dynamic material in textile structures.

3. Conclusion

From growth to decay and back to growth, the stages of plant life affect the expression of the textile object. As the example changes in time and through human management, it represents the conditions, using the stems and leaves as a layer of changing information and transforming form. With an emphasis on transforming expressions such as form and color and an extended lifecycle, the object was reactivated and illustrates biological processes of growth and degradation alternately recurring. Thus, it opens up for designing forms of human management and interaction within interior scenarios in which adaptive and responsive surfaces are created by using seeds as a transforming material for textile design. The changing expressions and interaction of the seeds with the textile construction will be explored further as well as the seed organization within other textile structural techniques such as pocket weaves, using specific materials for managing watering and nutrition.

References


This publication describes a joint teaching encounter in which first-year textile design students from the Swedish School of Textiles met first-year architecture students from Chalmers University of Technology. The workshop explored indoor gardening structures using textiles, substrate, and seeds, and was based on the On Textile Farming research project. Methods of inserting soil and substrate into textile structures were shared with the students, and presentations and discussions on the subjects of indoor gardening and sustainability were conducted to assist the students in combining textile and spatial perspectives. The publication focuses on the pedagogical challenges that arose as a result of the meeting of different traditions and disciplines, particularly with regard to students during the early stages of their studies. Differences in research approaches and undergraduate teaching are discussed, particularly in relation to fully exploring the level of complexity of a task.
Abstract: This paper presents experiences from a two-day teaching workshop where first year students in architecture meet with first year students in textile design for an assignment on building structures with textile, soil and plants designing for indoor gardening with the aim of inspiring for more sustainable lifestyles. The background is a research project on textile architecture with the objective of exploring this new field and to establish a platform for long-term collaboration between the disciplines of architecture and textile design. The paper addresses pedagogical challenges in the meeting between first-years students of different disciplines and traditions, but also in the meeting between research and undergraduate teaching. The students produced creative results but had difficulties in exploring the full complexity of the task. An evaluative discussion is based on observations, photo documentation, notes during group discussions, follow-up questionnaires among the students and reflections among involved researchers.

Keywords: Textile design, architecture, indoor gardening, teaching workshop, bachelor students

1. Introduction

1.1 The research context

The unexplored synergies between textile design and architecture was the starting point for a joint project that was granted funding 2016 to 2018 through the Swedish Research Council programme for Artistic Research. The project “Urban Materiality – Towards New Collaborations in Textile and Architectural Design” brings together three design institutions: HDK – Academy of Design and Crafts, University of Gothenburg and Chalmers University of Technology, the Department of Architecture, and The Swedish School of Textiles, The University of Borås. The theoretical part of the
Architectural teaching is increasingly challenged to embrace the complexity of modern society and models and representations of reality. For the architects the societal relevance is always present. Architectural teaching is increasingly challenged to embrace the complexity of modern society (Salumäa, 2016). Sustainability is one of them, digitalisation another. Architect students are taught to program their designs and to switch perspectives going from detail to the larger societal perspective and back again in an iterative process. A result of a process of “academisation” of architecture as a discipline, theory and method are often taught disconnected from studio work (Karah, 2015).

Practical skills such as hand drawing, model work and crafts have been compromised for other knowledge areas and material knowledge is increasingly lacking among architect students (Bell & Rand, 2006).

### 2.1 Textile design: Form and material I

Form and material I is a 15 credits course at the Swedish School of Textile that aims at developing the textile design student’s ability to give form to textile material through colour, construction and material. The course is given for the fifteen first-year students in textile design, all of whom have entered the programme through practical entrance exams including a portfolio, solving a task during an exam day and an interview. The course consists of a series of workshops with hands-on assignments on various topics exploring concepts such as line, direction, volume, form, texture, perspective, scale, two dimensions and three dimensions in textiles. The teaching is driven in the form of practical work, lectures, supervision and seminars. The course involves an individual reflection over the work and methods used in the form of a workbook where the whole design process is documented. Theoretical studies during the course include material science and colour theory with their separate exams.

The workshop “Earthly textiles” is one among several during the course. It aims at questioning and redefining the aesthetics and management of interior landscaping, based on textile structures and soil. 

The education of textile design is also in a process of embracing more academic approaches. From being taught mostly as a field of practice, in the past decade, existing models of teaching has been challenged to shift from teaching textile design to textile design thinking (Damitriou, 2014) from tacit knowledge to training for design rationale (Kans & Ritz, 1970). The textile students are challenged to reflect on their design explorations and to get critical perspectives on their design before they start to produce full scale mock-ups.

### 2.2 Presenting the two courses

#### 2.2.1 Cross-disciplinary encounters: project and methods

Architects and textile designers are both involved in the design process of products intended to be used for a specific purpose. The workshop “Earthly textiles” is an attempt to bring together these disciplines with a focus on the role of textile design in contemporary architecture. The workshop is intended to provide a platform for dialogue and collaboration between the disciplines, with the aim of developing new understanding and perspectives on the role of textiles in contemporary architecture.

#### 2.2.2 Cross-disciplinary encounters: challenges and benefits

The workshop is designed to challenge both textile designers and architects to think beyond their own disciplinary boundaries and to consider the potential for collaboration between the disciplines. The workshop is intended to provide a space for learning and exchange, with the hope of creating new opportunities for cross-disciplinary collaboration.
3. The workshop

3.1 A preparatory meeting

The workshop was introduced to the two groups of students two weeks prior to the event at a joint meeting at Chalmers University where the students could socialise around a coffee. The textile design student had also brought their preliminary design and material experimentations which were exposed on a table to the architectural students. There was a lecture about the research project “Urban Materiality” and Svenja Keune gave some inspiration for farming structures where she had used woven textile in which earth, seeds, plants and even watering systems can be installed (Figure 4) and knitted tubes (Figure 5 and 6) which can be filled with earth and in which seeds or plants can be cultivated. The intention was that the architect students should prepare for the workshop two weeks later on their own by reflecting on what they wanted to do and gather some material. No specific time were scheduled for the architect students to prepare for the workshop as they worked on other topics in parallel.

Figure 2, Example of design solutions that can be used for urban farming produced by Svenja Keune

2.3 ARK253, Architecture, environment and sustainable development

ARK253 is a 7.5 credits introductory course in sustainable building given at Chalmers for the first-year architect students. The course is attended by 80-90 students with a varied background in terms of earlier experiences. Up to 40 % of the students enter the school of architecture on practical tests and the rest on notes from college.

The course is structured around lectures, seminars, workshops and essay writing, and introduces the students to a broad overview of sustainability aspects. In the first weeks, thematic seminars accompanied with hands-on workshop give the students the possibility get acquainted with four aspects of sustainability: social & ethical aspects, materials & resource use, energy use and green & blue structures. Further, the students will make a shorter written assignment in which they are allowed to go deeper in one subject or question. Emphasis is on retrieval and critical analysis of information and literature as well as studies of current examples of sustainable building. The course aims at supporting an awakening process of personal identification and reflection in relation to more sustainable architectural design. The course is wrapped up by the writing of an individual intent on their personal view of sustainability to be used as a ‘programme’ for an up-coming studio called Space for dwelling in which they will design a detached housing unit. The joint workshop is given as part of the thematic green & blue structures and the outcome could give new input for the dwelling design.
Earthy textiles: Experiences from a joint teaching encounter between textile design and architecture

updated over time. A polaroid mobile printer was provided so that the students could complete their notes with photo documentations.

Figure 5. The layout of the workshop. The intention was that the students should divide their work with two students responsible for the maintenance of the structure including watering, one responsible for the documentation of the design process and the rest should implement/set-up the structure.

The place for the workshop was Chalmers University of Technology. Three different rooms were available: the art studios where a material library was set up, a large hall for experimentation “the concrete hall” and the working space studio for the bachelor students. The material library (Figure 6a and b) consisted of different textiles: raw textiles, textile produced by Svenja, textile tubes in different colours, and some textile modules produced by the textile design student in their course. Furthermore, there were earth, perlite, Leca pellets, pots, cultivation briquettes, seeds, plants, pipes, plastic bottles and different kinds of rope. For the students’ disposition, there was also a sewing machine. The workshop started with the students getting acquainted with the materials. The architect students had the possibility to ask the textile students about their modules and Svenja about her fabrics.

3.3 Starting to design and forming groups

The students were first given time for individual sketching so that everybody would have the chance to develop their own ideas before the group work started. The time for individual sketching was a bit less than one hour. A few “research questions” had been defined to lead the students in their work:

1. How to implement seeds/plants and substrate into textile structures?
2. How do these structures look like?
3. How do they form a spatial experience?
4. How will the structures be watered and taken care of (until June)?
5. How do humans, structure and space interact with one another?
Earthly textiles: Experiences from a joint teaching encounter between textile design and architecture

The student groups consisted of 78 architect students and 15 textile design students. The first plan was to divide the students in ten groups with one or two textile students and seven to eight architect students. However, only twelve textile students were present at the workshop and they preferred to work in pairs. Instead six larger groups were formed with two textile students and twelve to thirteen architect students. The groups were too large to function and some divided into smaller groups. Some students had started discussions of a common idea over lunch and wanted to remain in separate groups.

The groups started to engage with the materials rather quickly. Some groups moved up to the architect students’ work space while some remained in the “concrete hall”. Several groups seemed almost ready with their design on the first day and used the second day to plant seeds. Most groups decided to put the seeds and plants after they had finished the whole structure not at the same time as the earth was put in, as we had expected.

4. The final structures

In the end ten group designs were made, here we shortly present a smaller number.

4.1 The “intestinal lavage”

This group were inspired by the yellow knitted tubes which changed colour to an almost fluorescent green when filled with earth. Two bottles were added at the top to water the structure. The group remained in the concrete hall to carry out the project then moved it up to the architect studio.

4.2 “No name 1”

This structure was installed in the architect students’ work space. It was created with a grey tube filled with earth and perlite. Plants and seeds were added after the structure was installed.

4.3 “No name 2”

This project was realised using one of Svenja’s fabrics. Double layers in the fabric were filled with earth and perlite during coordinated and hard team work. The group had difficulties to find a suitable structure to hang up the fabric.

4.4 “The grid”

This groups based their design on fabric pockets that one textile student had brought. Another group did a very similar project but added tubes in the hanging line for watering.
5. Feedback from the students

5.1 Feedback from the textile students

An on-line survey was sent out to the textile students shortly after the workshop and a group discussion was held three days after the workshop. On the whole, the textile design students were very positive to working with the architecture students and would like to collaborate in the future, also with other design disciplines and universities.

What they had wished was more time to work together and that all students should start from the same point. The textile students felt that as they had already been working with the topic longer, they had come further into the process than the architecture students who came to the workshop more unprepared. While the textile students were ready to go up in scale and work with more experimental and spatial structures the architecture students were still on the prototyping stage making small flower pots. They also found it problematic that they had not visited the architect students’ working place before the workshop. They would have liked to prepare for example by studying movements and spaces. As the architect students share the space with other students in the second and third year, they were also worried to disturb the others. The result was that they more or less choose the first available spot.

The textile design students felt that they would have needed more time to meet with the architecture students before the workshop to get to know them and how they think. The groups were also too large to be able to work efficiently. The textile students did not feel quite comfortable in the group work. They felt that they could not influence or contribute enough to decision making. They would have liked to have a longer workshop, at least one day more so that they would have had time to experiment and realise more ambitious ideas. They said some of the architecture students had good ideas that they did not pursue simply due to time.

The modules that the textile design students had prepared and brought to the workshop were not used much, apart from some pockets. The textile students had expected the modules to be used more, perhaps combined in different ways. They felt that their work, which they had put a lot of effort into to finish in time got a bit lost on the table with all the other materials. The architecture students seemed to have seen the modules as finished products and did not add much to them. The textile designer’s
works and concepts could have been more thoroughly introduced to the architecture students. Here are three statements by textile students:

“I was disappointed by the fact that all the materials were mixed which meant a lot of things weren’t even used. We put a lot of work and time into these materials and stressed to get them ready in time.”

“Our modules were not used because they were already made. The architecture students did not use them because they were already finished. They thought they were boring to use. So, the time we put in producing them were wasted.”

Finally, the textile students observed some differences in working methods. They felt that they worked more experimentally, directly trying things out in the materials. The architecture students worked more with sketches and scenarios, some of which were very experimental and interesting but never experimentally, directly trying things out in the materials. The architecture students worked

5.1 Feedback from the architect students

An individual questionnaire was distributed to the architect students immediately after the workshop was finished. Unfortunately, there was a problem in the distribution and collection of the questionnaires and only fifteen filled in forms were received. However, the workshop was proceeded by a two-hour long discussion in five separate groups with all the students, and later by a one hour discussion with four invited student representatives. Notes from these discussions complement our feedback.

The architect students found the assignment exiting but complained about lack of organisation. They found it interesting to find new ways of using textiles and to experiment with greenery. The workshop was hands on and they liked to prototype. Approximately half of the group think that the workshop gave them new perspective to architectural design. Some architect students did not see the direct connection between the workshop and sustainability and found the assignment too simple to address larger societal questions. A majority thought that they had enough time for the workshop.

They found it interesting to meet with the textile students, but the short workshop did not give time for any real exchange. They would have wanted to be better prepared such as the textile students and have more time to discuss. The fact that they were less prepared made them look bad, said one student. Just like the textile students remarked, they recognise that they did not really use the modules that the textile students had prepared. Some perceived the textile students as unengaged, the fact that the structures were to be put in their studio place contributed to a distance to the textile students. The architect students had the impression that the textile designers felt that it was not their project. They themselves also felt intimidated to put their structure in the design studio. One group said that they put their design close up to the wall in order not to disturb.

They architect students also found that the groups had been too large to be functional and creative.

Some of the architect students noticed that some of their fellow students did not actively participate in the team work but failed to engage them. The smaller groups seemed to manage the teamwork better. Regarding working methods, the architect students recognise that they should have made more prototyping before deciding to go for one solution.

6. Discussion and conclusions

The results from the workshop shows some creative design and the encounter between the disciplines seems to have been a positive experience even though more time should have been given for exchange and meeting. A second evaluation later on during the semester will tell us if the meeting left some trace that can be shown in the design the student produce after the meeting.

As regards the planning of the workshop, this should have been better planned. A prime lesson is that we had underestimated the task of getting the students from two disciplines to collaborate. There was an imbalance as the textile students arrived more prepared. The textile students felt that the work they had already put into thinking about modules prior to the workshop was not used. The architect students needed to prototype themselves with the material before being able to go up in scale.

The students clearly did not fully use neither the spatial scale nor the time given for the assignment. Several groups finished already the first day and the structures were rather small, flat and two-dimensional. The impression is that they wanted to keep it safe not exploring their full creativity. The architect students also focused a lot on the technical part, the watering and the maintenance system. In some structures this was the starting point for the whole design. Instead of going into creative explorations they seemed to have searched for a quick solution to a given problem. This might also explain why the students did not integrate substrates and seeds at the same time, but planted plants and seeds in their finished structures in the end. Maybe they were looking for a finished result to present at the end of the workshop not thinking so much of the time perspective and the whole lifetime of the structure.

Comments from the students show that the architect students had not fully understood the complexity of the task. The textile students were outnumbered and felt that they had difficulties taking a place in the decision-making. They also felt intimidated working with the architect students’ place of work, and were seen as uninvolved by the architect students. The architect students also complained that they felt that the assignment did not relate to sustainability or architecture although they had lecture presenting the sustainability of urban gardening. The architect students of the first year are still searching for an identity as architects, and the assignment did not correspond to their idea of what sustainability is in the built environment. What they might not have realised is that collaboration and cross-disciplinary teamwork is one very important aspect of sustainability.

The students approach to keep it safe and to focus on solving a problem can be understood as an uncertainty of handling the design process. A majority, two thirds, of the architect students enter the school already performing at high degrees. They are high-performing students used to be the best in their class and not all of them are used to work with artistic methods. This is different from the textile students who all enter the school on trials and earlier artistic work and used to show their sketches and material samples. The first-year architect students are still intimidated by exposing their sketches and ideas to a large group.

For future collaboration in teaching, our conclusion is that we should go for more mature students, on the master’s level, post-graduate education or professional designers. There is a large interest in textile architecture among practicing architects that could be met with workshops.

Finally, the influence of the actual space where the workshop took place had been overseen in the planning of the workshop. The groups who worked in the studio space made flat structures and used neutral, grey or transparent textiles. The more creative structures were built in the concrete hall both in terms of form and use of colour. The architect students were worried to mess-up the space with water and dirt. Plastic bags had been provided to protect the carpet in the studio, and instructions had been given to be careful not to damage the carpet. The floor in the concrete hall is resistant to water and dirt contrary to the carpet in the architect students’ studio. This factor could have been inhibiting for the exploration of the materials and the assignment in that working environment. One conclusion is that it
might have been wise to advise them to sketch in the design studio, talk about the possibilities to
visually or physically delimit a space, then move down to the concrete hall to do some prototyping and
build the structure.

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Early textiles: Experiences from a joint teaching encounter between textile design and architecture
PUBLICATION S


The publication presents the first iteration of jacquard textiles woven at Svensson AB which have been exhibited in form of an installation at the Textile Museum in Borås and relate plants and the scale of the interior. The textile design, the production as well as the methods of inserting seeds and substrate into the textile envelopes are presented in the publication and led to the development of scenarios concerning how to live and interact with interior textiles in which plants are integrated and how they could mediate between the spaces from inside to outside and in between them. These scenarios were described in the Licentiate Thesis and build a foundation for the explorations on ways of living.
Growing textile hybrid structures: Using plants for dynamic textile transformation, an approach towards Biophilic Urbanism on the scale of the interior

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Abstract.

This paper attempts to illustrate a „Material System“ that can exemplify a hybrid material behavior through a designed assembly of two categories of materials (biological and textile). The transformable system is achieved by natural dynamic transformations, using the potential of seeds for their passive and active, adaptive and responsive characteristics. The paper will showcase a series of experiments illustrating alternative forms of plant organization, human management and dynamic transformation in textile interior scenarios. The use of jacquard double weave structures on industrial machines allows a variety of patterns and constructions. Pocket weave is used in order to create enclosures capable of accommodating external elements such as seeds seamlessly. Activated by surrounding factors and forms of human management, the final prototypes, presented within an interior scenario, attempt to utilize the various behavioral properties, creating a non–tech responsive structure. Consequently, the research opens up the design space for climate responsive architectural structures where the responsive capacity is embedded in the structure of the material system itself. The paper aims to contribute to the future development of biophilic design and biodesign in the context of textile and interior design.

Keywords. hybrid textile structures; biophilic design; textile transformation; biodesign, design for biocycling.

Figure 1 (The interior scenario that displays the hybrid structures, resulting from the developed material system)
Introduction.

In the context of this paper „Material System“ is described as an interdependent assembly of materials based on biological materials such as seeds, and textile materials, i.e. natural fibers, with an intention to create vegetal–textile compound structures on the scale of the interior.

This paper focuses on the assembly of hybrid interior textiles in a collaboration with Svensson AB aiming at connecting their departments for interior textiles and climate screens by proposing scenarios that bridge textile interiors with managing conditions for growing crops in greenhouse environments [1]. Therefore pocket weaves were industrial produced and further processed manually, i.e. filled with substrate and seeds as a transformative material. Consequently the possibilities of weaving as a textile technique with its dimensionally stable characteristics and variety in patterns (full width industrial jaquard) and bindings are explored. The transformations of the inserted biological material is activated by environmental conditions such as levels of moisture and light or forms of human management. Their transformation is expressed by changes in size, form, color, texture, pliability, weight and odor.

The paper hopes to contribute to the future development of biophilic design where sufficient and satisfying relationships between nature and humanity are as important as minimizing the impact of modern activities on the environment (Wilson, 1984; Kellert, 2016; Bealey and Newman, 2013). Thus, alternatives to indoor plant organization and their management which is in this context summarized as human management the experience are proposed and include activities such as planting, observing, harvesting, eating, touching, cutting, and different forms of watering. Consequently the material system holds potential for architectural applications in the context of hybrid houses, where domestic living spaces and horticultural practices, i.e. urban gardening meet.

Context

Nowadays, new concepts of living attempt to break the separation of human and nature through urban development, proposing new models of hybrid housing and urban gardening, where human management and food production intersect; here, these new models of living promote self-sufficiency towards rising prices, declining quality, food safety and the global food challenge (Doron, 2005; Bohn, 2005). Additionally these systems and new services satisfy the urge to experience nature as expressed by i.e. gardening and creative physical work (Louv, 2010). The direct relation to nature is also a response to new research discoveries, which push us to rethink our relation to the vegetation and urban living (Ryan, Vieira, and Gagliano, 2015).

ReGen Villages is a new visionary model for the development of off-grid, integrated and resilient eco-villages that can power and feed self-reliant families around the world. The architectural development of the ReGen Villages was undertaken by EFFEKT, a danish architectural office. They developed amongst others the overall site plan, the housing typologies, their features, the food production and the ReGen System. The Greenhouse area that encapsulates the entire house and creates space for private or social activities works as an extended living zone and is represented by common Greenhouse aesthetics and traditional ways of furnishing living spaces and plant organization. Beside the potential of addressing some of the challenges of a growing world population, the growing food crisis, the scarcity of resources and the human impact on the environment, ReGen Villages also wants to provide a social value by creating a framework for community and by reconnecting people and nature and consumption with production. As their main approach is „applying science into the architecture of everyday life“, nature in the ReGen Villages has a mainly functional purpose [2,3].

Kono Designs urban farm is an exemplary model of integrating natural experiences in today’s indoor-based work-life. The employees of Pasona Group Headquarters plant, grow and harvest their food in a nine-story building in the middle of Tokyo’s metropolitan area, where they share a common space with suspended tomato vines, lemon trees, broccoli and rice fields (Andrews, 2013). The vegetables and fruits are grown in shelves, beds, they climb on bars, cover facade and walls, grow down from ceilings and are stored below furnitures, thus they are organized, in or on rigid structures, covering specific places. The employees are taught by professionals how to plant, take care and harvest. Konos urban farm redefines urban food production and turns everyday office work inside out by adding co-habitation with plants, maintenance and the pleasure of gardening into everyday indoor activities [4].

The hybrid houses create a new form of interior as Warne describes: „Living in a greenhouse gives architecture a fourth dimension, where time is represented by movements of naturally recycled endless flows of growth, sun, rain, wind and soil in plants, energy, air, water and earth” (Fredriksson and Warne, 1993). Consequently the design field opens up for contributions that address new forms of habitation by bridging outside and inside aesthetics and activities and consequently propose new forms of living. Subsequently new fittings/furnishings are needed to illustrate, promote and shape these new environments. Textiles are commonly used in all areas, i.e. interior, horticulture, agriculture, landscape design, but are usually clearly differentiated in their aesthetic and functional properties, addressing their distinct usage. However, more attention needs to be aimed at the role of textiles, as dynamic and flexible element, contributing to an emphasis of the physical, sensual and embodied essence of architecture. This research aims to propose alternatives to indoor plant organization and their management by developing vegetal–textile compound structures that open up for new forms of interactions and expressions, addressing the fourth dimension opening up with the contemporary progressing developments in hybrid housing and contributing to Biophilic Urbanism on the scale of the interior.

Method.

The approach to develop a series of transformable interior textiles by using seeds as a smart material can be divided into five categories. The first step is to design the pattern of the cloth with its pockets and channels for accommodating the biological material. The second step is the textile construction, the bindings, followed by the third step, the selection of the textile material. After the fourth step, the industrial production, the biological material is chosen in the fifth aspect. The sixth step is the manual insertion of the biological material, i.e. seeds and substrate. The final stage is the further processing of the material system to create an interior scenario.

The first stage of the research focused on the pattern design for envelopes and structures that promote enclosures for the biological material to be filled in and which also enable the seedling and the substrate to transform and alter the textile structure [FIGURE 2-6]. Therefore the design is based on pockets in different sizes and shapes as well as stripes as hollow channels that vary in their thickness and curvature. The alignment of the stripes in warp or weft orientation effects the alignment of the stripes in regard to the cloths further processing.

336 I 337
The second aspect focused on the design of bindings in relation to the patterns and the intended manual insertion. Loose/open bindings create space for creating bigger openings to access an enclosure without destroying the construction [FIGURE 14]. Another point to consider is the potential for interactions between bindings and materials, i.e. germinating seeds, substrate, water, light. Dense bindings keep substrate, reduce the influence of light and create friction between cloth construction and the sprouting plant. Open constructions promote the access to light for the germinating seed and reduce the friction between construction and sprouting plant. For the selvedge two different bindings have been used [FIGURE xx]. The binding in the top shows a very open construction. The weft threads can be pulled out or cut easily to open the channels from the side to introduce substrate and biological material.

The third step, choosing the textile materials, was restricted in this case to an existing warp at Svensson AB and materials already at hand and experienced in weaving processes in house. The warp material is a 32/2 mix of wool 85% and Polyamide 15% and has been used as a weft material as well. Principally an organic combed 24/2 cotton material was used as in the weft.

The fourth stage of the research was the production of the textiles on a Picanol jacquard loom at Svensson AB. The width of the warp measures 4096 threads on a width of 150cm. The maximum size of a repeatable pattern is 4096 ends and 10000 picks. Thus the maximum dimensions of one pocket possible to weave on the machine is 150 cm wide to in between 300 – 600 cm high, depending on the pick density, and therefore suites/its an architectural scale.

The fifth aspect focused on the selection of the biological materials, i.e. seeds, but also substrates. Some purchased mixes of seeds, for example coriander, lentils, ncola and mungbeans have been used and selected because of their combinational taste and variety in color and dimensions of the seeds [FIGURE 12]. Seed-tapes have been used for their textile expression and the regular spacing of the seeds. Cotton padding, perlite and coconut tablets were chosen as substrates [FIGURE 9-11]. Cotton padding is used for growing sprouts, perlite is a sterile, white substrate used in hydroponics and capable of absorbing and storing moisture and coconut fiber tablets fit into smaller pockets and expand by applying water. As soil and fertilizers are not used in this series, the textiles cannot facilitate the growth of entire plants. The focus lies on the small scale interaction of the germinating seed and tiny sprouts that develop with internal energy.
is the density of the bindings, directed to enable openings or prevent substrate with different grain sizes from falling out.

The initial results of these set of prototypes reveal success in exploring pocket–weave structures for containing seeds and substrates and in illustrating an interior scenario with them. The maintenance by forms of human management was carried out by a sprinkler system and a water–balloon–drip irrigation system as well as by manual watering.

carpet

Derived from a small scale hand–weaving experiment, this prototype illustrates a full scale floor covering, filled with perlite and a mix of seeds, i.e. lentils, mung beans, radish and red clover. The wave–shaped surface design is carried out as channels, using the 2/2 and the 1/1 binding for creating a contrasting construction. The prototype is the only example where the warp–materials has been used as a weft. In contrast to the ceiling prototype the open and dense parts alternate and are used on face and back. Consequently the layer of growth will be effected by the contrasting constructions as well as the draping of the cloth on the floor. As the piece is filled with a lot of perlite, the seeds will have a more constant access to water. In this case the watering is done by the visitors using a watering can.

table cloth

Inspired by a circular matrix for plant growth, the tablecloth contains various seeds i.e. red clover, mung beans, in a mix and separately. The example aims to demonstrate the interaction of a range of germinating seeds with the cloth. Therefore the 2/2 construction was chosen for the face of the circular enclosures. The surface design consists of these circular enclosures as well as channels with a dense construction, which haven’t been used in this case. As in the previous example, the open construction
has been used to create openings to insert the biological material as well as to provide access to light. As different seeds have been used, they will create different layers of growth and interactions with the construction. Thus, the differences can be observed in one prototype. The watering here is taken care of by the sprinkler system due to the environment of the museum. As the sprouts are edible, they can be harvested and being eaten, creating an analogy to a set table.

Figure 38-43 (from left to right the series of images shows the process of inserting perlite, inserting the tubes for watering, a back view on the filled structure, balloons in the upper layer of envelopes for watering the ones below. The last two images show an observation of water flowing through the hollow channels without using a tube for water transportation - little water comes through the dense construction, most of the water flows down, building a puddle on the floor.)

Figure 45-47 (the pattern design based on a material exploration with a vegetal–textile hybrid crochet on a weave with a contrast of open and close constructions led to a seat pouf with envelopes that are filled with soil tablets and seeds.)

Derived from small scale experiments using weaving and crochet, this prototype focuses on designing enclosures as part of a distinct pattern. The construction is based on the contrast of the described bindings in different combinations. Using the interwoven construction in contrast to pocket-weave constructions using the open and dense bindings as described in the previous prototypes. The small enclosures are not connected but organized in a pattern capable of accommodating soil tablets, cotton padding and/or seeds, i.e., red clover, alfalfa, radish, burnet. The different possibilities of insertion, altering the pattern and their expressional effects on the surface design are explored. The inserted material is the foundation for the layer of growth, activated by forms of human management, in this case, by an automated sprinkler system. As the material does not absorb but rather prevent water from penetrating the cloth, it has to be watered very regularly for the seeds to germinate and sprout. The watering will then lead to expressional transformations, swelling of the coconut fiber tablet, expanding the pocket, germinating seeds and their interaction with the different bindings. As the processes of transformation and the watering interferes with the common usage for sitting, new forms of interaction open up. Beside observing the transformation of the pattern by the sprouts, they also can be harvested and eaten.

Figure 48 (The image shows all the used double weave constructions)}
Conclusion.

The initial results of these prototypes reveal success in hosting seeds and substrate and demonstrate the ability of using industrial weaving processes to produce fabrics to integrate biological elements to create a transformative material system. However, the process of textile design requires many rounds of trial and error until the desired behavior is achieved. Therefore observations and reflections on processes of transformation in regard to the surrounding conditions are vital data that can be gathered from the analog model. For future applications in an architectural context, i.e., hybrid housing, indoor gardening, these data could feed into the design of a computational model to support the design process through simulating the transformative material system and its response and adaptation to the environment. Immediate advancements in the transformative material system can be obtained with more experiments on different materials, patterns, production processes, forms of human management and surrounding environmental conditions in regard to plant growth and maintenance.

The proposed material system could redefine the aesthetics of inside and outside blends by designing and facilitating interaction possibilities between textiles and plants as well as with humans. Consequently the research described in this paper, contributes to biophilic design on the scale of the interior, by blending indoor and outdoor expressions into interior textiles. The material system reveals natural processes that open up a discussion for seasonal interiors, indoor climates, processes of degradation in interior scenarios. Thus, cultural and aesthetic bias are challenged and new methods for the textile design practice required.

Most spaces in between inside and outside, within built environments, are poor representations of their origin. Floor-plans of the Nature Houses provide a view on the interior. Furniture, textiles, materials, pots and flowerbeds meet, but they usually don’t interact with each other to express the hybrid environment, the hybrid nature they are part of. „We are beginning to recover a certain philosophical respect for the inherent morphogenetic potential of all materials” (DeLanda, 2004).

To most contemporary attempts of climate-responsive architecture, the development of no-tech responsive architecture differs as all the responsive capacity is embedded in the structure of the material itself. In the article „Material Computation: Higher Integration in Morphogenetic Design” (Menges, 2012) claims that architectural design approaches still struggle to fully explore the „materials’ richness of performative capacity and resourcefulness for design”. This also applies to the textile design practice. Generative computational systems that integrate material, form and performance in the design process, the integration and modulation of behavior and transformative capacities of hybrid plant-textile structures, can help simulating the design intend for textile design approaches on the scale of the interior. Consequently the development of interaction scenarios and fabrication methods is supported. Weaving therefore can be easily digitalized. Additionally the seeds potential should be included to estimate and simulate their transformation and their interaction with the textile construction, i.e. the changes in the surface design. The digital architectural process will be opened up for a new generation of materials with natural growth, requiring maintenance and proposing new variables for the design process.

References.


This publication presents the second iteration of jacquard textiles woven at Svensson AB, focusing on circular envelopes for accommodating plants. It therefore supports the discussion of circles in the 'Textiles as Plant Mediators' chapter of this thesis. Two concepts resulted from the experiments – 'textile permeability' and 'textile climate' – which are described and reflected on with regard to designing and understanding interiors as ecosystems. This concept is introduced in the publication, and developed further in the 'A Methodological Framework' chapter of this thesis.
On Textile Farming: Towards an Interior Ecosystem

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In Greenhouses horticultural textiles create healthier climates for plants, protecting from wind and insects, and improving and guiding the light. Likewise, indoor traditional interior textiles mediate between people and space, creating indirect light through shading the sun in a window and making a cold and hard bench feel more soft and look more colourful. Moreover, today’s horticultural practices increasingly enter the private realm since urban gardening and indoor greening systems are more popular and architects continue to propose joint living spaces for people and their vegetable cultures in order to promote more resilient and sustainable ways of living. Rahm argues that we could create interior spaces which are more natural than the exterior by reformulating the specific conditions of a natural niche inside a building. Indeed in recent years, the interest in plants as a vital material in an architectural context increased and has adopted various appearances which have in common their temporary expressions and a certain level of transience and arbitrariness for plant growth. However, many of the examples can be characterized by rigid materials and technical systems that lead to expressions that seem too natural. In relation to this, Keune’s exploration of textiles as a flexible system to integrate plant growth. The collaboration in this research with Svensson AB, a developer and producer of textiles for interiors and greenhouses, has led to a joint approach towards these two distinct areas, climate screens and interior textiles. By experimental methods, the interaction between plants and textiles is explored, using flexible supports constructs as a framework for seeds and substrate to be integrated. As a result this concept ‘Textile Permeability’ and ‘Textile Climate’ present a perspective in which textiles become a flexible interface guiding and melting into seasonal expressions of e.g. growth and decay. Both concepts are seen as a first step towards a textile interior ecosystem in which spaces are composed of relationships between biotic and abiotic components and natural and artificial therefore intersect. Here textiles could become a flexible interface guiding and melting into seasonal expressions of e.g. growth and decay.

Additional Key Words and Phrases: textile farming, designing with seeds, textile design, biomaterials, spatial design, seasonal interiors, plant adaptations

1 INTRODUCTION

At Svensson AB, where this research was conducted, interior textiles and horticultural textiles are developed in two distinct departments. Thus, both categories of textile products aim to create better climates for plants and people separately. In Greenhouses horticultural textiles create better climates for plants; indoors traditional interior textiles mediate between people and space, creating a more comfortable climate for them. In interiors textiles are used e.g. to make a cold and hard bench feel more soft, to highlight certain areas through colours, to represent the season, and to create indirect light through shading the sun in a window. With an increasing interest in forms of urban gardening, e.g. integrating a small vegetable cultivation into the home, horticultural methods and systems for plant cultivation enter the interior. Often these are based on rigid materials and shelving systems and exclude the natural biotic environment in which plants used to thrive in nature. Rahm argues that nature has always been excluded from interiors and that now as it doesn’t exist anymore and the whole world including external environments and their climates have been altered by human activity, we could create interior spaces which are more natural than the exterior by reformulating the specific conditions of a natural niche inside a building. In recent years, the interest in plants as a vital material in an architectural context increased and has adopted various appearances which have in common their temporary expressions and a certain level of transience and arbitrariness for plant growth. However, many of the examples can be characterized by rigid materials and technical systems that lead to expressions that seems too natural. In relation to this, Keune’s exploration of textiles as a flexible support constructs as a framework for seeds and substrate to be integrated. As a result this concept ‘Textile Permeability’ and ‘Textile Climate’ present a perspective in which textiles become a flexible interface guiding and melting into seasonal expressions of e.g. growth and decay.

2 EXPERIMENTAL WORK

The approach taken to enable and investigate textile plant interactions involves the creation of woven enclosures for the integration of seeds and substrate, to direct plant growth through different densities of the weave construction, to create microclimates in and around the structures through the interaction between climatic parameters, e.g. light intensity, relative humidity and temperature (Figures 1).

2.1 Set-Up

The publication ‘Hortitecture, The Power of Architecture and Plants’. The publication presents current developments in an architectural context: façades as bio-creative panels to host microorganisms, cryptograms, and more complex plants are researched by Crut and Beckett, Ludwig investigates living plant constructions to support or facilitate architectural form-work and Weisz utilizes ropes to vertically organise plants as a façade system that produces edible plants and improves the buildings climate [2]. At the same time, there is a rising awareness about the abilities of plants to sense, act and communicate, their symbioses and other important processes such as cleaning water and air, providing oxygen, and storing CO2 [3]. At the material scale, the interest in living biomaterials e.g. bacteria, fungi, algae has reached the textile design practice as well. Textiles are grown from roots [2], bacterial cellulose [4, 5] or mycelium [6, 7] and dyed [8, 9] or transformed with bacteria [10]. This biological paradigm brings an alternative perspective to the ways in which textiles and interiors can be designed and lived with. The collaboration in this research with Svensson AB inspired to an approach which speculatively connects the companies two distinct areas interior textiles and climate screens. By experimental research methods, the interactions between plants and textiles are explored through using seeds as a dynamic material for textile design and investigating double weave constructions as a framework for seeds and substrate to be integrated. As a result the concepts ‘Textile Permeability’ and ‘Textile Climate’ present a perspective in which textiles become a flexible interface guiding and melting into seasonal expressions of e.g. growth and decay. Both concepts are seen as a first step towards a textile interior ecosystem in which spaces are composed of relationships between biotic and abiotic components and natural and artificial therefore intersect.

Fig. 1. The image illustrates the set-up of the experimental work and the experimental goal: Textile Plant Interaction

Fig. 2. The image shows the design for the woven samples which were produced at Svensson AB.
On Textile Farming: Towards an Interior Ecosystem

The construction of samples is based on double weave constructions in which two warps are woven separately in defined areas to enable enclosures into which seeds and substrates can be inserted (Figure 1). The foundational weave construction connects both warps (the brown and purple areas in Figure 2), whereas the coloured circles mark the areas which create enclosures and in which different bindings were explored. Plain weave, satin weave, basket weave, twill weave and aida weave were therefore combined and the samples woven with an industrial Picano Jacquard loom at Vormson with a full size rapport, using a standard material for the interior textiles, a mix of wool and polyamide. The composition of the samples and their set-up is illustrated in Figure 3.

Fig. 4-7. The four images illustrate the insertion of cotton substrate and a nasturtium seed into a small circular enclosure

By separating warp and weft with the help of the tip of a bobbin (Figure 4) a hole was created in order to insert seeds and substrate e.g. soil or cotton padding into the envelope by hand (Figure 4-7) or by using a funnel. To close the holes wet and warp threads were put back into place (Figure 7).

2.2 Explorations

Fig. 8-13. Sprouts permeating the twill (8, 9, 11, 12) and the aida weave construction (10, 13). Figures 11-13 show the different stages of development, while some sprouts are already withering, two other types start to appear.

The first exploration was carried out with a large circular envelope with twill weave on one side and aida weave on the other. It is filled with soil and a number of different seeds and placed vertically. After some days of watering a number of sprouts managed to permeate both constructions in different areas of the entire face (Figures 8 and 9) and back of the envelope (Figure 10). White stems and bright green leaves which reach against gravity and grow in line with the warp, white roots appear in the bottom of the enclosure, illustrating their gravitropism, their growth response towards gravitation (bottom Figure 8). At the same time as the small sprouts collapse and wither, which means that they lose their force to direct themselves against gravity, that they shrink and change colour, two other types of sprouts appear in the very top (Figures 12 and 13).

Fig. 14-15. Figure 14 shows a lacunato kale sprout hiding inside a large circular envelope, Figure 15 reveals the development of the sprout by cutting open the front of the enclosure.

The second exploration was carried out with a large circular envelope woven with plain weave and basket weave and loosely filled with soil to which a hand-full of lacunato kale seeds were added. Since there was no visible evidence for growth for weeks of regular watering, a hole was created into the top part of the vertically oriented structure to see if there were some hidden transformations inside the textile envelope. The hole revealed the stem and leaves from a lacunato kale sprout hiding inside the textile (Figure 14). The lack of radiation caused the yellow colour of the leaves. Figure 15 illustrates the transformation by exposing the inside through cutting out one side of the enclosure.
The fourth exploration was carried out with a large circular envelope with a three-piece set of adjacent circular enclosures woven in plain and satin weave. The central one was filled with soil and a hand full of radish seeds and placed in a horizontal orientation. After a couple of days red roots appeared outside the envelope (Figure 18), the face remained the same. To help the sprouts permeate the weave construction small holes were created by separating warp and weft and one sprout appeared (Figure 19). To provide a suitable microclimate for the roots to develop, a bowl with soil was placed underneath the structure. The red roots together with the particles of soil create an aesthetic opposition on the area where the white warp intersects with a green and petrol web but creates an aesthetic blend in relation to the middle ring, where the black warp interweaves with a light blue and rose well.

3 ANALYSIS OF THE SAMPLES

The first exploration in which twill weave and aida weave form a large enclosure densely filled with soil provides a structure which seems suitable for the sprouts to work themselves through the construction in both back and in the front. Twill weave and aida weave are both categorized by plants which create an open weave fabric, making it more easy for the plants to interact with the construction and to permeate it.

The second exploration in which plain and basket weave were used provides a rather impermeable backside and a loose front, since plain weave is a dense weave construction and very durable and basket weave has a loose textile quality through warp and weft threads which interface in groups, resulting in a checkered appearance and a soft quality. It was due to the shape and form of the leaves, which were already too big and offered too much resistance that the plants did not fit through the construction and remained below. Therefore the relations between placement of the seeds, type of germination, permeability of the weave construction and time determine the interaction between plant and textile. Since there was no appearance of roots it could be concluded that the sprouts, at the time of observation, found enough nutrients, moisture and space to root in. This was not the case in the third exploration, where a horde plant extended its root system into the adjacent enclosure like a stem. The appearance of roots outside the textile envelope could be interpreted as search for better conditions and additional resources. In a horizontal orientation roots have less vertical space and substrate to expand in, the combination of little distance between seeds and textile and little soil in vertical direction increases the likelihood that they appear above ground quite shortly after germination, since they reach towards gravity rather than expanding horizontal. The orientation of the structure and the amount of substrate vertically available thus have a say in the life span of the integrated plant, which could be observed in the fourth exploration. The more substrate, the more moisture is available and the longer it takes for it to evaporate. However, roots above ground could be seen as a textile application since they share many similarities with threads.

In the fourth exploration the plain weave construction in combination with the seeds and substrate density prevented the stems and leaves from permeating the textile construction, the roots however managed to enter through the satin weave due to their pointy tip and growth power.

4 TEXTILE PERMEABILITY AND TEXTILE CLIMATE

Regarding the textile influence on the interior environment, the examples open up for two concepts: ‘Textile permeability’ and ‘textile climate’ condition each other and are both attempts to guide growth and enable interactions. Textile permeability enables interactions between plant and textile, and what is inside and outside of the textile envelope. The inside can be referred to as below ground since it is mostly a storage of moisture and seeds with substrate for root systems. Since the climatic conditions inside the envelopes in relation to relative humidity, light intensity and temperature differ from the space around, one can say that a textile climate emerges which together with the level of textile permeability determines the conditions for plants, e.g. to be activated, to thrive, to interact with the textile, to wither and to die, consequently their development enabled or restricted. Figure 20 illustrates a textile structure with rosemary plants in a window, as a sun-loving plant the structure can be turned towards the sun over the course of a day. The pea plants in figure 21 use the permeable weave structure to climb, both figures are thus exemplifying the concept of textile permeability, whereas figure 22 illustrates a changing textile climate by showing a gradient of wilting grass.

The textile creates a spatial division between the space enclosed by the envelope and the space outside of it and mediates between both microclimates. Temperature, relative humidity and light intensity over time are major climatic parameters for the onset of germination, whereas the availability and the amount of nutrients becomes more important over time. The textile-climate guides the life span of the incorporated plants. Dormant states are triggered by conditions in which moisture is absent or terminated to initiate dormancy or the death of plants as a form of preservation of a certain state of growth, e.g. leaves prior to flowering or flowers. Transformative states are triggered by states in which moisture is present. The spatial separation by the textile represents the division between below ground and above ground and consequently the division between roots and shoot and their processes: shoots are in search for light above ground and roots and shoots in search for water and nutrients below ground. However, whereas the space Textile Interactions – 12-14 September, 2019 – London, UK
above ground is almost limitless, the space below, inside of the textile, is not. Since there is a balance
between the space a plant takes above and below ground, the space below ground that a plant has access
to determines its development.

Seeds can be located in textile envelopes in different areas, as one per pocket or many. When horizontally
orientated, the seeds can be placed vertically in the through substrate expanded textile envelope. Here
they can be located in the top, close to the face construction in e.g. provide maximum space for the
downward root development and minimum distance for the up-reaching stems and leaves. The seeds can
be placed in the bottom, close to the rear construction e.g. let roots appear at the rear and to impede the
penetration of the face construction by the stems and embryonic leaves. They can also be placed in
between, with the same distance to face and back e.g. to observe the timely differences in root and shoot
development (Figure 20). On the horizontal axis, they can be located in the corners of a textile envelope to
e.g. accentuate them or in its centre to e.g. provide maximum substrate to the growing plant, as the
expansion of the envelope creates most space in the centre (Figure 21).

In a horizontal orientation, there is an up-facing side, the face, and a down-facing side of the cloth, the
rear. The face is usually exposed to light, which is absorbed or reflected by the textile structure and its
containing elements, e.g. substrate and by the ground on which it is placed. The seedling in a horizontally
placed textile envelope consequently responds to Phototropism with the parts close to its face. The
microclimate at the back is warm and moist. The roots, affected by gravitropism consequently grow
down and outwards of the envelope in search for a dark, moist and warm environment (Figure 22).

Fig. 22 illustrates a textile structure in a horizontal orientation and the microclimates that emerge inside and around
them.

The space available to the plants below ground can be determined by the size of the textile envelope but
also its orientation. In a 90°, vertical position, the inside of the envelopes, the part below ground, takes on
a vertical direction. Here, seeds can be placed differently within the structure. Situated in the top of a
textile envelope, the entire lower part of it is available for the roots to expand in, whereas it is more likely
that roots will appear above ground, on the lower part of the envelope, the lower the seeds were placed.
Other important factors for the appearance of roots are of course the size of the envelopes in relation to
the plant growth pattern in relation to time.

Fig. 23 illustrates a textile structure in a vertical orientation and the microclimates that emerge inside and around
them.

The vertical structure can direct the plants towards light or keep them in shadow (Figure 20). Here the
textile climate is more important, e.g. the level of moisture and the temperature. A vertical orientation
means that the hosted plants have more substrate in direction to gravity to root in, but they are also more
exposed to e.g. light, air and wind (Figure 23). Available humidity sinks down towards gravity. The
vertical placement, in comparison to the horizontal orientation, contains a more diverse textile climate,
drier and warmer in the top, more humid and colder in the bottom, it is space-saving and easy to move or
turn towards spots with e.g. direct sunlight for sun-loving plants. The flexibility and mobility of a vertical
textile makes the plants position more flexible and adjustable to their needs. The vertical position is
therefore more suitable for growing plants in favour of the plants development (biological perspective).

Whereas the horizontal orientation is more suitable for growing plants in favour of textile expression
(textile perspective).
5 DISCUSSION

In addition to the effects that the concepts have on textile design, there are also effects and conditions that relate to interior design. Since certain plants need certain environments and climatic conditions, spaces need to be analysed or designed for being suitable habitats for plants. The textiles can also mediate outside-to-inside transitions as illustrated in Figures 24 and 25, where a textile structure temporarily replaces a wall (Figure 24), protects the inside from wind and rain, while it absorbs moisture which is needed by the plants which grow in the fabric. Such a modularity demands some kind of spatial permeability as well, which could be understood as the flexibility of spaces to open and close, rearrangements, enabling access to outside experiences and expressions which could be mediated by the textiles. Consequently seasons, planting and harvesting times also affect the everyday life in the home. Everyday routines change and the time and attention that is and must be directed towards the textiles and their plants increases, unless the plants can provide themselves with e.g. water, or insects for pollination, by the textiles connection to the outside and a permeability of the space.

The design process becomes more complex, since the needs, e.g. amount and quality of light, space above and below ground, mix of nutrients and expressions of the plants in relation to time e.g. colours of the different parts over time, spatial expansion, directionality (standing, creeping, climbing) need to be considered. This automatically includes considerations about the positioning of the plants in relation to the textile (placement of the seed) and in relation to space (e.g. vertical or horizontal orientation, sunny or shady position). The textile perspective to plants on the other hand changes the view on plants and their development. The similarities in colour or shape, or that of roots and threads can be used to design temporal expressions which support the textile qualities rather than the full development of the plant.

Both concepts ‘Textile Permeability’ and ‘Textile Climate’ promote an intersection of horticultural thinking and textile design methods and practices. Textiles are suggested to integrate plants to create active and adaptive surfaces by using seeds as a dynamic material for textile design and to create more flexible modes of plant organisation indoors. In this work textiles are consequently proposed as a framework for growth, which connects to the works introduced in the context of this paper. Cruz & Beckect [11] argue that “the degree of colonisation on surfaces is dependent on both the inherent properties of the material itself and environmental conditions; this area of work asks design to explore the relationship between the material substratum and areas of the surface that enhance or inhibit growth, as well as the specific environment and organisms that thrive in it”. They explore morphological features such as protovity and roughness through which e.g. moisture is collected and retained to promote the growth of cryptogams. It is the common interest in morphological surface qualities in relation to environmental conditions which together promote plant growth that connect this research with the work of Cruz & Beckect. Textiles offer a high flexibility and permeability, ‘Textile Permeability’ therefore is seen as a way of designing ‘bio-receptivity’ through weave-constructions which result in e.g. interactions between roots and threads from a functional and aesthetic point of view. Such interactions can be observed in the work of Weisel and the hydroponic rope systems. Whereas Weisel utilises ropes ‘On Textile Farming’ explores double weave constructions to inhabit plants and the interplay in relation to e.g. colours and the orientation of a textile.

for the integrated plants which could be thought of as inbuilt expiry date. Through the integration of growth, expressions thus become temporary, their change can be activated and deactivated, their state can be active or dormant. Since a biological perspective is added to the life-cycle of interior textiles, expressions and events usually found outdoors enter the interior. Substrates and water could create dust, puddles and mud, certain plants need pollination. Consequently temporal expressions dominate permanent expressions and ‘Seasonal Interiors’ can be designed and guided.

The explorations into interactions between plants and textiles involve considerations about the blueprint of the plant, e.g. its type of germination, its colour in different stages, its climatic preferences, the construction of the weave, weather it is dense or loose, and the orientation of the fabric, vertical or horizontal. They are determined by the prevailing climatic conditions over time (Figure 26).

The two images show a greenhouse with textile structures suspended outside (Figure 25), inside and in between (Figure 26).

Keune

Fig. 26. This figure illustrates a model for designing interactions between plants and textiles based on woven structures.
On Textile Farming: Towards an Interior Ecosystem

structure. Textiles, in the context of this work are not seen as the only substrate, but as one of them and as an envelope for others. Further developments through textile engineering could focus on e.g. selective movement of moisture and nutrients in a given direction through the choice of textile material and construction, additional features for filtering the water which is running through the fabric, selective levels of resistance and decomposition within the textile structure. In relation to Svensson AB, ‘On Textile Farming’ proposes using textiles to inhabit plants and to create a beneficial climate within them instead of underneath them. The resulting material could then be installed in e.g. domestic interiors where it contributes to ways of living and growing which interact more through e.g. interior textiles which are used as usual, then activated and which gradually transform and change places towards the outside. In relation to Beyers concept of a textile microcosm, further development into what is called here textile permeability and textile climate could be extended by beneficial microorganisms and insects which are attracted to the textile properties and the textile design, e.g. colours and patterns. Creating interior spaces which are more natural than the exterior, as proposed by Kuhn, by reformulating the specific conditions of a natural milieu inside a building, opens up the design space in many directions. One direction stretches towards post-anthropocentric modes of designing textiles and spaces, since people will share their interior living space with other organisms. Here textile design can draw from different fields to create what could become a ‘textile interior ecosystem’. horticultural knowledge about e.g. the interaction of insects and colours in terms of attraction and repulsion and climatic conditions for plants, regenerative farming about e.g. companion planting; tissue engineering about creating textile bio-responsivity. A ‘textile interior ecosystem’ could therefore be a community of people, plants and other organisms, e.g. insects, microorganisms, which live in conjunction with textiles and other abiotic components through cycles of nutrients and energy, e.g. rainwater is filtered by the textile structure and provides moisture for the plants in it. The plants filter water and air and provide nutrients for people, whereas the people manage the climatic conditions of the interior, organise the growth in beneficial groups, move and expand the textiles according to the plants needs and through e.g. fermentation provide nutrients for them. The textiles either break down and turn into nutrients or substrate, or they last and form a permanent template for growth as part of an architectural space. In this scenario ‘Textile Permeability’ and ‘Textile Climate’ serve as two building blocks towards a ‘Textile Interior Ecosystem’. In a time in which the way we handle relationships to biotic and abiotic components is discussed and criticised, this research could open up a range of concepts unfamiliar to designing textiles and spaces such as designing indoor seasons with seasonal textiles, designing textiles for companion planting and opening the interior space for multi species relationships, in support post-control and pollination. Here, textiles create connections between the scale of the material and the scale of interior space by becoming a template for growth and a mediator between all biotic and abiotic actors involved.

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Textile Interactions - 12-14 September, 2019 - London, UK
This publication describes the autobiographical journey of the On Textile Farming research project in the form of a diary. This method was used to document and reflect on experiences of everyday life, and so the more personal aspects of the artistic research project are described, including subtle observations that would be difficult to describe in a factual way. Three short stories are presented, framed by factual discussions of the biological perspective of the experiences and what they added or opened up for with regard to textile design and the design of indoor spaces.
LIVING IN A PROTOTYPE RESEARCH DIARY

SVÊNJA KEUNÉ
Introduction

This publication illustrates my journey over the past four years of artistic research within the ArclInTex European Training Network. This journey started with a search for textile structures that adapt and respond to their environment, led to me studying the interactions between seedlings and textiles and resulted in me living in a prototype house in the Swedish forest in order to explore the spaces in between the inside and the outside. The diary presented here, containing three short stories, describes the magical subtle experiences that one has when conducting observational studies, which are difficult to describe in a factual way.
Coming to Sweden was a happy accident. The job postings for the ArcInTexETN project had been on my desk for weeks, sounding too good to be true. I finally applied for a PhD position in London while at a festival in Belgrade. The day I was to fly to the interview at the Royal College of Art in London I met my neighbour on the street and he offered me an apartment in Berlin. I didn’t get the job so took the apartment and moved from Hamburg to Berlin. Some weeks later while enjoying a residency at the porcelain manufacturer Kahla I received an inquiry from Svensson AB. Regarding the ArcInTexETN they were looking for someone to cover the same position as I had applied for in London, but in an industrial context in Sweden. I got the job, moved from Berlin to Borås, and occupied desks at the Swedish School of Textiles and in the design department at Svensson AB. I don’t enjoy living in small towns, however, and so moved to Gothenburg after a month. I was intrigued by the company’s history: a crisis in the 1970s had led to radical changes in the corporate strategy and, ultimately, the use of textiles to create better climates for plants, which reduces emissions created by e.g. heating or cooling Greenhouses. Today architectural efforts to combine living and gardening under the same roof12,13, urban farming14,15, designing with living materials9, research into the communication methods of plants6,7 illustrate efforts aimed at reconnecting with our natural origins and surroundings by uncovering their potentials and inviting e.g. plants into the home or using biological materials as a material for design9 and manufacture13. I decided to investigate seeds as dynamic materials for textile design14 in order to change the status quo of excluding natural experiences from interiors and how we live and interact with plants. With a background in designing responsive textile installations using electronics5,14, I am interested in how our understanding of textiles can be expanded through non-textile materials and techniques. Consequently, I look at plants from a textile perspective. However, I spent much of my days commuting, and while sitting on the bus felt homely, my experimental work was a mess. My experiments with plants fought for their survival in a storage space without windows at the Swedish School of Textiles in Borås, in my office at Svensson AB in Kinna, and in my bedroom in Gothenburg.
All the travelling and commuting came to an end when I found a hide-out in which to write my licentiate thesis in Summer 2017. It was my then-boyfriend’s place; a small house next to a forest and close to a lake, with some garden sheds, a big lawn, and a dog.

My computer, Elvis the dog, and I followed sunny spots on the property throughout the day.
We wrote on the wooden terrace, in the soft grass, on the hammock, and at the lake and the pedestal inside the fenced dog yard.
In the autumn I continued writing while lying on the carpet or sitting on the floor or in an armchair in front of the fireplace. Since early childhood I have used tables and chairs solely for storage. Elvis was always by my side.

We would hide from the rain and colder days in one of the garden sheds, tucked up in a sleeping bag and with the doors wide open to enjoy the panoramic view of the forest, the sound and smell of the rain, and the fresh breezes that I so deeply missed when in the fully climate-controlled university spaces.
I fell in love with the forest, the silence, the smell of snow, the warming sun, the echo of the lapping of the lake, the soft surfaces, the colours. I wanted to explore how to live in harmony with my environment, the seasons, and other animals.
For a month I lived in a 9 m² garden shed, and enjoyed the fact that just one door separated me from the garden. I also discovered the beauty of peeing under the moonlight.

Winter came with a crisis. The relationship didn’t work out, and I had to leave paradise.
I decided to create my own paradise, to finally become independent and to 'live my research' in a Tiny House on Wheels with a greenhouse attached to it, somewhere in the Swedish forest.
The house had to be small, but big enough; very simple, but comfortable; as cheap as possible, but made from high-quality natural materials. It had to have many windows and doors, but be as light as possible. It had to have several levels but a high ceiling, and be a prototype but simultaneously finished. It had to be carefully planned, but completed as soon as possible. There had to be enough space for all of my things, but I didn’t want to own things anymore.
Manuel was the first person I contacted, and the one who built my house. He is a biologist, now specialising in building tiny houses. He inhabits one with his two daughters. This project was a challenge for both of us, and an exciting journey over the course of the following 10 months.
In spring I was desperately looking for a place to park my house, which was to arrive at the end of July, but found out that farmers apparently don’t spend time on Facebook or housing websites such as Blocket. Luckily, I discovered a small shared house in the forest in Bollebygd. The journey to the meeting was an adventure; a 45-minute bus ride from Gothenburg central, then a 45-minute walk along a country road and gravel track, passing a burnt-out car and thousands of trees. Even though it was a beautiful sunny day, the trip seemed exhausting and endless. I decided that this was not a good option.
So, I moved there, blinded by this paradise and the three rabbits that live and run there in peace. The vegetables are fenced but the rabbits run free.
At that time, a biologist who specialises in wild bees and bumblebees and a student with two cats and a puppy lived there. I learned how to split wood and walk through wetlands, what dead bats look like, how to deal with ticks and deer flies, and how to make hay with a scythe.
After many greenhouse-building companies refused to build a mobile, customised one for me, I became friends with the nomadic, spiritual carpenter Alf. Alf lives in a caravan. After a crisis he changed his way of life, and now explores ways of living, working, eating, and being. He is especially interested in collaboratively building houses and communities in order to share his knowledge, life experience, and passion.
So, the two of us built the Greenhouse, in which I wanted to explore and experiment with the spaces between inside/interior and outside/external.

We used old windows and didn’t have much time to plan, and so worked quite spontaneously with what was available to us, but according to some parameters.
The Greenhouse needed to have a higher roof than usual in order to accommodate hanging textiles. One part of the floor had to be possible to open in order to access the ground/soil, and it needed shelves and curtain rods both inside and outside. One part of the Greenhouse needed to be open so that either the front or the terrace doors of the Tiny House on Wheels could be connected to it.
I changed the setting in the Greenhouse many times in response to the fabrics that were placed there, the activities carried out there, and the weather and the seasons.

Initially, it was very tidy and clear, and felt more like an exhibition space for showcasing larger woven fabrics.
Later on, the small samples were suspended from wooden sticks, hanging down through various openings in the floor. They looked like folders in an office rack. The textiles hung there, watered from above so that the excess water was absorbed by the soil or collected in a plastic box below to be reused. Saving water was very important during that extraordinarily hot and dry summer. I hoped that the experiments wouldn’t be dried out, carried away by the wind, or eaten by the rabbits.

While preparing some smaller samples, the floor was partially removed in order to create a workstation for the sewing machine. The feet and the pedal were resting on the grass, while I and the sewing machine sat on the wooden floor of the Greenhouse.
A wooden box filled with hay, compost and potting soil was mounted under the wooden floor in order to grow a mix of vegetables inside the Greenhouse. The compost would provide some nutrients and microorganisms and the hay some warmth and nutrients while it decomposes.

I loved to observe the rabbits and cats running around outside. They liked to explore and hide under the structure, as I did when I was attaching the wooden planks from underneith. It is a different perspective, and feels calm and comfortable.
I decided to build several boxes outside the Greenhouse in order to explore more conventional small-scale gardening. I dreamed about growing my own vegetables, eating great meals, and composting the scraps in the compost bin to produce new soil for later use. The biologist and I also discussed introducing ourselves to our new neighbours, who owned horses, and thought about asking them for some horse manure, which we could then transport in a barrel in a car or with our wheelbarrow.
In spending as much time as possible at the place where my Greenhouse and Petersilie – the name I gave the Tiny House on Wheels – would one day be united, I observed how the sun moved over the course of the day and what it felt like to sleep there at night.

Meanwhile, Petersilie was being built.
In my mind I tried to visualise how I would use the space, how I would feel lying in my hammock in front of the wood-burning stove or sticking my head out of the window in the roof to listen to the dancing and rushing trees. I calculated the exact height of the sleeping loft and bathroom in order to be able to have a standing shower and space to sitting upright in bed.
From time to time, I visited Petersilie in Uppsala to compare my imagination with reality and gain clarity regarding design decisions.
During these visits Petersilie and I were generally alone, so I had time to get to know all of the corners of the space.
In the mornings I had an outdoor shower in the sun using the garden hose. One can easily forget the amenities that one has gotten used to when embarking on adventures. To facilitate outdoor shower experiences, the house has a water outlet that is accessible from the outside.
Petersilie is entirely based on happy memories of past experiences, on speculations regarding future ones, and on design ideas relating to a simple lifestyle close to the outdoors, conducted with as little impact on the environment as possible and based on the idea of a continuous prototype.

Three months past the deadline and just as the autumn left, she was ready to be collected by a low-loader truck to be driven from Uppsala to Bollebygd.
Petersilie arrived at sunset and as ice flash-froze on the streets. My neighbour realised that his tractor might be too small to pull her and so called some of his friends for help. They arrived with an even smaller tractor, and suddenly disappeared when the dimensions of the house became apparent. They returned a short while later with a larger tractor and parked Petersilie at the crossroads. It was too dark and too slippery to go any further.
Petersilie had to wait, unlocked and with water damage. The next day, Alf came to provide help and stay by her side.
It was the worst day of my life, but I had the best support I could have wished for.

After two nights, the two-kilometre journey along the forest road began.
Stefan, a friend of the neighbour, prepared the road and pulled Petersilie in reverse the whole way, continuously adjusting the height of the whiffletree to prevent the façade from scratching the road. Alf directed the whole venture, while I fought nausea as I watched the fruit of my ten-year loan swaying from left to right. The insurance was only valid while Petersilie was in the parking spot, leaving the journey uninsured.
Petersilie slid sideways into a ditch ten meters from the parking spot as a result of the melting ice and rain. Stefan called a fork-lift truck, but the first that arrived was too small. The second, however, managed to get the house back on the road. Due to the curve of the road, the fork-lift truck was used to continuously readjust Petersilie and park her in place, just before sunset and heavy rainfall.
The following days and weeks were dedicated to stabilising and adjusting Petersilie, solving problems, worrying, and enduring sleepless nights filled with nightmares of disasters such as gas explosions, water leaks, collapsing soil, falling houses, and cancer relating to the smelly oil that was used to treat the interior wood.
Many external elements had to be fixed, too; the whiffletree, for example, had to be removed. It had been made detachable so as to facilitate access to the house from all sides, and I now realised that it would have been better to construct a solution that would allow it to be fastened on either side of the house, as this would have made it easier to manoeuvre Petersilie and to park her in tight spaces.

I also failed to get used to the sound of a little branch that continually tapped Petersilie in a resonant manner, causing her to make sounds akin to those of a groaning bear. In a weak moment, I cut the branch.
The planned moving-in party, which was intended to close the gap between the Greenhouse and the Tiny House while enjoying coffee and cake, never happened.
Instead, Alf and I undertook the task ourselves. Late one afternoon we built a bridge, covered it in liquid soap, and used an iron bar and all of our might to slowly unite the two structures.
When Alf is around, there is always an opportunity to go beyond one’s own limits.

When the structures had been united, so too were the living spaces of a mouse and myself.
Slowly, the interior took shape. On Christmas Eve all was white with sawdust. The branches of a fallen tree were intuitively sawed on my Feetup Yoga Chair, and screwed into place.
Organising the space turned into a spontaneous adventure, in which only some boards had to be organised.
The grey, yellow-lichen-coloured bark of the aspen that had grown in our garden is now a part of Petersilie and my everyday life.
The house was intended to support awareness in general, specifically regarding resource consumption. Therefore, firewood was chopped in winter, the water tank was filled every week, food and human waste were composted, and trash was carried to the recycling station.

Slowly, I began to experience the effects of my design decisions. One window was too low and the stone floor was too cold in winter, but the natural massaging action of the stones was exactly what I imagined and why I chose it.
The gas stove was chosen in order to cut down on the use of electricity and to have the option of one day integrating a biogas system to produce gas from food scraps\textsuperscript{18,19}. It was mainly used during summer, and occasionally in winter when the long process of heating up the wood-burning stove was not appropriate. The fact that biogas production only works in a warm environment highlights its seasonal applicability.
The wood-burning stove was chosen for a similar purpose; in winter it can be used for heating, cooking, baking, preserving, and drying food. Several manual adjustments could be used to substitute the water heater which is located in the storage space and is run with electricity.
Due to my use of homemade toothpaste and washing liquid, which contained microorganisms, the grey water was safe to use for watering the garden. A short test period, however, resulted in strangely shaped leaves in the garden, and so the grey water is now disposed of in the local sewage system. This is located underground, and belongs to the main house on the property where Petersilie is placed. However, in the future the grey water could be dealt with using a slow sand filter, a waste-water treatment area on the roof, or a pond, which could work as a water reservoir. In an off-grid situation, rain- or pondwater could be filtered of debris and used in the house through the use of an additional filter.
I share my home with worms\textsuperscript{23} and microorganisms\textsuperscript{24,25}, which help me to wash the dishes and eat my leftovers.
As there is a dry toilet there is no black water; instead, human waste is composted\textsuperscript{26,27} and after two years used to fertilise trees, for example.
In the future, the vermicompost for food scraps and so on will be integrated into vegetable patches using the keyhole principle. In this way, there is no need to turn and move compost from one place to another, for example from the compost area to the vegetable patch. Instead, the microorganisms and nutrients improve the soil in the place in which they are broken down and needed. By watering the compost, nutrients are washed into the vegetable patch and there is no need to disturb the plants’ microbiome through digging, for example.
There is no fridge to disturb the silence of the house; instead, there is a Zeti Pot, consisting of two ceramic bowls with wet sand between. Here, evaporational cooling decreases the temperature inside the container.
Petersilie provides a rather small living space in relation to normal homes, but five areas for living: outside, the Greenhouse, inside, the lofts, and the roof. Therefore, and due to the open framework, living with her is very diverse, and merges inside and outside expressions and experiences.
Tatami mats insulate the floor in winter and provide a comfortable place to sit or exercise. In the sleeping loft they are used as the foundation for a thin mattress, which can easily be moved downstairs for guests or on a hot summer night, when it is too warm in the loft.
Deep-set large windows provide a view of the outside, even the areas close to the house.

Scandinavian windows generally open towards the outside, and so no windowsill tidying is necessary.
In winter, I spent hours observing the changing light, snowflakes, and three rabbits.
Since childhood, I have loved hiding under a warm blanket and inhaling and feeling the fresh wind from outside caressing my face.
To her north, Petersilie is protected by birch trees. Just before spring each year, they share some of their sugary water with me.
The Greenhouse faces the south in order to get as much light and warmth as possible. In summer, a huge maple tree provides midday shade.
Since I wrote the licentiate thesis, I am even more allergic to sitting. The only way I can handle the process is to change positions and places frequently. Petersilie was designed to support this.

While sitting or standing on a ladder I can observe a small family of birds that have their house directly in front of my window.
When sitting or standing on a ladder, I can observe a small family of birds that have built their house directly in front of my window.
One day, a lacewing visited the roof, and from here I can observe deer without them seeing me. In the grass I can meet the rabbits on their way to their favourite spot for the early evening.
Learning about wild herbs made me realise that our entire lawn is edible. I drink it in each morning, and it tastes different every day.
Sleeping outside, spending time observing, and enjoying chance encounters continuously opens new horizons,
and one never knows who is coming by.
This year, 11.7-hectare forest will be cut down close to our home.
A lot of it has been cleared already, leaving behind a desert of destruction.

My former housemate, the biologist, said that even with reforestation the ground will release CO2 for 30 years, until the planted forest has found its balance again.
I believe in alternatives to current monocultural agroforestry and clear-cutting.
A friend recently asked me whether my living experiment has an expiry date, but I see it as a continuous journey.

My next goal is to create a little research community with humans and animals, and a piece of forest to live with and work for.
MULTISPECIES COHABITATION
In autumn, after a couple of cold days, I entered the Greenhouse to pick some samples for a workshop and noticed some flies. They looked like ants, with transparent wings exceeding their green and brown bodies. The little creatures were sitting on the textiles, hiding in the folds. It turned out that they were present in their hundreds, hiding from the cold. My housemate saw some on the bathroom window, too, desperate to enter the warm house. As I didn’t have the time to deal with the mass or the mess or the crowd, and didn’t know how to anyway, I decided to shake the samples off and freeze them later in order to kill any eggs.
When I worriedly told my mom about the unwelcome invaders she identified them as lacewing flies, which are beneficial insects that feed on aphids and other pests. However, it is apparently difficult to establish and maintain populations in fields of crops. But what were they doing in my house, where there are no aphids, just soil and textiles?

The lacewings occupied my mind; in my imagination, they slowly and unbeknownst to me took over my house, hiding in my underwear and jumpers, under my mattress, and elsewhere. They made me nervous as they flew in a hectic way, and produced noticeable sounds with their wings. I could hear them at night flying around above my bed when I was trying to sleep. I tried not to be angry when I saw one walking on my bedsheets, and aimed to catch them with a glass and take them out into the Greenhouse again.
I decided to face the issue head-on and learn more about them. I found a blog post where a person described being worried about lacewing flies and trying to find ways to get them through a winter. She described her attempts to feed them sugary water, and how one even followed her finger with a drop on it. I also found instructions for building a house for them. I decided to rethink my relationship with the little critters; I felt bad because I disturbed their sleep when I was cleaning the Greenhouse. I didn’t kill them consciously, but stepped on the ones that fell on the floor due to being half asleep through hibernation.

Now it feels like I am responsible for a mass murder.

While the lady in the blog post worried about one of them, I unconsciously killed maybe one hundred. I also found that nature conservationists encourage us to care for them. Apparently they need a cold but frost-free environment in which to hibernate. When they get too warm, they wake up and starve. Their larvae feed on aphids, but the adults feed on aphid urine. Thus, I concluded, there was no way the lacewings enjoyed hanging out in my bed and mating. They just came to find a cozy place to sleep—and how did I greet them?
While writing the paragraph on lacewings, I saw one of them sitting in the lampshade on my desk. I used a brush to offer her some honey water, but she sat still in the warm light of the energy-saving light bulb. Suddenly, the lacewing turned towards the sweet drop, but I did not see her drink.

I wondered what was going on in her mind.

About ten minutes later one of the drops disappeared and I saw her mandibles moving. I offered her another drop and she slowly turned towards it, antennae moving almost in the same rhythm as the electronic music I was listening to. I watched her clean her antennae, and waited for a reaction to the red and orange post-it notes I placed next to her, wondering whether it’s true that lacewings like the colour red.
Lacewings and Textiles

Green lacewings are members of the large insect family Chrysopidae, within the Neuroptera order to which brown lacewings also belong. The term ‘Neuroptera’ refers to net-like wings consisting of a complex arrangement of veins, which create a lacy appearance. Lacewings have four of these. In most species the adults are green, but some are black, brown, or reddish. They have large, golden eyes, and some parts of their bodies are filled with a symbiotic yeast that provides essential nutrients that they are not able to obtain through their diet. Adults of some species emit foul-smelling odours in order to defend themselves. Their eggs are usually laid on the underside of leaves, often hung on a thread-like stalk near to populations of aphids. The stalks may bear oily droplets that contain substances that provide nutrients or some form of defence to the egg or newly hatched larvae. Lacewings enter diapause and undergo dormancy when faced with unfavourable conditions, which causes a change in the colour of adults to reflect the dominant colour of the season. They also change habitat seasonally, searching for a cold but frost-free environment in the winter, for example. Lacewings react to the length of the day and night, temperature, moisture, and food in order to time their dormancy.32

The green and brown insects that were found in the Greenhouse and the folds of the woven fabrics are generally identified as and thus referred to simply as lacewings. The larvae are highly predatory, and very effective against soft-bodied pests such as aphids, leafhopper nymphs, and spider mites, which they kill. During their larval stage, they are able to kill a high number of these, which is why they are used in agricultural and horticultural contexts to fight pests. Some species that have advantageous characteristics are mass-reared and then released for this purpose. The adults of these species can be stored for long periods, do not require prey, and reproduce when fed artificial diets. As Tauber et al. state, however, lacewings have much greater potential in biological pest management than is currently being utilised.33,34 The larvae usually spin a silk cocoon roughly the size of a pearl; after two weeks of feeding and another two weeks, they transform into adults, at which time both their appearance and behaviour change. The adults usually feed on nectar, pollen, and honeydew. Lacewings have mandibles and antennae.35,36. Their large compound eyes are located on the sides of their heads, and they communicate by creating vibrations with their abdomen, which touch the surfaces they are resting on (usually a leaf). In order to perceive these low-frequency, substrate-borne sounds, they have scolopidial organs in their legs. They can also hear the ultrasonic signals of insectivorous bats. Lacewings are not the best flyers, but can move considerable distances with the help of the wind. The adults of many lacewing species are active at twilight and night, and prefer the colour red; as a result, NABU painted a nesting aid red.31

The critters can be attracted by planting sunflowers, dandelion, German chamomile, dill, angelica, and calendula, for example.
Lacewings are similar to textiles in a number of ways: Their wings are transparent and have a lace-like net, their eggs hang on a thread-like stalk, and their larvae spin themselves into a cocoon. Consequently, the expressions of lacewings could alter the expression of a textile in a temporary or long-term way by adding biological materials to it. The textile could contain plants, which are beneficial for many insects, and so attract lacewings and keep the environment pest-free. There is also the possibility that textiles could be used as an environment for egg placement.

"With respect to oviposition by two species of the brown lacewing genus Sympherobius, the frayed fringe of a coarsely woven cloth stimulated copious egg laying in culture.”^38 This evokes several ideas and considerations with regard to designing textiles with and for lacewings. As lacewings are beneficial insects, could textiles accommodate them during winter? How could textiles attract them using specific patterns and surface expressions? How could textiles provide them with food during warm periods in winter, when they may wake up too early and die from hunger? How can textiles create an ecosystem that supports a stable population of lacewings in a greenhouse environment, for example, in order to prevent insect pests? How can textiles mediate the spaces used by people and lacewings?

In order to address these ideas, the preferences and behaviours of these insects have to be included in the textile design process, and so the textile design practice has to be open to a perspective that includes another species as one of the main users. The textile has to create a beneficial microclimate that fits the life cycle of the critters, preferably covering the different stages of their development – egg, larvae, and adult – as well as their behaviour and environment.

As lacewings communicate using vibrations, these must spread through the textile just as they do through a leaf. With this specification, textiles may even possess advantages, as their surface area generally far exceeds that of a leaf. As the eggs are placed in close proximity to their potential prey, such as aphids, the textile has to be placed close to plants that could be or are infested. The larvae usually walk around aimlessly unless they find their prey. The further the larvae can move during that two-week period, the more effective the textile is as a biological pest agent. Considering this and the change in habitat depending on the season, the textile collection for lacewings and people could be made as a set, consisting of a textile with a range of folds in which the lacewings can hibernate and that is a cold but frost-free environment, and a textile information sign to draw their attention to potentially aphid-infested areas.
The concept of insects living in close proximity to humans poses several challenges. As is illustrated in the diary excerpts, the number of hibernating lacewings in the corners of the Greenhouse was in the hundreds. Rearranging or even using the space became complicated as the lacewings were sleeping and thus not very responsive, which led to population losses. Consequently, I concluded that they needed an environment in which they could live undisturbed. Some of the lacewings managed to get into the house and were found on the ceiling and windows and in some of the corners. During the day they were barely noticeable and didn’t move, but during the evenings and at night they were attracted to the lights and flew around in a moth-like, unpredictable manner, creating noise through the movements of their wings. Such an intimate connection can easily disturb the relationship between people and lacewings or other insects.

How the textile, which is hosting them, is placed is therefore an important factor. The textile needs to not only communicate its potential to the insects and to humans, but mediate between the two so as to ensure that the needs of both are met. Furthermore, the example illustrates that knowledge of the insects is a major factor in creating empathy, showing respect for, and caring about the critters. Prejudices and fears, aided by inadequate knowledge, can lead to negative reactions from human inhabitants.
Pursuit of a Caterpillar

One sunny afternoon in August I saw a huge caterpillar, orange and about ten centimetres long. He crept very purposefully up my grey and white curtain. I moved the ladder and followed, observing him for a while. Once he had reached the top he crawled back down the other side, and so I followed him to greet him again at the bottom. Obviously, he did not find what he was looking for and had to continue his search.
Back in front of the computer, I found out red goat moth caterpillars live in and feed from trees for up to four years, and in that time can do a good amount of damage. They also smell of vinegar, and this allows infected plants to be identified. I decided to have a sniff around.

I think about the dedication with which the caterpillar climbed up my curtain. What was he looking for? The grey and white striped pattern of the curtain makes me think that, as my house is surrounded by birch trees, maybe the caterpillar thought he was climbing one! Too bad no bird found the orange and black critter in this exposed position. The Romans apparently ate red goat moth caterpillars, but as a vegan I would prefer to give my winged friends priority.
I wish I could invite bees, butterflies, and bumblebees into my home for a drink and some work on the tomato, and strawberry plants. Then I wouldn’t have to take them outside to meet their pollinators and do it myself, brushing flower after flower after flower...

My relationship with flowers is not half as romantic as that which some bees have with them. If they are big enough, bees can sleep there, holding each other’s legs when the flower closes at night and so sleeping in a colourful, safe, and cosy bedroom.  

If it is possible to attract critters with textile patterns, I wonder why we are so poor at using them. Instead of wondering why butterflies and bees follow us when we are wearing colourful dresses, simply trying to have a drink, we could finally learn about graphic design for insects in order to help them where they can find a rest, a nest, and the next seat at the insect bar.
Red Goat Moth Caterpillars and Textiles

The caterpillar was identified as a red goat moth caterpillar. After mating, adult females lay their eggs individually or in small groups in cracks in the bark of temperate deciduous forest trees. They usually prefer weakened or already dead trees. After they have hatched, the caterpillars eat and live in the bark of the trees until they have shed their skin several times. Later, they penetrate deeper into the wood, which they bore holes in when making pathways. These have an oval cross-section and are up to two centimetres wide. The caterpillars can measure up to ten centimetres in length, and have a red and purple stripe across their back and black heads. Trees can die as a result of the feeding, particularly with an infestation of multiple caterpillars. Older caterpillars smell strongly of vinegar, which can be noticed in the area around the infected plant as well. This ‘goaty’ smell is where the name comes from. After two to four weeks, their development is complete. Pupation occurs in different ways: Either the caterpillar leaves the tree during the autumn and digs itself into the ground and pupates after hibernation, or it hibernates in the tree and buries itself in the earth after hibernation. At the end of their feeding period, they can also pupate in the wood of a tree in a cocoon that is about six centimetres long, and made of caterpillar threads and gnawed wood. Supposedly, the Romans reared them on a diet of flour in order to eat them as a delicacy\(^{40}\). The moth is active at night, and flies from the end of May to the beginning of August. In 1762, Lyonet noted that the larvae contains three times as many anatomically different skeletal muscles as humans\(^{42}\).

As there are birch trees with grey and white bark in close proximity to the curtain that the goat moth caterpillar climbed, it may be that it was attracted by the grey and white pattern of the fabric. The red goat moth caterpillar is a pest, however, and can intensively damage trees by both eating their bark and infecting them with a fungus that the critter lives in symbiosis with in order to degrade and so digest the wood more easily. Fighting them is not easy as the caterpillars are very defensive and their bite is quite painful, which is why they are of interest primarily to larger birds, such as magpies, rather than smaller ones. However, they are usually not easy to catch. Consequently, a textile curtain that attracts them but on which they are exposed to predators might be an interesting design concept: The textile design would have to possess certain characteristics that the caterpillars and female moths are attracted to in order for the moths to lay their eggs on the fabric rather than a tree. This could be achieved through the surface expression and odour, for example, or perhaps even by providing shelter and food. In this way, the caterpillars could be harvested by birds or people and provide a nutritious meal. Consequently, the textile could be an agent of pest control, mediating between pest and predator.
The Mousemate

While cleaning the Greenhouse I met my secret mousemate. I saw her running, hiding behind something. I felt happy to have a housemate, but was not used to a fast-moving mouse in close proximity. I guess she felt the same. I talked to her to make myself and her more comfortable. While carefully continuing the cleaning I saw her some more, but she had left by the time I finished.
Several days later I noticed a strong smell and found some holes in the plant boxes containing soil. Plus, some of the plants had been nibbled on. I came across two of my fabrics spotted with mouse poo. One of them – a doubleweave with thick strands of carded wool – had been used as a bedroom, I suppose, whereas the other – a single-cloth woven with a yarn filled with beans – had been torn and bitten, the beans eaten.
At first, I was sad about this invasive destruction, but also happy that the weave had been of use and appreciated by another species.

*Maybe it could even be possible to design a cloth in cooperation with a mouse.*
The cooperation came to an abrupt end when my mom wanted to clean the car when she and my dad came to visit. She was wondering about the broken watering can until she found a mouse tail sticking out of its spout. We were very sad about this tragedy.
The same day, my dad found some tracks in the snow and I had a sleepless night. A loud, rhythmic noise kept me awake. After a while spent wondering, I concluded that there was another mouse trying to access my seed collection, which was in a plastic container. The acoustics of the Greenhouse and the box amplified the sound in a way that meant that the mouse filled the entire house with its nocturnal attempt. I never saw her.

Several days went by while I thought about how to deal with this situation. I imagined a large family of mice falling on my head while I was trying to find their nest in order to relocate them. Maybe they felt my stress and the approaching danger; I never saw or heard them again.
Sometimes I think about inviting them to spend the next winter in newly designed mouse homes so as to test what they like best – wool or jute, vertical or horizontal space, suspended or partially underground...

Would they eat their home if it was edible? Would they consume everything, or just nibble some holes to use as doors or windows?
Textiles and Animals

Mice are known to invade homes in order to find food and shelter, particularly as winter approaches. They are small rodents that reproduce quickly and have a pointed snout, small rounded ears, and a long tail. The house mouse is the best-known species, and is also a popular pet.

The mice that were populating the Greenhouse were attracted by the many places they could hide and build their homes, as well as by the seeds and plants that they found in the environment. They were especially attracted by two textile pieces; one was used as a shelter and one was eaten, presumably because of the integrated beans. With the approaching winter, the temperature in the Greenhouse often dropped below zero, and so the mice were looking for a warm shelter when moving in. The piece of cloth was placed upright to form a vertical tunnel, the edges (which were also selvedges) covering the interior with a thick woollen frame. To enter, parts of the cotton and paper warp yarns were bitten to create a hole. The other hand weave, in which beans in a hollow yarn were woven into a plain weave with a relatively harmonious expression due to the even distribution of the beans, was partially eaten. Over time, the beans were removed from the structure, which was found lying folded on a shelf. The underside had also been accessed via a hole created in the woven structure. Before all of the beans had been eaten, the cloth was removed from the shelf and stored out of the reach of mice in order to ensure that it was possible to document how it had changed.

Initially, both textiles were woven to accommodate plants, with two different strategies being used to insert seeds. The beans were introduced using a tube, then woven as a weft. The woolen structure contained grass seeds, which were spread on the carded wool while weaving. The sharp and thin seeds entangled in the fibrous wool, and so became entangled in the weave.

This experience triggered a range of thoughts relating to how to react when other species live in the immediate vicinity, and how to make use of the benefits that our surroundings offer. Living with mice and lacewings was a challenging but interesting experience which might recur in the coming winter. Until then, there is time to think about how a temporary cohabitation could be better planned for both sides, such as by building a lacewing-home. The experience pushed me to reflect on my house and how it could be customised to accommodate not only myself but plants and certain wildlife, and to do so by acknowledging the privacy of all involved and thinking about which textiles could be useful and how to design, fabricate and arrange them.
Living in the Bollebygd forest for one year has very much changed my view of the world. I am no longer able to stand big cities, spend a long time in closed rooms, and not feel personally offended if I have no access to fresh air because the air conditioning of a building has taken the reins. Moreover, I realised the beauty of staying in one place and not travelling and commuting so much. Despite creating a Tiny House on Wheels due to my nomadic lifestyle, my heart yearns for a place with a long-term perspective. I want to connect with my home and its surrounding and try to imagine what the Swedish forest would look like if people had not cut it down for timber; I want to make it an edible forest, as the indigenous people did with the Amazon Rainforest for over 4000 years. I also wonder what textile design for insects could be like, and what adventures living with Petersilie will provide in the future.
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