On Textile Farming:
Seeds as material for textile design

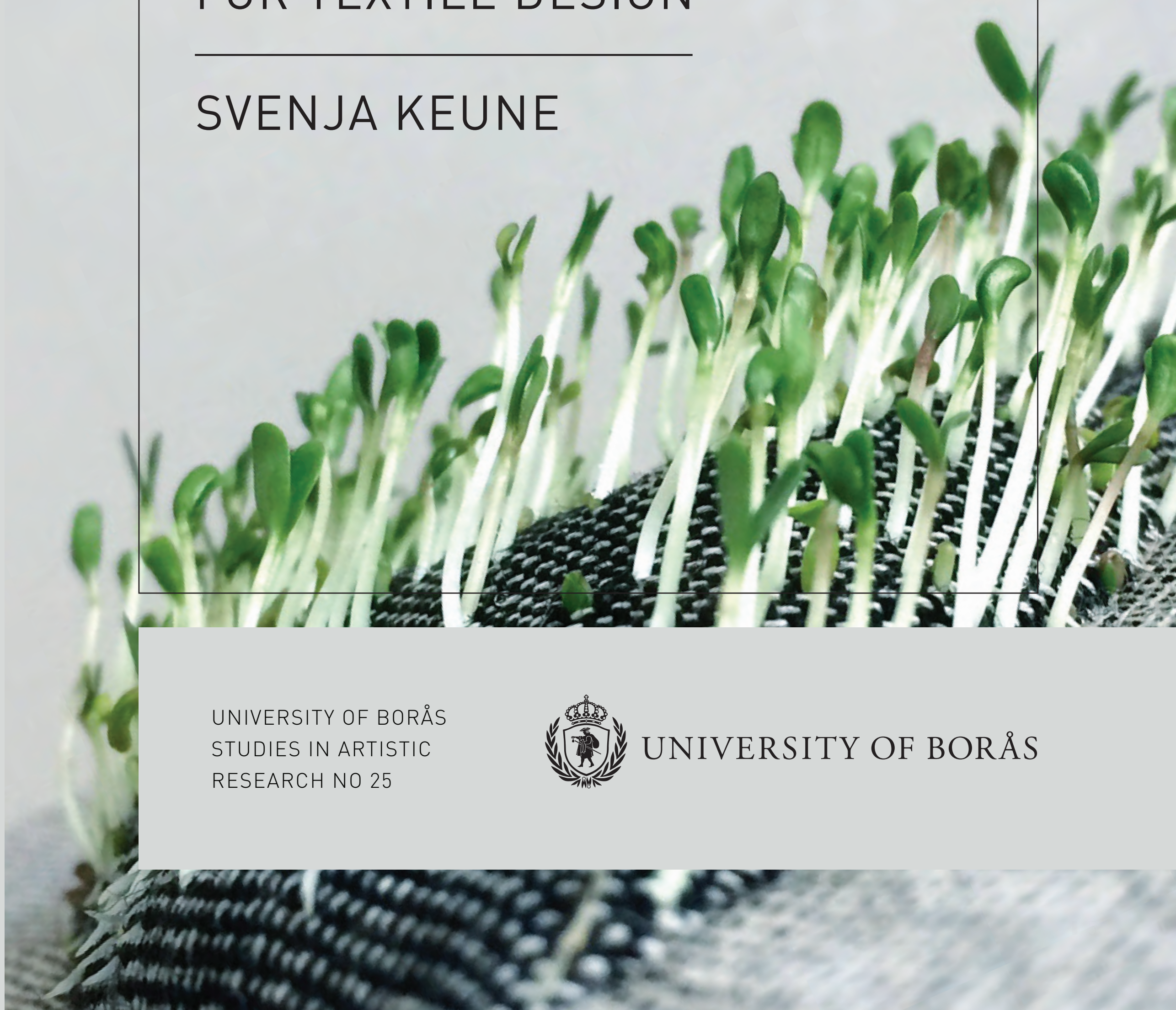
Presently, designing with living systems such as insects, fungi and bacteria has become an area of extended interest, proposing collaborative processes of designing and manufacturing - as a solution for symbiotic ways of living. On the scale of the interior, modern systems for interior gardening, combining both functional, e.g., food supply, purifying the air, and aesthetic values, experience exceptional popularity, ensuring a complementary perspective on horticultural landscapes indoors. As a result, the spaces where people live and crops grow increasingly intersect and therefore open up for developments that bridge both areas and where aesthetic perspectives become equally important. However, modern indoor gardening systems are shaped by commercial horticultural practices, bringing reservoirs such as buckets, tubs or tanks, mostly built of plastic, into the homes. Textile Farming aims to explore alternative forms of plant organisation by blending seeds and textile structures into a hybrid material for textile interior scenarios. Consequently the materials' performative capacity becomes part of the textile design process. A foundational part are forms of human management, e.g. activation of the seeds, maintenance of the plants, interaction with the hybrid textile structures within and beyond interiors, that leads to experiences and expressions. By practice based design research and through a series of design examples that explore the transformative potential of seeds in textile structures, alternative forms of plant organisation and methods for the textile design process lead to scenarios that propose alternatives to how we live with and organise plants today.

THE SWEDISH SCHOOL
OF TEXTILES
UNIVERSITY OF BORÅS

ON TEXTILE FARMING

SEEDS AS MATERIAL FOR TEXTILE DESIGN

SVENJA KEUNE



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ABSTRACT

On Textile Farming: Seeds as Material for Textile Design

Designing with living systems such as insects, fungi, and bacteria has become an area of strong interest, proposing collaborative processes for designing and manufacturing in order to facilitate symbiotic ways of living. In the interior, modern systems for interior gardening that combine both functional – e.g. food supply, air purification – and aesthetic values are currently experiencing exceptional popularity, bringing about complementary perspectives on horticultural landscapes indoors. As a result, the spaces in which people live and crops grow are increasingly intersecting, opening up for developments that bridge both areas and where aesthetic perspectives become of increasing importance to practical ones. However, modern indoor gardening systems are shaped by commercial horticultural practices, involving generally plastic reservoirs such as buckets, tubs, and tanks. *On Textile Farming* as an ongoing research programme, explores alternative forms of plant organisation by blending seeds and textile structures to create hybrid materials for use in interior scenarios. Consequently, the performative capacity of materials becomes part of the textile design process. A foundational aspect of this approach is forms of human management, e.g. activation of seeds, maintenance of plants, and interactions with hybrid textile structures within and beyond interiors that lead to alternative experiences and expressions to common ones. Through practice-based design research and a series of design examples that explore the transformative potential of seeds in textile structures, alternative forms of plant organisation and textile design methods have led to the production of scenarios that explore how we live with and organise plants. The results consist of design examples that feature static and dynamic expressions indoors, focusing on combining interior and exterior spaces by facilitating growth, wilderness, and decay in textile structures. Thus, the seeds enable alternative life cycles for interior textiles. These perspectives are discussed in an industrial context as the project was conducted in collaboration with AB Ludvig Svensson, a Swedish textile company that specialises in interior textiles and climate screens. The project thus contributes to the development of biophilic design and stimulates discussion of the human/nature dichotomy and perspectives on interior design. Textile interiors that grow, degrade, and can be harvested, eaten, planted, and reactivated challenge our understanding of materials and architecture, and invite us to rethink our aesthetic and cultural bias towards change in domestic spaces by exploring natural processes indoors. As these forms of interaction and conditions redefine behaviour and prevailing states indoors, the present current definition of 'the interior' is challenged and opened up for discussion.

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CONTENTS

INTRODUCTION

Structure of the Thesis

The underlying framework of this thesis is the ArcInTex European Training Network (ETN), which aims to strengthen the foundations of design through experimental research that, connects architecture, interaction design, and textiles and develop perspectives for more sustainable forms of living (ArcInTex ETN, 2017). *On Textile Farming* as a design research programme proposes alternative ways for people and plants to cohabit in spaces in which forms of living and growing intersect. The programme functions as a foundation for investigating seeds as dynamic materials, as they are alive, active, adaptive, responsive, sensitive to their environment, and able to transform, and can thus be used as smart materials in textile design.
In order to reconnect interior environments and natural habitats through the everyday presence of and interaction with plants, the interior, textile-based landscape is used as a supporting medium for seeds in order to propose alternative aesthetics and contribute to more sustainable forms of habitation.

On Textile Farming is embedded in the ArcInTex ETN work package context of 'Textile thinking for adaptive and responsive interior design – the scale of the interior', which has the aim of addressing 'Textile structures for adaptive and responsive interiors (textile design)'. This has been undertaken in an industrial context at Svensson AB, a company that develops and produces interior and functional textiles such as climate screens.

This thesis presents the research programme by first providing a general overview of the project's conditions and assignments. The 'Introduction' chapter discusses the research area with a particular focus on the current shift in interest in the artistic fields away from computational design and smart materials and towards bio-materials and design that can be considered to constitute or involve biological paradigms (cf. Collet & Foissac, 2015). The underlying framework for the practice-based PhD work, conducted in collaboration with Svensson AB, is described in the 'Formal Project Conditions' chapter, which precedes 'Rethinking Nature – Towards a Biological Revolution On the Scale of the Interior', in which different design perspectives involving sustainable design practices are discussed and compared in relation to the field that this project is intended to contribute to. Recent bio-technological breakthroughs have triggered a shift, wherein the advantages of biological systems and bio-materiality within science (Stamets, 2005; Trewavas, 2005), technology (Chieza & Ward, 2015), art and design (Kretzer, 2017; Myers & Antonelli, 2014), and philosophy (Marris, 2013; Ryan, Vieira, & Gagliano, 2015; Morton, 2012; Clément, Rahm, & Borasi, 2007) are increasingly being acknowledged. This

STRUCTURE OF THE THESIS

development opens up for alternative forms of hybrid interiors, which in this context are developed with a focus on design. The 'Bridging Interior Textiles and Climate Screens at Svensson AB' chapter describes the interactions between the academic and industrial aspects of the research project, and is intended to provide a conceptual framework that contributes to current thinking regarding the paradigm shift towards bio-materials and design, through an artistic and practice-based research programme. The 'Hybrid Environments' chapter provides an overview of related art, design, and research works that exemplify these perspectives. The research programme *On Textile Farming* forms a foundation for conducting research, and proposes alternative aesthetics of and interactions with interior landscaping that features plants by exploring two major areas:

I Textile expressions, using seeds as dynamic materials for textile design
II Forms of indoor gardening through textile design materials

The programmatic approach and research through art and design methodology are described to provide an overview of the contextual frame, research methodology in an industrial context, and collaboration with Svensson AB. The 'Results' chapter describes how *On Textile Farming* contributes to knowledge within the textile design field and presents methods and variables for designing with seeds, a concept for extending the life cycle of hybrid textile structures, and a model which introduces biophilic design into the field of interior design as a means of designing interactions between humans, plants, and textiles. The examples are presented according to the methods described in the 'Results' chapter and categorised into two series. Series I investigates seeds as dynamic materials for textile design and categorises the examples into dynamic materials, surfaces, and shapes. Series II explores the possibility of using striped and circular patterns in pocket-weave as a means of organising plants. The investigations [that resulted in the examples] were conducted in collaboration with Svensson AB and further developed into interior scenarios. The interior scenarios opened up for reflection on the experimental work in relation to the contextual framework and aims and objectives of the programme, as well as the ways in which people and plants can cohabit in interiors and beyond. The 'Discussion' chapter describes how the research will be further explored and which perspectives will be used in relation to this.

FORMAL PROJECT CONDITIONS

The ArcInTexETN

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. 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 the 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), the Berlin University of the Arts (DE), University of Borås (SE), and the companies Philips (NL) and Svensson AB (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, 2017).

This is the first time that Svensson AB has hosted an artistic researcher at their premises, providing the foundations for investigating the influence of corporate environments, academia, and industry in an exploratory fashion. Within the company itself there are two departments; one designs and develops interior textiles for the public sector, while the other develops functional textiles, e.g. climate screens, for the horticultural sector (Svensson AB, 2017). This intersection of perspectives led to the development of *On Textile Farming*.

RETHINKING NATURE

Towards a Biological Revolution on the Scale of the Interior

Recent scientific (biotechnological) breakthroughs, such as the discovery of inter-plant communication through mycorrhizal networks (Simard et al., 2012), developments in Genetically Modified Organisms (Phillips, 2008), and the more general environmental crisis of the present, have triggered a shift wherein the advantages of biological systems and bio-materiality within science (Stamets, 2005; Trewavas, 2005), technology (Chieza & Ward, 2015), art (Myers, 2015), design (Kretzer, 2017; Myers & Antonelli, 2014), philosophy (Marris, 2013; Ryan, Vieira, & Gagliano, 2015; Morton, 2012; Clément, Rahm, & Borasi, 2007), and industry (Ecovative, 2017; Hebel & Heisel, 2015) are acknowledged. In the design field, those practices that are inspired by natural processes and aesthetics undergo rapid and diverse development. The following chapters provide an overview of environmentally sustainable design philosophies, research, and works in art and design with an environmental focus that propose shifts in how we perceive, live with, and define nature as part of the interior. The application of these philosophies and principles to the field of textile design and production allows a fundamental change in common practices to take place, and offers the possibility of completely overhauling how and why interior textiles are designed and manufactured and how they perform and interact in the context of their applications. Thus, they open up a design space, allowing how we define, perceive, design, interact, and live with nature to become part of the interior practice.

Nature as Example

The concept of 'sustainable design' (or 'design for sustainability') is frequently used today, and has its origins in the field of ecodesign. It is a complex notion that considers both environmental aspects and the social and economic implications of design (Montana-Hoyos & Fiorentino, 2016), and is intended to "eliminate negative environmental impact completely through skilful, sensitive design" (McLennan, 2004). Biomimetics (or biomimicry) imitates natural models, systems, or elements to solve complex problems. 'Cradle-to-cradle' (or regenerative design) is a biomimetic approach to designing products and systems that focuses on a holistic and economic model through a safe, productive, and circular metabolic system that utilises organic and technical components/nutrients (McDonough & Braungart, 2002).

'Design for Disassembly' is a 'closed loop' concept and technical metabolism, and is similar to cradle-to-cradle in that both are analogous to natural biological metabolisms, wherein waste holds nutrient value, and both consider the process of deconstruction during the design phase. Desai and Mital describe Design for Disassembly as an organised way of taking apart a product that has been systematically assembled in order to address e.g. end-of-life objectives, such as reuse, remanufacture, and recycling (2003). The concept – along with other sustainable design strategies – is currently a focus of research in fashion and textiles, and is being applied by businesses to change the ways in which textiles are produced (Rissanen & McQuillan, 2015), add value to waste (Schmidttakahashi, 2017), and produce products that are biodegradable (Freitag, 2017; Moulds, 2015). However, designing a product's entire life cycle is not yet a common practice, and usually not considered during design processes. Jensen and Sommer state that "[w]e must rethink the way we build and design into a scalable, value-driven practice of the resource economy", proposing in Building a Circular Future a process consisting of three components: Design for Disassembly, a material passport, and a description of how individual parts can be recycled and returned to the circular economy. They state that the circular economy should be embraced, and that doing so will bring forth alternative business strategies that will allow architectural structures to be dismantled without significant harm and or loss of resources (2016).

Within the built environment, alternative concepts for living that attempt to reconnect humans and nature, such as hybrid housing and urban gardening, are highly popular. Here, where dwellings and spaces for local food production intersect, self-sufficiency as a means of counteracting the detrimental effects of rising prices, along with the more global food challenge, is promoted (Doron, 2005; Viljoen et al., 2005). Urban agriculture has a variety of positive effects, increasing the availability of healthy and nutritious food (Blaine, Grewal, Dawes, & Snider, 2010; Duchemin, Wegmuller, & Legault, 2008; Minnich, 1983) and reducing human impact on the environment (Doron, 2005; Flores, 2006; Halweil, 2005; Howard, 2006). Despommier proposes "vertical farming", wherein crops are grown in specially constructed buildings using hydroponic and aeroponic farming methods. The advantages of this approach are season- and weather-independent food production, and thus more reliable food supplies. Such vertical farms can be designed as parts of a closed-loop system to include water recovery and waste-to-energy conversion. Moreover, as the horizontal space of cities is often limited, vertical farming can contribute to more resilient and sustainable cities through local food production (Despommier 2011a; 2011b; 2013). In addition to these functional aspects, such systems and services also satisfy the urge to experience nature in an embodied form, as is currently expressed through e.g. gardening and creative physical work (Louv, 2010). The fact that modern society offers relatively few opportunities for daily contact with nature is part of the legacy of the Industrial Revolution, and our fascination with and longing for nature is a response to new research discoveries which push us to rethink our relationship with vegetation and urban living (Ryan, Vieira, & Gagliano, 2015). As a result, alternative products and environments are constantly being developed within the fields of interior and product design. Most of these fall within the scope of indoor gardening, are derived from horticultural practices (e.g. aquaponics and hydroponics), and are 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 (Marder, 2012; Ryan et al., 2015), and used (Scherer, 2016; Ludwig et al., 2012).

Rethinking nature

According to the Collins dictionary´s definition, "Nature is all the animals, plants, and other things in the world that are not made by people, and all the events and processes that are not caused by people" (Collins English Dictionary, 2018). Marris, among others, questions our understanding and definition of nature, claiming that the notion of preserving a pre-human state of nature is an outdated dream that prevents us from having a fuller relationship with it (Washington, 2015). Marris argues, quite convincingly, that it is time to look forward, to create a "rambunctious garden"; a hybrid of wild nature and human management (2013). She also refers to what Gilles Clément describes as the "landscape of the third kind" (Clément, Rahm, & Borasi, 2007), asserting the importance these places to being regarded as natural and thus highlighting the need for a new definition and perception of nature. Clément, an influential landscape architect, ecologist, botanist, entomologist, and – above all – gardener, is well known as an environmental thinker. The "landscape of the third kind" describes the 'spaces in between' – the fallow land that is left to itself, forgotten, or lies between nature reserves and mono-culture fields. It is a refuge of biodiversity, where domestic and wild species meet and the regenerative force of nature is expressed. Clément understands the role of a gardener as one who guides and enriches in sympathy with natural processes, and is of the opinion that a reserved approach leads to stagnation. The inseparability of humanity and the natural world, which he is promoting, is the main principle of humanist ecology (Ibid).

Kellert describes the current environmental crisis as a "design failure" and "avoidable aspect of modern life", and in Building for Life – Designing and Understanding the Human-Nature Connection refers to a dilemma: On the one hand, the success of the modern world depends on controlling and converting nature; on the other, human health and well-being depends on healthy and diverse natural systems (Kellert, 2012). Morton, however, argues that nature itself is a modern concept that separates and does not assist in understanding and taking action to prevent further damage to ecological systems. He protests against "rigid ideological categories" such as those of human/animal, culture/nature, etc. Morton introduces a "mesh" with which to understand the "inter-connectedness" of existence (2012), referencing Ingold's "meshwork" (2011), wherein the interpretations or meeting points are "knots" (2015). This concept is extended through his term "correspondence" to describe the nature of these connections (Ingold, 2016).

Forms of nature that are envisioned as being threatening to inhabitants, material formations, or ideas that constitute nature, and that appear and are created by built environments, are discussed by Gissen. So too is "subnature", which he understands to be crucial in contemporary debates regarding architecture, urbanism, and nature: "Subnature is not about what is natural to architecture; it is about the natures we produce through our most radical architectural concepts." In contrast to desirable forms of nature, subnature is often identified as lesser; as primitive (mud, dankness), filthy (smoke, dust, exhaust fumes), fearsome (gas, debris), or uncontrollable (weeds, insects, pigeons). This type of nature, Gissen declares, is under-theorised, -discussed, and -visualised in architecture, but could "advance a seemingly neo-Victorian and neo-Haussmannite vision of urbanism in many global cities" (Gissen, 2009).

Additionally, in the interest of minimising the impact of the activities of modern humanity on the environment, it is essential to establish sufficient and satisfying relationships between the two. Two concepts that are of particular relevance here are based on the relationship between humanity and the natural world: restorative environmental design and biophilic design. Whereas the former seeks to repair this relationship, the latter intends to generate positive experiences of natural and built environments (Dias, 2015). Wilson describes biophilia as "the innately emotional affiliation of human beings to other living organisms" (Wilson, 1984), while Beatley and Newman call for a broader adoption of biophilic design on urban scales and biophilic urbanism in order to create more sustainable and resilient – i.e. biophilic – cities (Beatley & Newman, 2013). Biophilic urbanism addresses the environmental and, economic (and emotional) challenges of living in cities today, and therefore promotes contact with nature and the natural world as a fundamental approach to better deal with them (Beatley, 2017).

Biological Revolution

Hebel and Heisel predict a radical paradigm shift in how building materials are produced, concluding that there will be a ´fourth industrial revolution`; a shift towards regenerative (agrarian) sources of materials that need to be cultivated, bred, farmed, and grown (Hebel & Heisel, 2017). This is a response to the non-regenerative material sources that were mined during the Industrial Revolution, and is linked to the agrarian age which prevailed before that. Hebel and Heisel explore a concept for architectural design and production which is based on the use of agrarian resources in urban environments through small-scale, on-demand production. This bio-mechanised or bio-industrial production requires respect, adaptation, and the development of frameworks of regulations, norms, and standards, and so a different understanding is needed, allowing unique product processes that are similar but not identical (Ibid.). A radical shift in the form of a bio-revolution is proposed by Collet, who assumes that developments in synthetic biology will change how we conceive, design, and produce, just as biologists are now able not only to observe, but "code and re-programme life":

"I can imagine in another few decades having access to a design platform that produces the associated sequence of biological blocks and digital code whilst I design the perfect hybrid plant that will produce metres of fabrics through its roots. The colours, the strength and elasticity of the fibre as well as the aesthetic of this bio fabric will have been designed and programmed with this hypothetical new software." (Collet, 2012)

Imhof and Gruber support the notion of the "ecocene", where human actions augment and enhance the planets living ecosystems and where, one might say, correspondence is to be found where once we saw only boundaries (Imhof & Gruber, 2016). René Dubos, a nobel-prize winning biologist, suggests that humankind and nature need to retain their wildness, which in turn lead to an endless process of evolutionary creation (Kellert, 2012). Kellert states that interaction with nature is critically important for human well-being and development, but extensively diminished in every-day modern life and among increasing urbanisation. He argues that progress and civilisation will be held responsible for this development (ibid).

Hybrid Environments

Merging Nature and the Built

In The Shape of Green: Aesthetics, Ecology, and Design, Hosey criticises the so-called aesthetics of green and sustainable design: "Aesthetics are fundamental to both culture and nature, and if sustainability refers to the graceful interaction between them, it must have a sensory dimension" (2012). Biodesign, through involving biomaterials, represents a similar perspective. Collet describes biodesign in adaptive architecture as the point at which "the symbiosis of physics, biology, computing, and design promises the redefinition of what we call architecture today" (Kretzer & Hovestadt, 2014). Similarly, Mauri asks: "how far can the interrelationship between construction and spontaneous growth in nature be taken?" (Myers & Antonelli, 2014). This chapter examines design and architecture examples in which expressions of indoors and outdoors meet, and areas for living in and growing crops intersect. The first section illustrates the importance of time in an architectural context and conceptual work, raising the issue of opening architectural spaces to natural expressions such as weeds and wildlife. The second focuses on architectural solutions that bridge interior and exterior spaces; the third section examines interior environments that incorporate interior and exterior expressions and interactions, followed by robotically controlled ecosystems which provide a more speculative perspective to how organising, growing and living with plants could become like.

A Temporal Perspective on Materials and Architecture

Space and time are resources for which living organisms compete. Time, as the second key aspect of growth, is considered in a very different manner when it is thought of in relation to a structure in the field of architecture. Here, every action is concentrated on the rapid completion of construction – the end of the building process and the start of functionality. In a biological context, however, there is no defined final state, as the very principle of biology is cyclic; instead, there is the strive for maturity, the major goal of ensuring procreation (Imhof & Gruber, 2016). For the last few centuries, ideal forms of architecture have been independent of time and processes of decomposition. Decker proposes overcoming this by pursuing permanence, achieved through static construction and tough materials, and emphasises the use of performative materials, designed to be independent of time and inert with regard to external stimuli and ambient energies, in architecture

(Decker, 2016). Consequently, architects and designers might consider designing and building with "time in mind" (Franck, 2016) and embrace this fourth dimension in design processes (Decker, 2016). Cairns and Jacobs refer to the "life" of architecture, arguing that it is the responsibility of the architect to conceive and create this through the art of design. They question the relationship between architecture and death, along with processes of waste, deterioration, and destruction (2014). In relation to architectural forms of death, Stoner assigns nine afterlives to buildings, each of which is a possible beginning and without a definitive end; Abandonment, demolition, deconstruction, preservation/conservation/restoration, renovation/rehabilitation, adaptive reuse, reoccupation, pure expression, and resurrection (Stoner, 2016). Goffi also refers to lives in architecture, writing of "unfinished fabrics of time" which are coated with history and offer a basic texture for imagining futures and offering continuity and succession (Goffi, 2016). As objects that are affected by external conditions and expressed by seasons, activities, and transformative materials, architecture shows its transformative presence through time-based changes, wherein "time is local and embedded in the moment" (Taylor, 2016). Thus, form is a matter of a more flexible, complex, and diverse practice (Cache, 1995). To return to living organisms; one of the preconditions of their existence 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, 2009). In relation to matter time can be seen as a fabric that expresses past and present as well as the possibilities of the future. When considered during design processes, be they architectural or of textile structures, these fabrics can express and be designed to change faces, and go through several lives and afterlives in response to the cyclic flows of nature.

Super Galaxy: NYC Tropospheric Refuge, by Jason Johnson and Nataly Gattegno (Ibid.) is an architectural system that proposes that the upper floors of a high-rise building be open to water and urban wildlife. A robotically controlled floor influences the occurrence of puddles and wet zones, which are to be used by groups of people and migrating fowl. The entire surface shifts in response to real-time global and local datasets such as weather and pollution, and desired micro-climates, heat exchange, light, and sound (Ibid.). Super Galaxy exemplifies the concept of subnature, and not only questions our understanding of architecture as static and alien to the environment in which it exists, as well as to nature and human beings, but opens up for new forms of 'indoors' and 'outdoors' in an urban environment through the possibility of interacting with wildlife and experiencing nature within a high-rise building. Incorporating subnatures into a design process by merging areas of living and growing is an interesting perspective in relation to the research programme and is linked to time, as the fundamental variable for change in e.g. architecture and nature. In relation to this research programme, time is a fundamental material for designing and living with textile-seed hybrids. By connecting textile design processes and biological materials, the biological life cycle becomes part of the expression of materials and spaces. *On Textile Farming* consequently introduces a temporal perspective to both textile design and interior design. The temporal and biological perspectives open up for alternative expressions of materials and architecture, leading to new ways of designing spaces and, in turn, complementary approaches to blending the indoors and the outdoors blends and alternative ways of living with nature. Thus, time is a fundamental variable for change.

Nature and Architecture

When designing for environments that combine architecture and nature, expressions of the exterior enter the built environment or vice versa, bridging the indoors and the outdoors. At her studio InsideOutside, located in Amsterdam, Petra Blaisse dedicates her design practice to bridging interior and exterior, body and architecture, using textiles on different scales and nature as inspiration to reinforce the dialogue between landscape and interior. Blaisse sees textile curtains as second skins, creating fluid atmospheres that challenge the static nature of architecture and drawing inspiration from the construction of clothing and images found in natural orchestrations of texture, colour, and scent. Her approach to landscaping with textiles in the interior captures the attention of spectators from every angle and distance, and addresses not only vision but hearing. In an interview with Weinthal, Blaisse refers to the garden as an element for creating "awareness of change, climate and the influence of time, light, sound, temperature, moisture, draught, movement and decay" (Weinthal, 2008).

The Swedish architect Bengt Warne made similar observations with regard to his hybrid environments: "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." In 1974 he began developing what he called Naturhus ('nature house'), which was used as a centre for research, development, and demonstration. The living area of approximately 150 square metres is surrounded by a greenhouse, creating a space between the indoors and the outdoors that both increases the available living space and makes it easier for plants to survive during the winter through the existence of an additional microclimate (Fredriksson & Warne, 1993).

The ReGen Villages project, which was launched during the summer of 2016, takes the concept of the Nature House to a new level by proposing off-grid, integrated, resilient eco-villages in northern European countries. Due to an approach that takes "applying science into the architecture of everyday life" as its motto, nature in the ReGen Villages has a primarily functional purpose (Cooke, 2016). ReGen Labs undertakes research in resiliency and regenerative system design, taking a holistic approach to future systems of sustainable living by combining a variety of innovative technologies such as energy-positive homes, renewable energy, energy storage, door-step high-yield organic food production, vertical farming, aquaponics and aeroponics, water management, and waste-to-resource systems (Frearson, 2016). Thus the living zones represent common interior aesthetics whereas the areas where crops grow are shaped by technological developments and their aesthetics which is based on efficiency rather than physical experience between inhabitants and plants. Both projects aim to creating spaces in which people and plants have the ideal climate conditions to thrive and are able to meet under one roof. 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 interaction and symbiosis. Textiles can, however, through their adaptability and flexibility, mediate more embodied forms of interaction that not only propose alternative ways of connecting with and caring about plants, but create perspectives relating to a symbiosis on an aesthetic level. The increasing overlap of scientific and artistic research not only strengthens both areas, but also opens up for alternative practices that challenge and replace existing paradigms. As this development is currently in its infancy, however, a huge amount of further work is needed. Advanced holistic housing projects, which are often linked to research labs that aim to further develop regenerative systems through modern technologies, offer opportunities to conduct artistic research.

Plants in Interiors

Having examined architectural structures, the focus of this chapter now turns to interiors and contemporary solutions for indoor gardening, as well as bridging the spaces of humans and plants by creating different forms of interaction – here summarised as 'human management'. Interior spaces are generally 'managed' by furniture, which Weinthal describes as "a piece of technology that lets us inhabit and be comfortable in a world we have made for ourselves". He also argues for more physical, sensual, and embodied forms of architecture that contribute to the plasticity and tactility of space (2011). With increasing interest in interior gardening, architecture retains the characteristics that Weinthal laments the absence of, and this chapter presents examples of how the coexistence of plants and humans could be redefined on the scale of the interior and how their aspects inspire this research.

Kono Designs' Urban Farm is an exemplary model of integrating natural experiences into today's indoor-based working life. The employees of the Pasona Group Headquarters plant, grow, and harvest their food within a nine-story building in the middle of Tokyo's metropolitan area, where they share space with suspended tomato vines, lemon trees, broccoli, and rice paddies (Andrews, 2013). The vegetables and fruits are grown on shelves and beds, cling to bars, cover façades and walls, hang down from ceilings, and are stored below furniture; thus they are organised, within or upon rigid structures, in specific places. The plant organisation follows common forms, in that they grow vertically on shelves or walls, are placed in automated hydroponic systems, or hang down from horizontal structures in the ceiling. Metal, plastic, straight lines, squares, boxes, and pipes are the dominant expressions. The employees are taught by professionals how to plant, take care of, and harvest the crops, and the herbs and vegetables are available in the company's restaurant. How plants can be integrated or organised by furniture was explored by Aust. The *Wohnbeet* ('living-room flowerbed') is a combination of a chair and a flowerbed and was created to link plant and living spaces and place a focus on human-plant interaction in an interior. In this way, Aust embeds digging, weeding, and dirty fingernails in the interior, and enhances ownership of a design process involving plants through the creation of a living scenario (Aust, 2010). The example illustrates a piece of furniture that functions for both plants and people, where an embodied experience is promoted. The proximity between both creates not only bodily contact, but an increased awareness and, potentially, emotional bond. Consequently, it exemplifies aspects of biophilic design on the scale of the interior. Both of the projects described here provide new perspectives on how co-existential living in interiors might look, feel, taste, and smell, and how the maintenance of plants can become a special physical and sensory experience.

Plants and Machines

Modern systems for indoor gardening often conduct the maintenance of and regulate the environmental conditions for plants autonomously, and thus combine both functional (e.g. food supply, purifying the air) and aesthetic values (see e.g. Andrews, 2013). This chapter discusses two research projects that involve an element of symbiosis between robotics and plants on the scale of the interior. In agriculture and horticulture, forms of autonomous maintenance are already an integral part of research and practice, however, the following projects present futuristic perspectives and speculative scenarios.

Plants & Machines is engaged in the development of robotic ecosystems, including hardware and software, for growing food in living spaces, and as a result received funding under Horizon 2020. The software developed monitors irrigation, ventilation, light spectra, temperature, and humidity, and controls the hardware that manages the aquaponic, hydroponic, aeroponic, and deep-water culture systems. The hardware of the company's robots serves as an easy-to-use prototyping tool and supports the DIY philosophy. The robotic indoor gardens are intended to digitally bridge the gap between humans and nature, able as they are to support the growing of food everywhere – in boxes and fridges, on balconies or rooftops – as the project's website suggests (Camilleri, 2015). *Plants & Machines* raises questions relating to soft robotics, such as 'what if robotic ecosystems were soft?' The available range of highly specialised materials, technical textiles, and soft sensors is growing steadily and already in use in many industries, including healthcare, clothing, and automotive. In the agricultural and horticultural fields, textiles are currently used in relatively simple ways, e.g. in weed and insect control.

Flora Robotica is a highly cross-disciplinary project across the fields of computer science, robotics, molecular and cellular biology, zoology, advanced mechatronics, environmental sensing, and architecture. The project's objective is to investigate and create societies of symbiotic robot-plant bio-hybrids. The synergies created by these hybrids will allow plants and robots to have new functions, such as producing architectural artefacts and living spaces and creating alternative architectural design opportunities by fusing the design and construction phases. The project investigates braided structures in relation to constructing artificial growth processes, and influencing plants through artificial stimuli (Hamann et al., 2015). This symbiotic relationship between robots and natural plants is to be used in walls, roofs, and benches, for example, in living spaces. The project has relevance to this work due to the many similarities of the two projects, such as the goal of an equitable symbiosis, the time-based transformation of the structures, and the use of a textile technique to organise the plants and promote human-plant interactions. Bringing textile thinking into an area that is driven primarily by technologies based on digital fabrication, monitoring, and autonomous management systems provides alternative perspectives to rigid architectural structures and opens up for including ´soft technologies`,e.g. biofabrication, textile sensors, and (co-)designing with living systems.

Designing with Living Systems

Rethinking the design practice

Recent developments in the field of smart textiles – in which digital components and electronics are embedded, providing additional functionalities such as sensing, communication, transformation, and the conducting of energy – have shifted both the functionality and expressions of textiles from static and passive to dynamic and active (Worbin, 2010; Dumitrescu et al., 2014; Talman, 2015). In addition, and in reaction to the concept of biodesign, a change is occurring in materials; this is away from inanimate ones, and towards those that are alive or have been co-designed by systems of living organisms. As Antonelli argues: "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). This chapter examines the implications of this approach for design practice, provides examples of researchers and designers working and designing with living systems, discusses contemporary research relating to material systems that can assemble themselves through their intrinsic, responsive capacities, and explores these principles in relation to textile design research.

Imhof and Gruber explore the concept of living as architecture through their research project *GrAB – Growing as Building* (Imhof & Gruber, 2016), wherein growth principles are investigated by exploring hydrogel, mycelium, slime mould, algae, and bacterial cellulose. The project aims to utilise abstract natural growth principles in architecture, using biomimetics to integrate biology into material systems and biological organisms and concepts into existing architecture. Imhof and Gruber thus examine metabolic systems and the hierarchical organisation of living organisms, and in one investigation explore the structural capacity of plants. The volumetric expansion and shape-changing of plants is bound to water uptake/content, and influences e.g. the change in shape of seedpods. Imhof and Gruber also conducted an explorative design process 'in collaboration' with slime mould, wherein they observed how it covered a three-dimensional architectural model in the process of growing. With a comprehensive presentation of principles and exploration of growth mechanisms, obtained through experimentation with biological materials, *GrAB* sharts a path that has great potential for developing textile practice within the research programme. Imhof and Gruber also emphasise the need to consider feasible life cycle designs in the development of architectural applications, and are of the opinion that independent or semi-independent systems will challenge our attitudes towards exerting and retaining control of the systems that we live in, and that great potential lies in the combining of agriculture and building industries. This opinion is shared by Hebel and Heisel, who predict a "fourth industrial revolution" – a radical shift towards agrarian sources, particularly within the construction industry (Hebel & Heisel, 2017, p.8). This postulation implies that not only design practice but industry must adapt and learn how to produce materials by cultivating, breeding, raising, farming, or growing them, as is already being undertaken by e.g. Ecovative Design and MycoWorks for example (Ecovative Design, 2017; MycoWorks, 2017). In the research project *Botanical Factory*, Collet and Foissac explore how an understanding of botany and horticultural techniques can inform design processes and alternative, sustainable manufacturing using plant systems (2015; Myers, 2015). They argue for a new framework within which materials are designed and manufactured, and thus a paradigm shift in the field of design by examining the environment of plant growth and new manufacturing processes. Here, semi-predefined products are grown by taking advantage of existing plant ecosystems that utilise the sun and water for the process of growth as part of a process of "botanical fabrication". From this perspective, plants are partners or service providers, and so Collet and Foissac propose adaptation to the natural rhythm and duration of growth of plants, in place of interference.

Rather than bringing the natural sciences into the design field, Tissue Engineered Textiles does the opposite: The project, conducted by Amy Congdon in collaboration with the Tissue Engineering and Biophotonics Division of King's College London, explores how materials and traditional textile crafting techniques, such as embroidery, crochet, and lace-making, can be used to create alternative approaches to tissue engineering, and whether they could be used to quite literally 'grow' future garments (Congdon, 2017). The presented projects exemplify how design and fabrication processes and approaches change in relation to designing with living systems as part of a 'biological revolution', and provide information regarding the possibilities inherent in the methodology of this research.

Approaches to Designing with Living Materials

The extend to which architecture can benefit from a structural understanding of plants is explored by Gruber (2009, 2011) and Ludwig et al. (2009, 2012). Gruber, as a researcher who specialises in biomimetics in relation to architecture, uses a biomimetic approach to develop applications that are inspired by e.g. plants, whereas Ludwig uses vegetable structures to support or facilitate architectural formworks. In 'Biomimetics in architecture – inspiration from plants', Portoghesi describes aspects that are common to both plants and architecture: "In architecture as well as in living beings, decoration as an element of self-representation serves to identify parts, reveal their hierarchy and even their stages of development" (Portoghesi, 2000). Architecture and plants have always been strongly interconnected due to the fact that plants are a foundational material for architectural constructions, and their efficacy in such applications remains undisputed. Another general fact that relates to plants is that form and architectural construction are defined by the choice of material (Gruber, 2009). Gruber also notes the high efficiency of plant structures, their adapted geometry, contrasting characteristics that allow simultaneously for stability and flexibility or water repellency and absorption, and extraordinary capabilities such as self-healing. Moreover, she highlights the diverse array of mechanisms by which plants anchor themselves to the ground that have not yet been adopted by the field of architecture, even though the engineering principle of foundations for the purposes of stabilisation, supply, and distribution of resources are very similar. However, the world of plants offers a broad range of highly efficient archetypes to draw upon and design with: Plants move continuously, despite their fixed location, and respond and adapt to environmental factors. This morphogenesis of plants in response to light (phototropism), touch (thigmomorphogenesis), and gravity (gravitropism) offers potential for design:

"What if we could engineer the environment of a plant to control the shape of its branches? For example, could we use positive and negative gravitopism to create a 90 degree angle on a branch and thus pre-form the branch of a tree for a section of furniture?" (Collet, 2012)

Ludwig's research involves a contemporary interest in using vegetable structures to support or facilitate architectural form; his research project on the "vivification" of architecture, *Grow!*, is a "living plant construction" (Ludwig et al., 2012). Here, an architectural future that merges technology and vegetable organisms has resulted in a constructed object that is simultaneously bonded to a living organism. *Grow!* is characterised aesthetically and spatially by the qualities of the chosen species of tree over the course of the seasons. Ludwig is currently in the process of developing techniques that will allow vegetable structures to be utilised in architectural contexts through the interoperation of technical joining and vegetable growth, producing a compound structure consisting of vegetation and architecture (Ludwig et. al., 2009; 2012). Although Ludwig's interest is functional, the structures he develops are distinctly aesthetic: Over the course of their growth, the trees intersect and create a wall-like structure that responds to environmental stimuli, representing the natural life cycles of trees as influenced by the seasons. The inseparable connection between technical structure and plant creates a hybrid structure that combines two very different worlds, resulting in an object that possesses multifunctional potentials for symbiotic living by taking into account their needs and abilities. This is precisely the aim of *On Textile Farming* in connecting textile structures and plants.

Bioreceptive Facade Panels is an Engineering and Physical Sciences Research Council-funded project which, through environmentally driven geometric design and the fabrication of bioreceptive seeded concrete panels, aims to provide an alternative to existing 'green walls'. In relation to this, Cruz and Beckett introduced 'architectural bark', wherein the façade itself hosts microorganisms, cryptogams, and more complex plants (2016). The material's properties and structural characteristics, such as the level of porosity of the façade panels, are intended to create the proper conditions for the growth of cryptogamic covers (algae, lichens, and mosses) such that the panels do not need additional maintenance. A monitoring system records raw, quantitative data regarding the transformation of the panels in the form of photographs and measurements. Here, design is used to explore not only the relationship between the substrate and surface areas that enhance or inhibit growth, but the specific environment and organisms that thrive in the substrate material.

In relation to this research, it is interesting to note that *Bioreceptive Facade Panels* involves the biocolonisation of lower plants, i.e. cryptogams. The bioengineer

Olivier Guillitte 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". Thus, the bioreceptivity of a material is a key factor in its becoming biocolonised, as are environmental conditions (Beckett, 2018; Syn.de.Bio, 2015; Cruz & Beckett, 2016).

In 'Bioreceptive design: a novel approach to biodigital materiality', Cruz and Beckett discuss architectural bark as a concept and describe their application of interdisciplinary methods and concepts. They developed bioreceptive design as a new research field in order to explore ways of directly embedding nature in the fabric of a material on an architectural scale. Their particular focus is designing scaffold systems, and as a result have borrowed heavily from the field of tissue engineering, in which research is performed to develop bioscaffolds – biocompatible substitutes for biological structures. Bioscaffolds exhibit voids and pores to provide space for the attachment and growth of cells.This porosity can be translated into weaving constructions and so can function as in tissue engineering; working in conjunction with the textile material itself as a scaffold and nutrient source, degrading as the plants grow. The materials can be biodegradable or rigid (non-degradable) depending on how permanent they need to be, and can work as temporary scaffolds, barriers, or multifunctional scaffolds or exhibit more permanent characteristics, functioning as "a delivery system for growth stimulating factors, remaining as part of the object throughout its lifespan" (Cruz & Beckett, 2016). Cruz and Beckett state that bioscaffolds can be understood in architectural, biological, and mechanical terms, and propose scalar hierarchies according to their design for architecture. The key advantages of textile technologies such as weaving, knitting, braiding, embroidering, and electrospinning are precise control over fibre size and orientation, pore size, geometry, interconnectivity, total porosity, and surface topography (Akbari et al., 2014; Moutos, Freed & Guilak, 2007).

The artist Diana Scherer is fascinated by the dynamics of below-ground plant components, and studies and manipulates root systems to explore the 'intelligence' of plants. For the *Interwoven* project, Scherer uses underground templates to shape roots into textile-like structures, which burrow, expand, and eventually fill moulds; the roots are first guided by a structure, then become the structure (2016). Scherer's artistic work is based on floor coverings, and causes the viewer to reflect on future textiles and landscapes, bridging the interior and the exterior. As the designing/shaping process takes place underground, it is only visible by interrupting the process and exposing the roots. Observing and incorporating not just leaves and stems but sprouts and roots into the textile design process – and using textile structures to shape growth – are objectives of this research programme, and so Interwoven is an important work in relation to this thesis.

Collet's *Biolace* and *Botanical Factory* explore how an understanding of botany and horticultural techniques can inform design processes and alternative, sustainable approaches to manufacturing that use plant systems (Collet & Foissac, 2015; Myers, 2015). *Biolace* explores the potential for synthetic biology and botanical fabrication in relation to growing lace using plant roots, manipulating them using macramé. Both projects *Biolace* and *Botanical Factory* question the ethics of synthetic nature and explore how an understanding of botany and horticultural techniques can inform design processes and alternative, sustainable approaches to manufacturing that use plant systems.Collet's practice inspired the process of co-designing with seeds within of this research project on several levels; utilising e.g. textile and horticultural techniques in the design process and using speculative design and images as research artefacts, which met with generally positive responses and were much-discussed.

At the time of writing, Chieza and Ward are in the process of developing a closed-loop manufacturing system for textile dyeing and printing using bio-pigments that are produced by living bacteria (2015). Their collaborative research project *Faber Futures* aims to establish a alternative crafting discipline at the point at which design practice and synthetic biology meet, and so can be categorised as bio-hacking. Chieza and Ward investigate processes of co-design using living technology by folding and creasing textiles into which bacteria are introduced, creating deliberately constructed patterns. One of their hypotheses focuses on material paradigms and the idea that designing with living systems improves the design landscape (Ibid.). Using living materials to alter textile structures in this way opens up for complementary design methods, techniques, materials, and expressions. The bacteria also require a very specific environment in which to grow and reproduce, developing according to the conditions and thriving where they feel most comfortable – in this case the folds arranged by Chieza and Ward. Consequently, a process of co-design with living systems takes place, wherein textile techniques and hybrid methods that incorporate biology and design processes are blended.

These examples show that it is important to factor in the characteristics of the scaffold material and every level of its structural hierarchy, e.g. from fibres and yarn to textile construction more broadly in order to design its bioreceptivity and to facilitate a symbiosis featuring biocolonisation to occur. Thus the plants' basic needs in terms of environmental conditions need to be factored in when combining and integrating seeds into a woven textile structure.

Self-Assembly

Menges' interest in natural systems relates to the field of climate-responsive architecture; performing research using a responsive material system with a focus on the material behaviour of wood, which reacts to humidity, and using a biomimetic approach, he takes the pine cone as a foundation for his investigations. Its "ingrained responsiveness" (Menges & Reichert, 2012), which is an integral part of all natural systems, holds potential for architecture in the sense that it causes architectural features to constantly adapt and respond to environmental conditions, in that the shape-changing of the pine cone is intrinsic, fully reversible, infinitely repeatable, and immediate. Thus, it is a system that does not require sensors or actuators, and can be designed and manufactured for "tunable self-transformation" (Correa et al., 2015), wherein the silent movements of the wood are a result of the material's hygroscopic behaviour and anisotropic characteristics (Correa Zuluaga et al., 2013; Menges & Reichert, 2015; Menges et al., 2014; Krieg et al.,2014; Correa Zuluaga et al., 2015).

The pine cone is explored using biomimetics and in relation to textiles by *Programmable Knitting*, a research project by Scott. Her first result, "Knitted Assembly" (2013, 2015), illustrates the structure of a material system by combining textiles and veneer. To further develop her research, she used the biological principle of structural hierarchy to design fabrics with inherent shape-changing behaviour, and mapped the model onto the hierarchies of fibre, yarn, knit stitch, and knit structure. Accordingly, the "smart behaviours" of her second result, *Programmable Knitting*, were integrated through the structure and led to the "Responsive Knit System", which provides a technical method of communicating these complex interactions. Thus, Scott's work constitutes a design system which details the programming rules for the production of shape-changing knitted textiles (2016, 2017), and shows that textiles are indeed "a technology as well as a material", in the words of Ramsgaard, Thomsen, and Bech (2012).

In 2015, the results of the *bioLogic* project, developed by the Tangible Media Group at MIT Media Lab, were published. These consisted largely of a textile surface that expands and contracts in response to body temperature and moisture, and is activated by living bacteria. The cells were grown and harvested in a laboratory (Yao et al., 2015), then partially printed on a laser-cut pattern; this was incorporated into a garment that was designed to allow a certain degree of movement in relation to the temperature of the body. The results of the project were to be used in the creation of responsive fashion and costumes, in that the textile surface can be used as a smart, self-actuating textile that senses and reacts naturally, without electronics. The bacterial coating is invisible and reacts to heightened body temperature resulting from e.g. dancing; the subtle movements of the textile pattern reflect the cut and coating of the fabric.

In these examples, bacteria, wood, and knitting, just like the seeds used in *On Textile Farming*, react to moisture, causing a physical change that leads to a transformation of the expression. The reactions created in the projects discussed above, however, are reversible, while the seeds, once activated, carry out their pre-programmed cycle of growth and transformation in a permanent way.

PROGRAMME

On Textile Farming: A Research Programme

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 Svensson AB but operate separately, the combining of the IT and CS departments for the purposes of an artistic research project open up for development perspectives that exemplify the passion for innovative solutions and complementary markets that Svensson AB has exemplified throughout its history. The fact that Svensson AB is currently undergoing a reorganisation process at the level of both management and production processes underlines the company's forward-looking perspective. Alternative approaches that by their very nature raise questions can be answered through experimental design; these may bring challenges to be solved or require conditions that might or might not exist in the near future. However, they deepen and expand discussion and collaboration within the company, beyond the immediate future and towards long-term perspectives, where research is an important driver of actions and reactions that can contribute to more sustainable ways of living.

The proposal to bridge the two departments of Svensson AB was motivated by the company's philosophy of "improving life for people and plants", and based on experience of developing highly aesthetic and functional products (Svensson, 2018). 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 absorbance, 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. Thus, the expertise in developing aesthetic and functional hybrids might created a common space for exchange and new product families and applications, and so may lead to new business areas.

This research examines the intersection of interior textiles and living systems such as plants, exploring the relationship between textile structure, natural growth, and 'wilderness' indoors, a central element of which is continual transformation as a result of the life cycles and built-in obsolescence of living organisms. *On Textile Farming* explores the design possibilities offered by biological and textile transformations and transience, based on the notion that the integration of elements that can e.g. grow and degrade challenges the concept of permanent buildings that are generally intended to be durable and long-lasting. 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, such as that of patterned interior textiles (bedclothing), to dynamic and reversible ones, e.g. digitally augmented interior textiles (Kuusk, 2016). 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 and so contributing to the field of biophilic design on the scale of the interior. This biological perspective requires complementary variables such as humidity, light, and time.

By exploring the intersection between living and growing, alternative perspectives on living, involving organising and maintaining plants in hybrid spaces, arise. In order to showcase the possible scenarios in which these alternative forms of hybrid cohabitation can take place, a range of interior textiles, manufactured in collaboration with Svensson AB, were produced. These took 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 use and location. They thus 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 transform, these textiles close the gap between the interior and the exterior, different environments, and nature and architecture.

Designing with living systems such as insects, fungi, and bacteria by engineering natural behaviour has recently become of interest to many artistic fields, and involves proposing collaborative processes of design and manufacture as alternative approaches to a novel material category for living. 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 an alternative perspective on horticultural landscapes on the scale of the interior. Here, the research programme considers the combination of textiles and plants to be a hybrid material for use in the interior, and so *On Textile Farming* aims to question and redefine the aesthetics of interior landscaping by exploring seeds as dynamic materials for textile design. With a special focus on human-plant interaction, the research programme concentrates on searching for alternative ways in which processes of growth and decay may inform design practice and lead to complementary textile expressions. Rather than simply providing functional solutions for indoor gardens, the artistic research programme aims to propose perspectives for future forms of living with plants, and suggest how textile design knowledge can generate alternative aesthetics and interactions in interior spaces.

The programme will explore 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

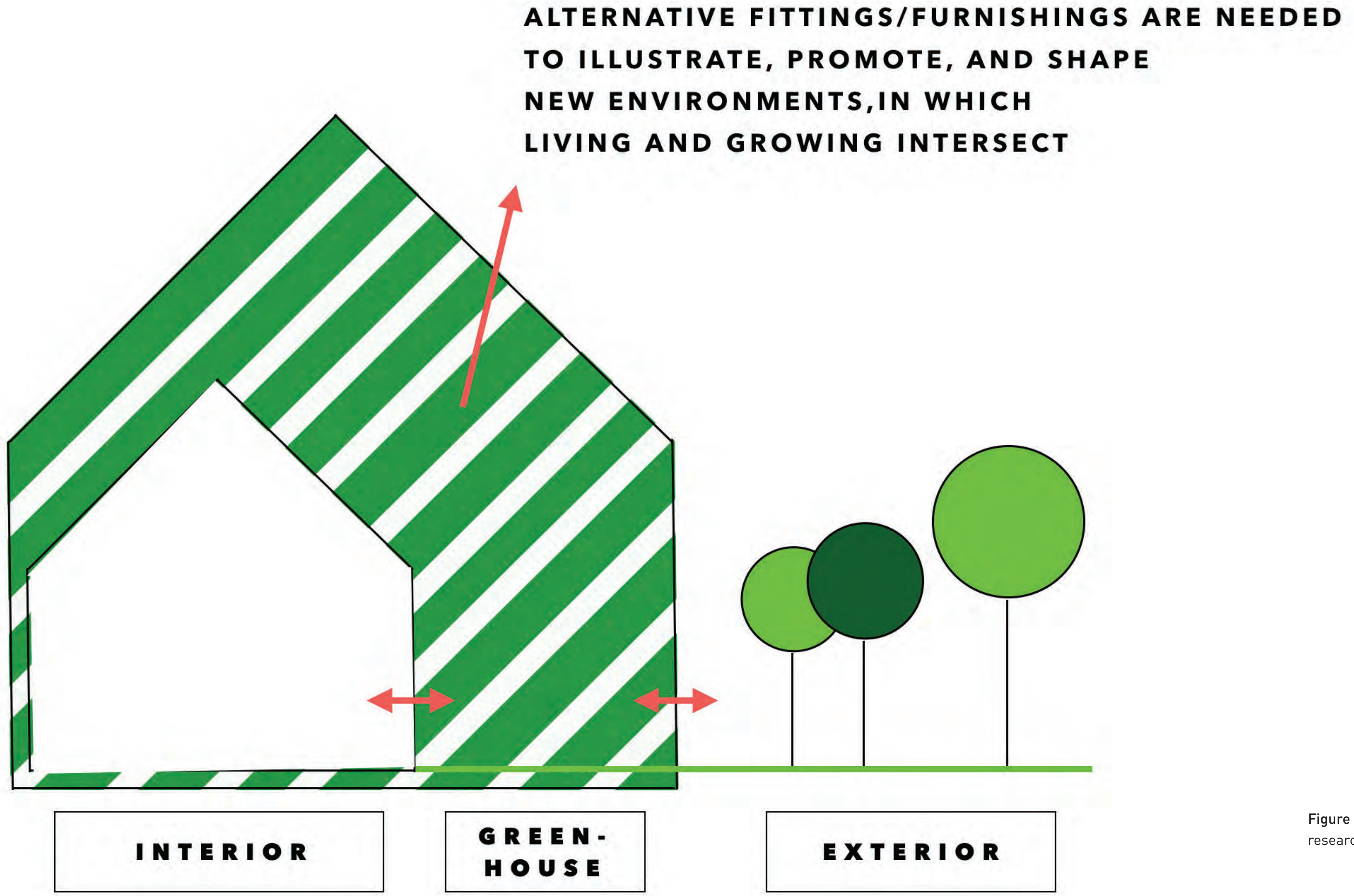


Figure 6: A graphic illustration of the aim of the research programme.

RESEARCH APPROACH AND METHODOLOGY

Practice-Based Research Through Art and Design

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; here, living and growing intersect, people and plants are connected, and textiles are approached from an alternative perspective and seen as biophilic materials for interior design.

The contextual frame therefore relates different areas of research: textile design, interior design, and biodesign (Figure 2). Smart textiles, as a field within the area of textile design, enhance dynamic aesthetics and performance in textiles by combining sensing and response capabilities and textiles, and provide a framework for textiles to connect with and exhibit dynamic expressions in environments. Recent research contributions have opened the door to responsive and living materials and thus created a connection to the comparatively new research field of biodesign. These contributions explore living materials as alternatives to electronics, providing new approaches and methods that inform the methods of *On Textile Farming*. Biodesign is a sustainable design principle that differs from other approaches by implementing living organisms as foundational materials. New design programmes, approaches, and methods in the field use the inherent potential of living materials and provide alternative perspectives on enhancing aesthetics and functions, and even replacing industrial or mechanical systems with biological processes. Thus, they open up for multi-method approaches that bridge art, science, and design; consequently, more holistic perspectives on design are facilitated, and it is in this way that biodesign supports the research programme of *On Textile Farming*. Through their adaptive and responsive structures, which are in some cases alive, these contributions lead to new perspectives on interior design and question the relationship between humans and nature in relation to living spaces.

Biophilic design intends to generate positive experiences of natural and built environments for people, and thus provides a biological perspective on interaction design in an architectural context. This relationship between humans and nature, resulting from experiences and expressions, links to the research programme, which aims to propose novel interior interactions with plants facilitated by textiles.

Svensson AB, the company that hosts this research, contributes with access to expertise and production facilities of the two departments: Interior Textiles and Climate Screens. This intersection of perspectives was the foundation for the

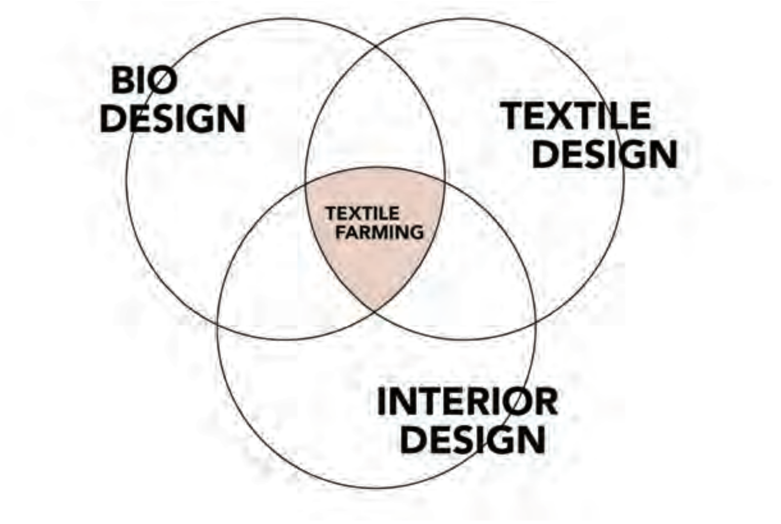


Figure 2 : An overview of the contextual frame of *On Textile Farming*

development of *On Textile Farming* and integral to the practice-based research and contextual framework.

On Textile Farming presents research through art and design (Frayling, 1993; Archer, 1995; Cross, 2001, 2006); here, the construction and evaluation of research artefacts/examples is of fundamental importance with regard to generating knowledge and advancing practice. Artefacts do not primarily represent knowledge in this context; rather, they are instruments for its generation as "epistemological and methodological medi[a]" (Jonas, 2015). Experimentation and reflection are the core processes of this approach, and are carried out in a close dialogue with the explorations as 'reflecting in action' and 'reflecting on action'. This leads to the creation of theory, that which is more a by-product of the process than the main focus of project-grounded research (Zimmerman et al., 2010). As the focus of theory and practice lie in the field of exploration, unexpected insights can result from experimentation and reflection, leading to new concepts and "new forms of knowledge" (Rendell, 2005) that express "the language of experience" (Stappers, 2007, p. 87) and open up the field to alternative perspectives.
Thus, research through art and design is of an ´multidisciplinary`(Findeli et al., 2008) nature and suitable for use in more general inquiries relating to e.g. environmental or societal problems, and consequently has a relatively general theoretical scope (Ibid.). This framework is compatible with the ArcInTex ETN programme, which was established to provide flexibility in order to use 'non-reductionist' design principles and ´multimethod`(Gray & Malins, 2004) approaches to facilitate the obtaining of unexpected insights and advance practice through the perspectives of other disciplines. This flexibility as regards non-linear design processes and unexpected directional developments is the foundation of the research programme of *On Textile Farming*, which began life within the ArcInTex ETN research topic of 'Textile structures for adaptive and responsive interiors', with electronics as the main components for conducting the research.

The programmatic perspective, with a strong focus on textiles, is reflected in the ArcInTex ETN programme, wherein practice-based design research connects areas of design such as textile and fashion design, architecture, and interaction design in order to design more sustainable forms of living. Thus, the overall aim of the training network is to "introduce new design programmes", "introduce and display new design techniques and methods", and "introduce and display new perspectives on design aesthetics" (ArcInTex ETN, 2017). Therefore, textile thinking is the programmatic and methodological foundation and common ground that the alternative propositions outlined in this thesis are based upon. In this context, textile thinking relates to how textiles – materials, products, clothing, and interiors – within textile design are understood and applied in our lives. Here, a special focus lies on sensitive design expressions which promote consciousness about the ways in which we live (Ibid.). Textile thinking in relation to *On Textile Farming* refers to how our understanding of textiles can be expanded to include alternative materials, e.g. seeds and plants, and how this understanding can lead to alternative methods and techniques for textile design. Textile thinking is used to inspire and develop relationships on the scale of the surface (between seeds and textiles), on the scale of textile design (between designers and textile-seed hybrids), and on the scale of the interior (between users, textile-seed hybrids, and space).

On Textile Farming, as a research programme (Binder & Redström, 2006; Löwgren, Larsen, & Hobye, 2013; Redström, 2011, 2017; Hallnäs, 2010) rests on Redström's three-step iterative process: formulation, realisation through experiments, and formulation of results through reflection, which can lead to revising the programme in order to bring a new level of precision by proposing new definitions. 'Programme' consequently refers to a set of intentions that are explored through design experiments, and so there is a mutual dependency between programme and experiments, as the latter are materialisations of the programme/initial intentions. 'To enable a programme to facilitate the creation of experimental dialectics it must be sufficiently robust to withstand the influences of practice, but open to the dynamic process of experimentation and the unexpected (Redström, 2011). Löwgren et al. understand the contribution to knowledge of the programme itself, rather than simply the way a programme produces outcomes through experimentation (Löwgren, Larsen, & Hobye, 2013). Similarly, Cross introduces the term "designerly ways of knowing", which is embodied in the design process and its products, and results from, among other elements, nonverbal thought and communication and modes of cognition.

In this research, the dialectic of the programme and experiments was subject to major changes at the beginning, as exploring materials and techniques in parallel to contextual research and experiencing the industrial context at Svensson AB led to several refinements. From there, the two major areas that the programme was to explore were specified:

I Textile expressions, using seeds as a dynamic material for textile design
II Forms of indoor gardening through textile design materials

The relationship between the programme and experimentation became an underlying framework, and evolved into an approach to conducting the research. Appreciation of the iterative process of practical and intellectual (writing) work comes, according to Harrison, from an awareness of occurring and developing thoughts, intentions, and decisions (2002). In this process, the examples play a major role, exemplifying the theory and embodying the information that cannot be expressed in theoretical reflections due to the limitations of language (Biggs, 2004). Thus, they are instruments for interpretation.

Through ongoing development in the field of biodesign, much of which promotes the use of materials that are new to the textile design field, alternative design spaces are opened up. Consequently, there is a need to investigate and question these complementary possibilities in order to better understand their consequences and develop techniques, methods, and perspectives relating to aesthetic expressions for the design of more sustainable ways of everyday life in relation to the ArcInTex ETN programme. Schön describes design as a "reflective conversation with the materials of a situation" (1983), while Stappers considers the function of research prototypes to be expressing "the language of experience" (2007). The "agency of artefacts" is thus a primary characteristic of project-grounded research, where both researchers and artefacts can influence directions and decisions (Savic & Huang, 2014) – which in turn are triggered by insights that derive from experi-menting, interpreting, and reflecting. Accordingly, the key characteristics of research methodologies in art and design are experiencing; exploring; gathering, reflecting on, and interpreting information; and communicating this knowledge (Gray & Malins, 2004). Research artefacts lead to the generation of theoretical articulations and intellectual argumentation.

In Collets' speculative design-led research project BioLace, the research artefacts are intended to apply the potential of synthetic biology to a possible future in which plants bear not only fruit but textiles, creating accessible design scenarios in order to expose their social impact. A range of post-2050 design scenarios were created; these took the form of physical objects that expressed design concepts, and were photographed.The design probes and animations not only explore how textile products could be designed and "biofactured", but illustrate their potential in thought-provoking ways. Consequently, a critical inquiry occurs and the research artefacts facilitate an intellectual discourse, as took place when the textile-seed yarns were discussed with some of the technicians at Svensson AB. Here, a discussion of concrete possibilities and uses in industrial machines (weaving and warp-knitting) took place, which led to the creation of an example using the warp-knitting machine, as well as insights regarding the explorations being conducted by personnel at Svensson AB.

The results of practice-based research suggest changes in the form "of a present state" and "in how things are done"(Jones 1992, p. 6), meaning that these results are not presented as knowledge relating to concrete things; instead, they propose alternatives to already-existing methods or situations in design (Cross, 2007, p. 43) in order to advance the practice itself (Jones 1992, p. 6). These suggestions are presented and built by experimental work in order to open alternative design spaces and complementary perspectives, represent the programme, and illustrate methods and materials for design (Hallnäs & Redström, 2006). Biggs emphasises the importance of the link in between research artefacts and text in communicatinge knowledge effectively, and highlights their interdependency (2004, p.7). In this sense, and in accordance with Löwgren et al. (2013), the iterative interdependency between the programme and the experiments, which also results in reflection becoming an integral element of the programme, is a contribution in itself. However, in the context of *On Textile Farming*, the results that were derived through reflection suggest a biological perspective on smart textiles and textile interaction design, including methods of and variables relating to co-designing with seeds: how to integrate them, how to manage their life cycles, and how this informs alternative ways of living.

On Textile Farming is a research programme that is being carried out in collaboration with Svensson AB, and thus connects research in academia to industry. Experimental and speculative artistic research approaches are often in conflict with the fact-based perspectives of companies, and practice-based research results are, as Jones states, often concerned with changing practice and questioning contemporary methods and design situations rather than presenting concrete knowledge that supports the rapid solving of the problems of today (Cross, 2007; Jones 1992). Thus, academia and industry frequently do not share a perspective on time, and this fundamental difference involves a range of other opposing motivations.

Overcoming obstacles to introducing future concepts to the market in order to achieve economically viable and socially relevant effects was the focus of an investigation by ten Bhömer. Here, the connection between research and academia was approached using research-through-design and collaborative design processes to build complex methods, connecting designers and stakeholders in close-to-the-body applications (ten Bhömer, 2016). From this perspective, the designer is not just facilitating in processes with multiple partners, but actively engaging in them, and making use of a specific group of skills. Ten Bhömer uses an approach inspired by the concept of "embodied interaction" (Dourish, 2001) for developing close-to-the-body applications. Here, prototyping and the prototype – which ten Bhömer sees a distinction between – play a major role in the research as collaborative design processes are used to investigate how an embodied approach can established contact between designers and stakeholders and how prototypes support the sharing of multidisciplinary knowledge (ten Bhömer, 2016).

Within her industrial PhD project in collaboration with the Danish company Gabriel A/S, Bang utilises participatory design by including stakeholders and their personal experiences in developing methods for describing the emotional qualities and values of textile applications (Bang, 2010). Her programmatic approach is application-oriented and practical, and addresses the urge of the textile industry to include user participation and value innovation in relation to the development of products. Bang developed the "tripod approach" to designing and exploring applied textiles by relating fabric, object, and environment to one another, the observant, and the participant from the perspective of the textile (Ibid.). This tool for creating dialogue has been combined with aspects of the repertory grid (Fransella et al., 2004) and "four pleasures" framework (Jordan, 2000) to explore and discuss aspects of participation.

Mody conducted "use-inspired basic research" in cooperation with Philips Research (NL), applying textile thinking and methods from practice-based design research to investigate how LED technology can be expanded beyond traditional two-dimensional applications and into a spatial context in order to create architecture (2016). The hypotheses were tested using three modes of material evidence and three different sites as evaluation contexts, as is proposed by Raamsgard Thomsen and Tamke (2009).

The Philips Design Probes research initiative is an example of speculative design research in an industrial context. These projects, which envisage lifestyle scenarios 5-15 years in the future, seek to understand socio-cultural and technological shifts and spark both debate and technological innovations (Philips, 2017). Sustainable and adaptive living, the future of food, and biotechnology are the primary driving forces behind the development of the research artefacts. The overall intention for the research initiative is to create visions of the future, leading to technological innovations with the potential to meaningfully improve people's lives.

The four research examples discussed in the preceding paragraphs constitute different approaches to tackling the challenges that occur in relation to different perspectives within academia and industry. *On Textile Farming* is thus committed to a comprehensive approach that includes research examples and a programme of hybrid interior textiles as boundary objects to support cross-disciplinary communication and the transfer of knowledge across boundaries (Star & Griesemer, 1989; Carlile, 2002). Additionally, the far-future lifestyle scenarios envision possible future developments that provide perspectives on bridging the departments of Svensson AB, and their efforts to allow more research to flow into product development in order to offer customers new perspectives.

Artistic Research at Svensson AB

Bridging Interior Textiles and Climate Screens at Svensson AB

Svensson AB, 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.

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 made use of warp-knitting and man-made materials on a large scale. Developing textile-based solutions for climate control and energy efficiency, Svensson AB began its journey towards becoming a pioneer and world leader in functional climate screens for greenhouses in the 1970s, supporting the global trend of the greenhouse cultivation of vegetables and flowers. The screens manage humidity, temperature, and UV radiation according to specific requirements, resulting in optimal growing conditions.

Today the company has two departments, both of which are highly specialised. The Interior Textiles (IT) department develops upholstery, curtains, and solar control systems for the public sector, and works closely with architects and contractors. These products must comply with the guidelines for public spaces and meet requirements relating to abrasion, fire protection, acoustics, and maintenance. They are therefore woven primarily using Trevira CS and wool. In addition to functional applications such as shading, room separation, and upholstery, aesthetic qualities are of fundamental importance, and so the IT Department has its own design department that leads, organises, and oversees the development of new products and collections.

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 climate control, ground cover, weed control, insect control, horticultural textiles, and weather protection. The products developed by the CS department are based on polyolefin, polyester, aluminium, and modacrylic.

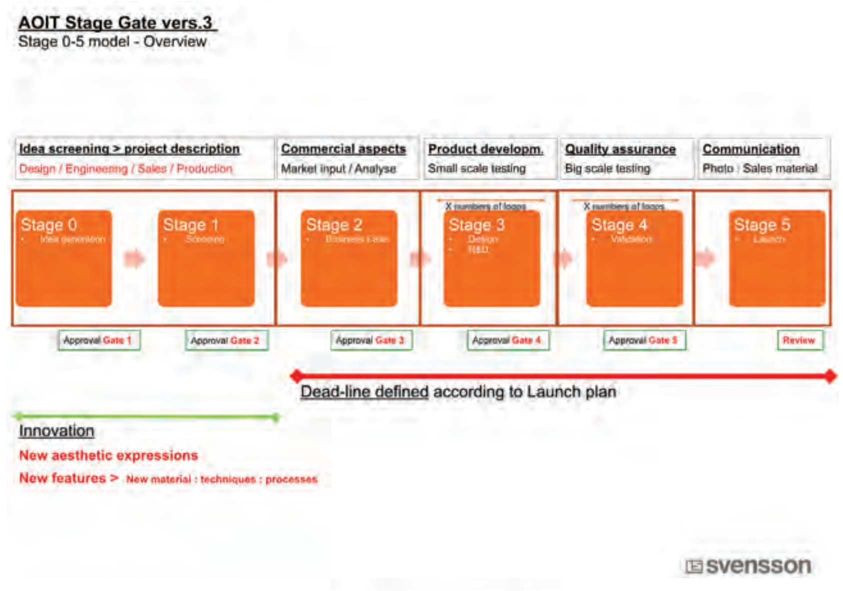


Figure 3 : The development plan with five quality-assurance gates used by the Interior Textiles department of Svensson AB (from Dorte Bo Bojesen, 2017)

In order to ensure that the development of new designs and products meshes with the company's visions and strategies, design and product development within the IT department involves an evaluation process that is framed by the stage-gate process. Ideas for products and expressions that have emerged from Svensson AB's Think Tank and Ideas Library are evaluated by applying current prognoses and tendencies that are notable within the area and its design, production, sales, capacity, and technical development. Design trends in architecture, fashion, and art with a focus on material, form, and colour are reconciled with developments in sales, examined by observing sales statistics, market tendencies, and competitor positioning. Thus, tendencies in design, sales, and production become approved strategies, resulting in design and development plans or a launch plan that covers a four-year period. For reasons of quality assurance, this plan passes through five 'gates' when being evaluated.

Through its participation in the ArcInTex ETN, Svensson AB and its IT Design department has opened itself to artistic and practice-based research, strengthening the foundations of the design field and using these to create

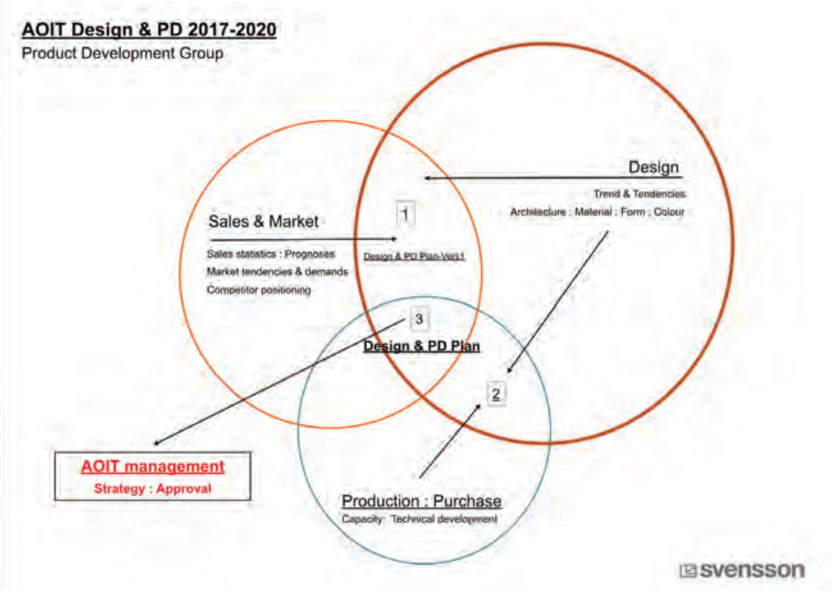


Figure 4: A Svensson AB management strategy for the Interior Textiles department, with three stages for developing a design and a product plan (from Dorte Bo Bojesen, 2017).

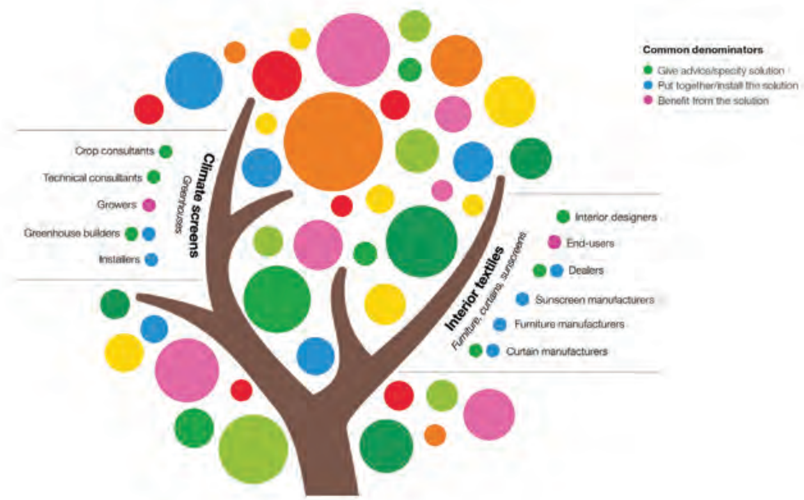


Figure 5: An illustration of the two branches of Svensson AB: The Interior Textiles and Climate Screens departments (from Svensson Brandbook, 2016)

sustainable forms of living for the future. The integration of research is only one part of an ongoing restructuring of the company, however – and a temporary one at that – but represents openness and the pursuit of innovation.

The company has repeatedly demonstrated the importance of being open to new developments and alternative business models. Considering recent developments in urban gardening and farming, a clear increase in innovative solutions with reference to cities, architecture, and the interior is evident and expressed in all societal strata: From rooftop greenhouses (Pons et al., 2015; Gotham Greens, 2017) to hybrid homes (Greenhouseliving, 2015; Frearson, 2016) and shelving systems designed for hydroponic plant breeding in domestic interiors (Aouf, 2016), gardening and farming have become both status symbols and necessary practices in areas in which fresh fruits and vegetables are expensive or difficult to obtain (Doron, 2005).

The CS department has already contributed to projects relating to rooftop greenhouses and hybrid homes (Svensson AB, 2016). However, as the ArcInTexETN research programme notes: "As natural science and engineering science introduce new materials and new technology, there is an increasing need to explore their possibilities and consequences for the design of our future living environments" (ArcInTex ETN, 2017). Although the horticultural sector, ever-adapting to the needs of a growing world population, is constantly expanding into new environments, there is a great demand for domestic living spaces that are more concretely connected to gardening and farming. The growing interest in these sustainable and adaptable forms of living has led to increases in the number of eco-villages, nature houses, and urban and indoor gardens, and so 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. Modern gardening systems are shaped by commercial horticultural practices, bringing containers such as buckets, tubs, and tanks – which are generally made of plastic – into people's homes (Vertical Green, 2018). Here, complementary aesthetic perspectives are needed to illustrate, promote, and shape these environments in which living and growing intersect, and to represent and enhance their hybrid natures.

Alternative solutions are needed in order to maintain competitiveness with fast-developing markets, and introducing responsive materials into industrial processes requires complementary design and production processes. It also questions the notion of interior textiles in relation to the contract market, which requires certain standards (e.g. inflammability and washability). However, it is hoped that the introduction of alternative concepts, methods, and processes that conceptually bridge the company's departments will result in dialogues regarding the potential of joint projects in relation to hybrid environments. These projects would merge the current gap between the two business areas, which have distinct customer groups and needs and requirements.

DESIGNING WITH SEEDS

A Framework for Designing Interior Textiles

Proposing seeds as materials for designing adaptive and responsive textiles adds two alternative perspectives to the current array of methods of textile design: Firstly by dynamically transforming the expression of a surface design over time through surface changes in terms of e.g. colour, dimensions, and structure (i.e. on the scale of the surface); and secondly by changing the ways in which we live with textile-plant hybrids (i.e. on the scale of the interior). Textile Farming thus proposes a framework for designing interior textiles by focusing on these two perspectives in order to promote a more holistic view on textile design processes in relation to surface and interior design.

The life cycles of interior textiles are usually bound to their context, e.g. part of a piece of furniture (a tablecloth belongs to a table, a pillowcase to a chair or sofa) or architecture (a curtain belongs to a window, a carpet to the floor). While the location of a textile can change its function is invariable, and when a textile can no longer fulfil its function it is disposed. A carpet for example can be placed e.g. in the bedroom first, then in the kitchen and the hallway but it is usually bound to covering the floor. If the carpet no longer meets the expectations of appearance and performance, it will be disposed of.

Figure 6 depicts the life cycle of a textile-seed hybrid wherein the life of an interior textile is extended by a biological life cycle that opens up different possibilities for interacting and living with the textile. The model thus provides a framework for both the designer and the user; the former can use it to design and describe an extended life cycle for an interior textile, while the latter is able to understand and implement this.

The model consists of three successive phases – dormancy, growth, and afterlife – which are determined by the actions 'activation' and 'deactivation'. The dormancy (sleep phase) is considered from a purely textile perspective due to the biologically passive seeds in the textile-seed hybrid. Activation triggers the textile's transformation – the growth phase – which combines the textile and biological perspectives. The transformation is dependent on environmental factors such as humidity and the availability of light and nutrients, and can be influenced by forms of maintenance. The natural process of growth can be influenced or halted at any time by an act of deactivation relative to the relationship between the transformation and the design intention, e.g. by terminating the supply of resources/environmental stimuli. This results in a biological 'dormancy wherein only the textile interaction remains; in this state, the structure is stable and its expression a result of textile and

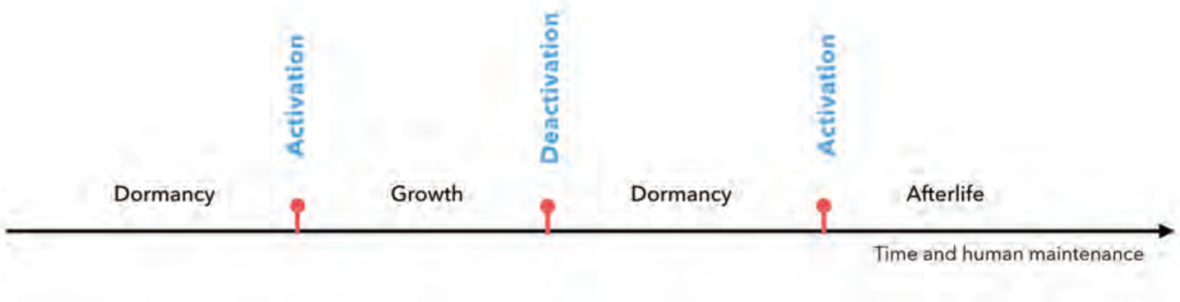


Figure 7: A new life-cycle model for interior textiles, with the four stages that can be influenced by human maintenance.

biological transformation. Another activation offers three possibilities for the afterlife of the textile-seed hybrid: it is left to decompose, reactivated, or planted. The second and third possibilities expand the model by a few steps, as biodegradation is, in essence, disposal. The second activation therefore extends the hybrid's transformation into a second biological cycle. Reactivation is an attempt to trigger inactive seeds that did not react to the first activation, while planting allows the hybrid structure to further develop in the sense of given resources, e.g. in an exterior garden. However, the afterlife is an infrequently utilised possible development path in relation to the transformation of textile-seed hybrids; the usual end of a life cycle is an infinite dormancy or a premature degradation initiated by e.g. mould. The use of a mixture of natural and synthetic materials also changes the life cycle as it means that only a part of the structure biodegrades.

By changing the placement of the hybrid and maintaining it over time, the hybrid structure erodes the boundary between interior and exterior and changes their relation to the designer and the user, as well as to its environment (the interior space). Considerations regarding the life cycle of an interior textile, in terms of different patterns of use that occur after the textile can no longer fulfil its initial function, are generally not part of the textile design process, and watering is not a common way of maintaining an interior textile. The model therefore provides a more holistic perspective on designing textiles in regard how they can be used connecting the interior and the exterior.

How dynamic biological expressions by integrating seeds as material in textile design can be designed is shown in Figure 8, which provides a more detailed model for designing surface expressions using textile design processes. The method

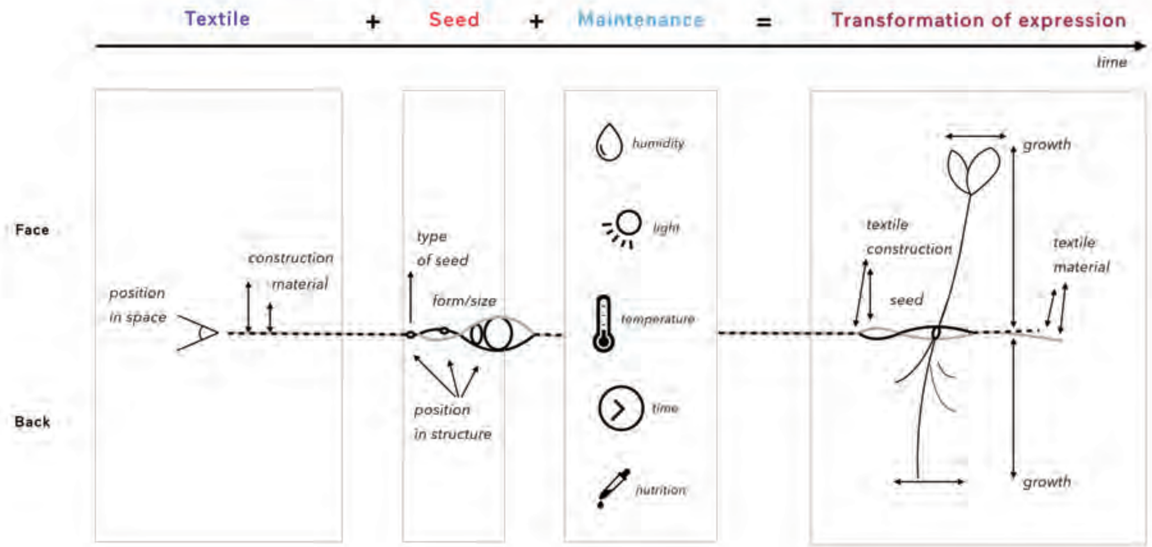


Figure 8: A method for constructing textile-seed hybrids, and the four variables.

combines three sets of variables relating to the seed/plant, the textile, and the environment. The variables that define the textile's characteristics and interactivity are the material, technique, structure, and position in space. Material choice affects the tactile and visual aesthetics of the textile, as well as its evaporation or storage of moisture though capillarity. Different densities promote or restrict the growth of sprouts, and the angle and position of the textile influence their direction of growth. The variables that influence seed behaviour are material (the intrinsic characteristics and external appearance), form, size, and the position of the seeds in the textile structure, e.g. yarn, tubular knit, doubleweave. The seed itself contains information pertaining to how and under which conditions it will develop as well as the length and direction of the growth, which is also affected by the angle and position of the textile and environmental factors. The form and size of the seeds is an important factor in their integration with the textile, together with their position, degree of visibility, and degree of disruption to the structure (binding). Environmental variables such as light, time, temperature, nutrients, and humidity are defined by direct or indirect forms of human maintenance, and affect how seeds develop in relation to the supporting textile structure. This interaction with the textile – the bio-transformation – can be described from a textile perspective through changes in the expression of e.g. the material, structure, and colour, and from a biological perspective based on changes in the expression by as a result of the pattern of growth, e.g. length, direction, colour, shape.

By adjusting the design variables according to a design intention, the interaction between the seeds and the textile determines the surface expression. The final expression of the textile-seed hybrid is a product of the interplay between various actors: the designer who develops the hybrid, the user who activates and maintains it, and the seed that transforms it in relation to the human management (cf. Pinto et al., 2013). The understanding that the user brings with regard to the hybrid influences its aesthetic qualities, which are therefore unique and so open up for an alternative perspective on textile interaction design.

In addition to the transformation, the ways in which textile-seed hybrids are used and how they react to forms of maintenance can be seen from the two perspectives outlined above. Thus, textile-seed hybrids can be used from a textile perspective – when one is sitting on a sofa, walking on a carpet, covering oneself with a blanket – and from a biological perspective – soaking seeds, washing, harvesting, and eating sprouts, observing growth. Textile-seed hybrids can function from a textile perspective, e.g. by covering furniture, surfaces, or humans or absorbing moisture and sounds, and from a biological perspective, e.g. in terms of their swelling and germinating and changing colour and shape. Designing these irreversible dynamic expressions (bio-transformation) requires involving complementary design principles and variables in the textile design process.

In this context, the design examples of Series I were created in order to achieve a deeper understanding of the roles of seeds as living materials that transform the surface expression of a textile, and therefore to also explore the role of the designer who develops the hybrid. Series II explores how textile-seed hybrids affect forms of living, and thus investigates the role of the user who influences the transformation through forms of maintenance. Both series explore an extended life cycle that results from the interplay between textiles and a biological perspective.

EXAMPLES

Integrating Seeds and Constructing Plant Containers

On Textile Farming, a research programme with a multidisciplinary approach, exists at the intersection of many fields; in terms of artistic methodologies, it constitutes "a pluralist approach using a multi-method technique" (Gray & Malins, 2004, p. 21). It is the result of an iterative programme of experimental dialectics, and is intended to increase the usage of responsive biomaterials in the field of textile design, suggesting a perspective that complements those of smart textiles and alternative ways of living with plants. Having experimented with a range of biomaterials, seeds were explored with regard to their dynamic potential for new expressions in textile design and alternative plant organisation in interior spaces..

Series I: Seeds as a Dynamic Material for Textile Design

Series I comprises a range of examples that were created to exemplify and investigate the programme of methods for designing textile-seed hybrids. The examples are categorised according to their dimensions into dynamic materials, surfaces, and shapes, and were produced using knitting, felting, weaving, and crocheting.

Series II: Textiles as Forms of Indoor Gardening

Series II explored the potential of doubleweave with regard to organising plants and alternatives to common forms of indoor gardening. The programme of hybrid textiles focused on pocket-weaves, which were manufactured in collaboration with Svensson AB using one of their Jacquard looms and black and white warp. The examples were categorised as either dynamic patterns or dynamic interiors. For the former, a range of pocket-weave patterns were equipped with seeds and substrate to illustrate their dynamic potential after activation. The latter explored the relationship between interior textiles and objects of the interior, e.g. furniture, and the examples created were augmented with scenarios that open up for an alternative perspective on spatial design and the life cycles of interior textiles.

Publications

This thesis is based on the following publications.

Series I:

Keune, S. (2017). Co–designing with plants. Degrading as an overlooked potential for interior aesthetics based on textile structures. The Design Journal, 20(sup1), S4742–S4744. http://doi.org/10.1080/14606925.2017.1352977

Keune, S. (2017). Alive. Active. Adaptive. In International Conference 2017 of the DRS Special Interest Group on Experiential Knowledge (Vol. 19, p. 90).

Heinzel, T.; Keune, S.; Walker, S.; Peciulyte, J.: Al Dente Textiles. Notes on edible textiles as economic and ecological intermediality, In Proceedings 6th STS Italia Conference | Sociotechnical Environments, Trento, November 24–26, 2016

Series II:

Keune, S. (2017). Growing textile hybrid structures: Using Plants for Dynamic Textile Transformation, an Approach Towards Biophilic Urbanism, 3rd International Conference of Biodigital Architecture and Genetics, ESARQ, Barcelona, 2017 (Vol. 3, p 264).

Exhibitions

Several of the experiments created during Series II were exhibited at:

Exhibition of on-going research, experimental work and prototypes in textile design from the Smart Textiles Design Lab at Techtextil 2017 in Frankfurt on 9-12th May 2017. (2017). Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:hb:diva-12489

Speculate, collaborate, define – textile thinking for future ways of living. Textile museum in Borås, March 23 -7 May 2017

EKSIG 2017 - Alive. Active. Adaptive. International Conference on Experiential Knowledge and Emerging Materials, 19 - 20 June, Het Nieuwe Instituut, Rotterdam, The Netherlands

MoOD and Indigo Brussels 2017, 6-8 September 2017, Tour & Taxis, Havenlaan 88, 1000 Brussels. Hall 1, stand B17.

SERIES I

Seeds as a Dynamic Material for Textile Design

This chapter introduces the materials that were used and the set of methods that was created in order to explore the embedding and integration of seeds, plants, and substrate in textiles, as well as managing and extending the life cycles of textile-seed hybrids and their meaning for the field of smart textiles and alternative forms of living, influencing the design of interior spaces. 'Dynamic Materials' describes the creation of 'textile-seed yarns', which were the foundation for the 'Dynamic Surfaces' and 'Dynamic Shapes' sections, wherein knitting, felting, weaving, and crocheting were used.

Knitting, particularly circular knitting, holds great potential with regard to flexible structures that can be filled, stuffed, stretched, and shaped, and therefore can adapt to different shapes, inserted materials, and shape-changing processes caused by transformations and plant growth. Knitting is thus discussed in the 'Dynamic Materials' and 'Dynamic Shapes' sections. Weaving, a foundational technique in creating textile surfaces, was chosen based on the stability of form that it facilitates, ease of industrial-scale production, expertise available at Svensson AB, possible patterns, structures, densities, and materials that it allows. For organic, three-dimensional shapes, intuitive processes, and experimental materials, crocheting was found to be the best textile technique, and so was central to the experiments described in the 'Dynamic Shapes' section.

These methods both integrate alternative materials and techniques into the process of designing textiles and add life-cycle management in order to consider the entire life of a textile, including usage and disposal. A range of complementary perspectives that are rooted within this more holistic view on textile design, promoted by a speculative approach to exploring their possible implications, was therefore utilised.

Crafting Textile-Seed Hybrids

A supporting medium is needed in order to integrate seeds into textiles. In gardening practices, seed tapes are a common means of managing seeds in order to store and plant them, reducing the amount of seeds needed, clearly defining the distances between seeds, and speeding up and improving the accuracy of sowing. The medium is a biodegradable tape that decomposes while the seeds germinate (Pleasant, 2015). Pre-seeded mats or carpets enable uniform or variable vegetation coverage to be established in the desired pattern and density, prevent erosion, reduce setup time and weed growth, and provide nutrients (Horton, 2010). Permanent mats block weeds and organise the plantation based on templates that indicate the placement of seeds in relation to their needs, label them, and reduce the need for watering through built-in irrigation (Horton, 2013).

In Series I, the integration of seeds in textiles using craft-based techniques was carried out on the level of yarn and textile structures. In the context of this thesis, 'textile-seed yarn' refers to a textile material which can be used as a ´yarn` to be applied using textile techniques such as weaving and crocheting. All constructions where seeds and textiles have been merged fall under the umbrella of the term 'textile-seed structure'. The collective term used is 'textile-seed hybrid' or simply ´hybrid`.

The textile-seed yarns were a combination of seeds and textile material; more precisely, chickpeas, mung beans, barley grass seeds, and corn seeds were manually inserted into a tubular knitted crafting yarn, and small ones such as alfalfa or brokkoli seeds were integrated in a yarn through an industrial cotton-spinning process. Thus the methods of producing the textile seed yarns are based either on inserting or integrating. The hybrid yarns were then used for weaving and crocheting as one of the three approaches to creating hybrid structures that combined textiles and seeds. The second approach was to combine seeds and/or substrate with wool in a process of needle- or wet-felting, and the third approach was to insert seeds and/or substrate into knitted structures or doubleweave.

Series I primarily explored textile-seed yarns two-dimensionally in relation to weaving, and three-dimensionally through crocheting to in order to investigate textile-seed structures in active and passive states. Textile-seed structures, wherein doubleweaves were filled with seeds and/or substrate, were the focus of Series II. Here, full-scale pocket-weaves industrially produced at Svensson AB were created to explore stripes in the form of channels for water supply, pockets on the scale of patterns, and contrasting bindings on he scale of textile structure. These investigations were conducted with a focus on textiles as a medium for plant organisation.

Textile Material: Knitted Tubes

Various commercially available tubular materials, made of either of cotton or a mix of wool and other materials auch as polyamide, were used to envelop the seeds. In the context of this thesis the term used to refer to a combined material with wool is ´woolmix`. Both materials, cotton and the woolmix, were explored in different colours, diameters, densities, and thread strengths. Although both wool and cotton absorb moisture, a clear difference between them is that wool is generally able to absorb almost one third of its own weight without becoming noticeably damp or clammy to the touch due to its highly crimped fibres and hygroscopic characteristics. The pattern of the cloth is clearly visible in both dry and wet conditions due to the smoothness of the fibres. Cotton and wool are the focuses of this work, although other materials and combinations were also used during the experiments, as is made clear where appropriate.

The proportion of lanolin in the wool affects the water-repellency of a woollen product. Water droplets bead and roll off the surface instead of being absorbed, and this must be considered when planning the watering of woollen textile-seed hybrids. The scaly structure of the fibres provides them with natural antimicrobial properties, which is important in relation to managing living materials. Despite the fact that the decomposition of wool takes a relatively long time, it is often used as a fertiliser to improve the growth of plants due to the nutrients that it contains, its water-storage abilities, swelling capacity, and ability to assist in preventing the acidification of soil.

Cotton biodegrades much faster than wool and can be damaged by e.g. mildew and prolonged exposure to sunlight, but is quite resistant to heat and various

Figure 9: A wool mix (48% alpaca, 30% merino, 22% polyamid).

Figure 10: 100 % Cotton

detergents. Cotton is a seed fibre and consists of natural cellulose polymers, and so is hydrophilic; thus, its fibres become roughly 20% stronger when wet, which is an important factor in relation to the watering processes that facilitate and support the sprouting of the seeds.

Moisture and the substances dissolved in it, e.g. colouring particles, are distributed through capillary forces, which can lead to the discolouration of the fibres or cloth. Cotton takes longer to dry than wool, which can promote the spread of microorganisms and mould and thus cause premature degradation.

Biological Material: Seeds

The seed of a higher plant is part of its process of reproduction – a small package containing a tiny plant and its first meal for the germination process, which is the reactivation of the seed's metabolic machinery based on internal and external conditions such as temperature, water, air, and light (Raven et al., 2005). External conditions can be manipulated by forms of human maintenance. Knowledge of the requirements of seeds for germination and growth is crucial to understanding, predicting, designing, and manipulating how textile-seed hybrids transform in textile structures. Both passive and active expressions were explored during the experiments, as were aspects such as integration, activation, transformation (growth), and deactivation in order to understand how design interactions between seeds and textile materials and structures can be designed.

Seeds vary not only in terms of shape and structure, but 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 for their development. Delays to germination have evolved in most non-cultivated plants, the most common of which today is desiccation (Toole et al., 1956). A dormant seed contains an embryonic plant and nutrients to sustain it, which are protected by the seed coat. This protective layer is not only a defence against adverse external conditions, but communicates information regarding the exterior to the inside of the seed. The seed coat therefore maintains specific levels of metabolic and photosynthetic activity, and is permeable in order

Figure 11: The five types of seed that were used as dynamic materials in textile design processes. The seeds are not shown to scale, but are in the correct proportions in relation to one another.

to facilitate gas exchange (Radchuk & Borisjuk, 2014). Provided certain conditions are met, such as the correct levels of moisture, temperature, and oxygen, the onset of germination takes place and is perceptible as an increase in respiration and water absorption (Toole et al., 1956) and lengthening of the radicle.

Mung beans, alfalfa seeds, barley grass seeds, corn seeds, and chickpeas were chosen to be integrated into textiles due to their different characteristics in terms of shape, size, and expression of growth. Both mung beans and alfalfa seeds belong to the epigeal group of germinating plants, which means that they germinate above ground and have an embryonic stem (hypocotyl) which pushes the seed leaves (cotyledons) to the surface. They usually contain little nutrients, and so urgently need external nutrients. Both have two embryonic leaves and are termed dicotyledonous ('dicots'). Barley grass seeds, corn seeds, and chickpeas exhibit hypogeal germination, wherein the seed leaves remain underground. Barley and corn, as members of the grass family, are monocotyledons , (meaning that they only have one leaf), whereas chickpeas are dicotyledons (and thus have two leaves).

Figure 12: The germination behaviour of alfalfa seeds from Day 0 to Day 5.

Alfalfa are the smallest seeds of the chosen five. They are simple to sprout and very small, which made them easier to integrate into a mechanical process. Due to their being relatively difficult to see when placed within a passive structure, they also enhance the contrast between the passive and active expressions. Figure 12 shows epigeal germination and the two embryonic leaves.

Figure 13: The germination behaviour of mung beans from Day 0 to Day 5.

Mung beans have a very regular, oval form and smooth surface, and so are similar to oval beads in size and shape – facilitating their insertion into tubular materials. Figure 13 shows the strong radicle and the embryonic stem that will later push the seed leaves upwards.

Figure 14: The germination behaviour of barley grass seeds from Day 0 to Day 5.

The sharpness of the form and surface of barley, however, make insertion more difficult, although they do make the seeds resistant to moving once in position in the tube. Barley and corn, as grasses, grow quickly and are strong and straight once grown. With their anatomy and the force of the hypocotyl they are able to push through many surfaces and into objects, enlarging them vertically. They also develop long, strong, and dense networks of roots.

As a result of its smoothness, corn is easy to insert, and is available in many different colours. Its form is similar to that of a compressed droplet. The image shows the early stages of germination, the swelling of the seed, and the expansion of the radicle in response to the force of gravity.

Figure 15: The germination behaviour of corn seeds from Day 0 to Day 5.

Chickpeas have a round shape and beige colour, and resemble pearls. They are the biggest seeds of the chosen varieties, meaning that they are very visible in textile structures but function well as three-dimensional elements and add rigidity to the general expression of a textile. The image shows the hypogeal germination, the growth of the radicle, and the embryonic stem (epicotyl) that pushes the plumule upwards.

Figure 16: The germination behaviour of chickpeas from Day 0 to Day 5.

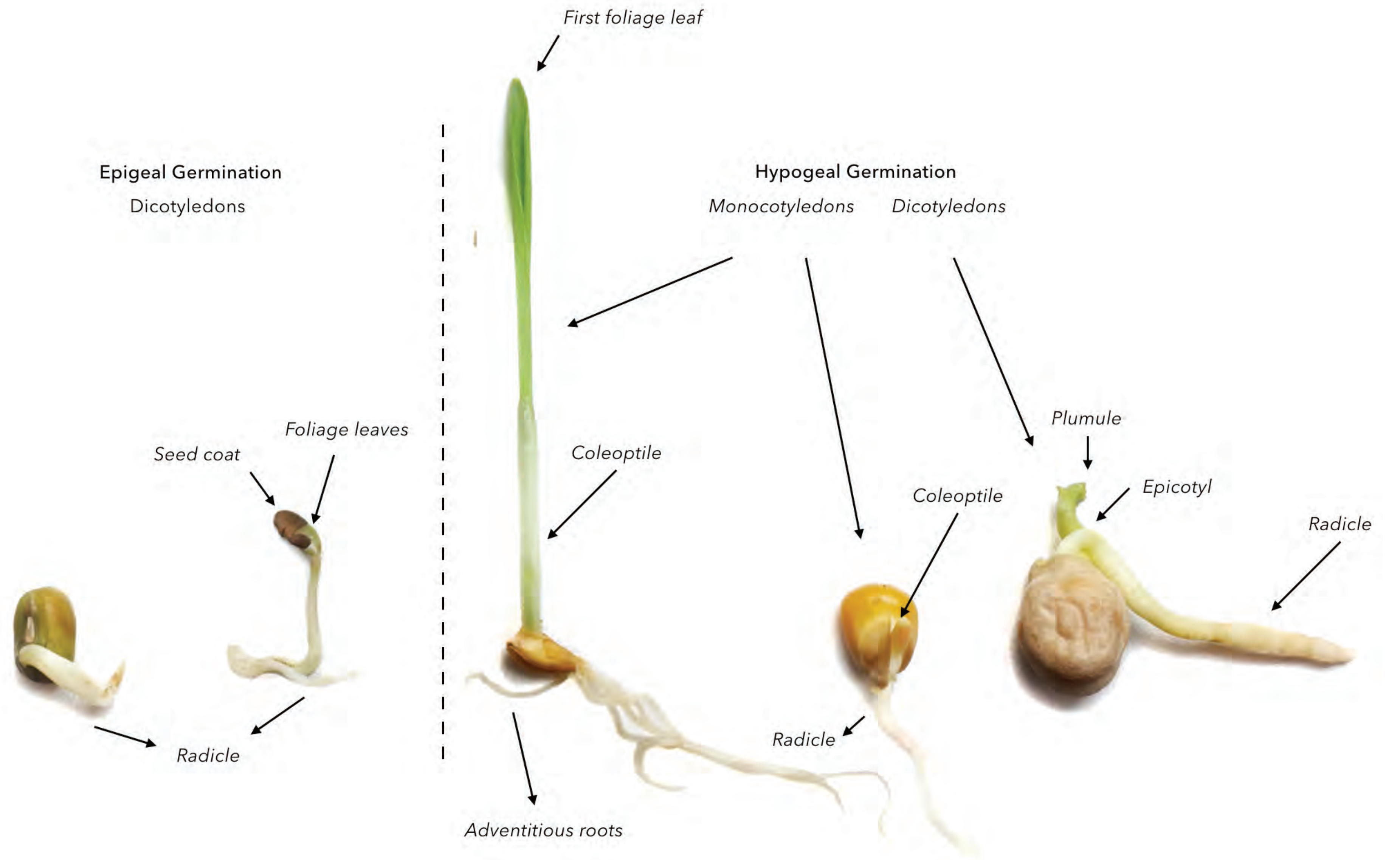


Figure 17: Two forms of germination, which allow the selected seeds to be differentiated between.

Series I

Seeds as Dynamic Materials for Textile Design

Series I involved three levels of creating textile-seed hybrids, described in the sections 'Dynamic Materials', 'Dynamic Surfaces', and 'Dynamic Shapes'. The materials created served as the foundation for most of the experiments involving the creation of surfaces and shapes using hand-weaving, crocheting, felting, and knitting.

Dynamic Materials

The focus of these samples was inserting, integrating, activating, maintaining, and managing the life cycles of textile seed yarns (hereafter referred to simply as 'seed yarns'). The setup and methods used, as well as the materials produced, were the basis for constructing plant containers using different textile techniques in order to explore two-dimensional surfaces and shapes.

Figure 18: The seed yarn after activation.
Figure 19: The seed yarn fabricated by Nawar Kadi at the Swedish School of Textiles in Borås, photographed after the carding process

Dynamic Surfaces

The samples described in this section focused on hand-weaving, investigating the textile-seed yarns and their interactions in and with textile structures based on passive and active modes. In addition other methods of inserting and integrating seeds into textiles such as knits were applied.

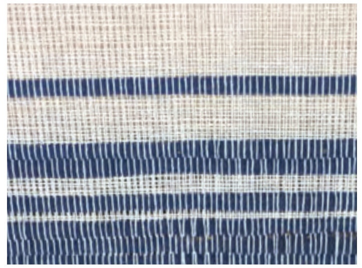


Figure 20: A hand-woven cloth with inserted alfalfa seeds.
Figure 21: The activated cloth began sprouting.

Dynamic Shapes

Three-dimensional textile seed structures were the subjects of the examples presented in this section, which explored transformations in size and shape. In addition, interactions with textile structures – which open up for alternative ways of living with plants through textile objects that gradually transform into them – were investigated, as were the life cycles of the textile objects.

Figure 22: A knitted vessel with a chickpea rim.
Figure 23: The knitted vessel with chickpea plants.

DYNAMIC MATERIALS

Exploring Textile Seed Materials

The creation of the following examples involved one manual and one automated process for producing textile-seed yarns. The setup for this process is described, and represents the general methodology by which the examples were produced and described. The examples show the transformation of a yarn in relation to exploring how seeds and textile materials interact with each other. How these materials interact on the scale of the surface is described in the following chapters, which focus on dynamic surfaces and dynamic shapes. Thus, the dynamic materials described in this chapter were the foundation for the experiments of Series I.

How the expressions of the dynamic materials transformed over time is documented by using Figure 7 for illustrating the stages in the life cycle of each experiment. The main variables of each example are collected in a table to provide a final overview. The table relates to Figure 8, which represents a method for constructing textile-seed hybrids, and was the basis for the reflections on the examples.

4 Day 8

Figure 24: A close-up of the cotton-corn yarn eight days after activation.

Exploring a Cotton-Corn Yarn

This example illustrates the transformation of a textile-seed yarn using a cotton tube and corn seeds. The dynamic changes in the expressions of the yarn were investigated in order to develop an understanding of designing, using, and activating textile seed yarns in textile design processes and weaving.

Setup

A tubular yarn was chosen as an envelope/supportive medium, constituting a material system that can be used for craft-based textile techniques such as crocheting and hand-weaving. Mung beans, alfalfa seeds, barley grass seeds, and corn seeds were inserted manually, using a straw or paper funnel to hold open the tubular yarn, then squeezed into position. To insert the chickpeas, the opening of the yarn was stabilised using tape, and this reinforced rim enabled direct insertion by hand. The smooth shape of the corn and the chickpeas allowed them to be pushed through the tubular yarn and into place, and they were then positioned with regard to the distance between them. Inserting the barley grass seeds was more difficult due to their sharp shape, which often became caught in the tubular knit. At times seeds were separated using knots, which also kept them in place. With larger seeds and a smaller diameter of the tube, the tension between the seed and the tube kept the former in place, as which is visible through the adjustment of the tube to the shape of the seeds (Figure 26).

In the example shown in Figure 27, the corn seeds were introduced into the rose cotton tubular knit using a straw, then positioned throughout the length of the tube. The yarn was then placed on a plate and soaked, rinsed, and drained 1-2 times per day.

Figure 25: A close-up of a tubular cotton yarn.

Figure 26: A seed yarn, wherein the tubular knit adjusted its shape to the integrated corn seeds.

1 Day 0

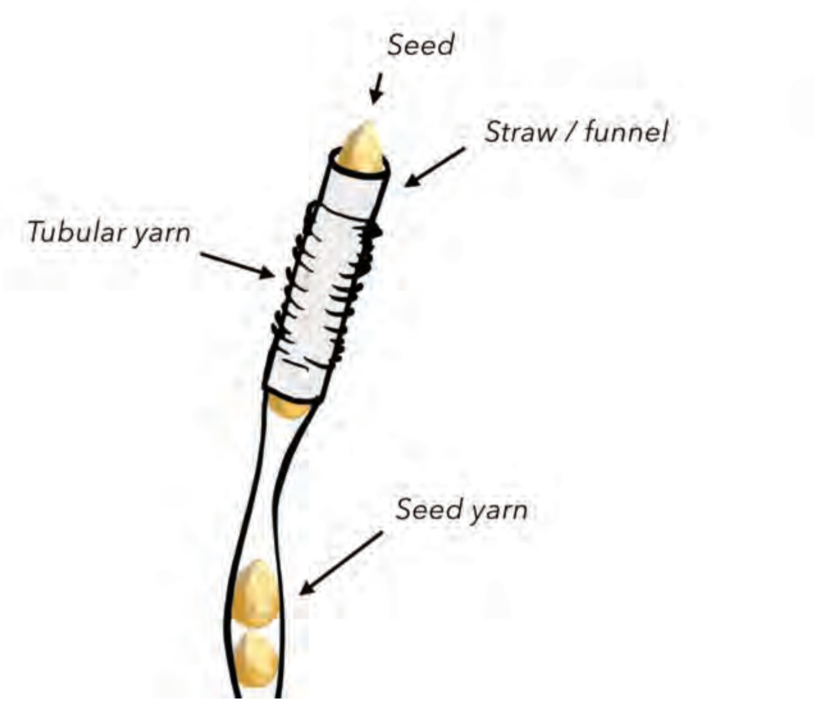


Figure 27: The empty textile envelope and the chickpea yarn that was used to crochet its funnel-shaped rim.

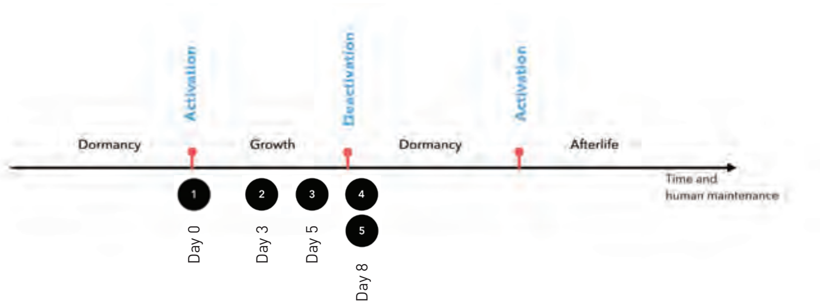


Figure 28: A diagram that illustrates which parts of the life cycle the figures 24, 26, 29-31 belong to.

Transformation of the Expression

Figure 25 shows a textile material that was used as a carrier for the corn seeds; a crocheting yarn made of cotton, consisting of a tubular knit with a relatively open, flexible structure that can be widened across the opening to insert the seeds and tightens when it is stretched lengthways. Thus, the yarn can hold seeds that stretch the structure in place by friction. Consequently, the seeds are prevented from falling out of the tube, but dynamic in terms of their position within it. Corn, with its smooth surface, can be moved by hand lengthways through the tube or is moved due to the process of weaving or crocheting.

The soaking of the corn caused it to swell as it took up water, and the radicle began to grow out through the knitted structure. As the yarn rolled and changed its position with each movement, the radicles changed their direction, as shown in Figure 31, growing downwards due to gravity or horizontally when restricted, constantly correcting their direction of growth. This was also true for the development of the coleoptiles, as shown in Figure 32.

Figure 29: Within three days the radicles had grown out of the knitted tube in search of water and nutrients.

2 Day 3

Figure 30: The cotton-corn yarn developed radicles and extended its coleoptiles

3 Day 5

Figure 31: The radicles and coleoptiles changed colour and expanded.

4 Day 8

Day 8

Figure 32: Due to the movement of the tube, the roots and coleoptiles grew in different directions.

While the radicles fit through the knitted structure, the coleoptiles had a greater diameter and strength and thus sometimes broke it as they grew (Figure 30). The different stages and directions of growth can be observed in Figure 31, which shows coleoptiles of different heights and colours as influenced by the stage of their development and the availability of light, and two inactive corn seeds and a coleoptile that changed direction. Figure 32 shows two radicles growing in opposite directions and a colour gradient, which starts with dark red and ends with white at the tip of the root. The coleoptiles ranged from white to light green, going into deep green for monocotyls that became visible as they were pushed through the coleoptiles. The shoot passed through and partially dislodged threads of the knitted tube, and finer roots emerged from the foot of the coleoptiles near the radicle.

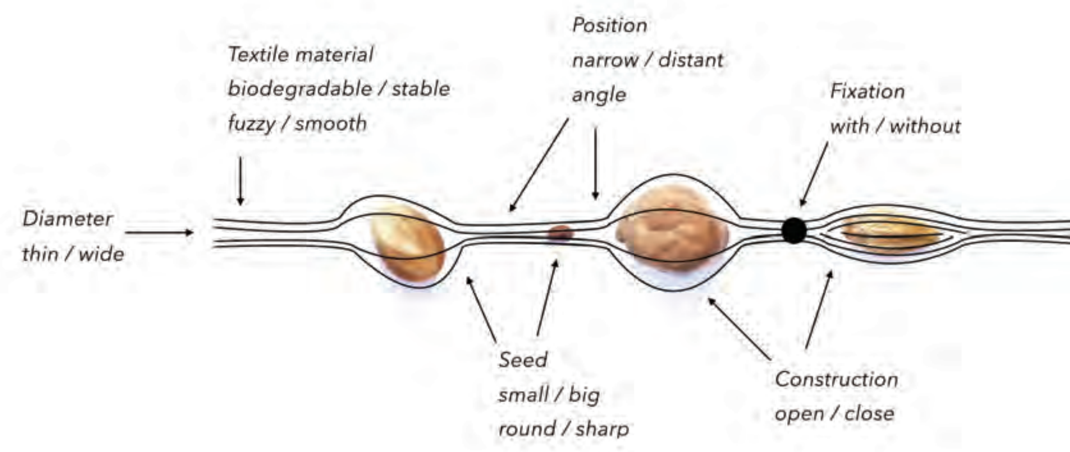


Figure 33: The parameters for designing seed yarns and dynamic surface expressions.

Reflections

This example illustrates how seeds can be integrated/turned into a textile material system that allows them to be used in craft-based textile techniques, and how they can transform over time using moisture to activate and maintain them. A key parameter for the transformation of the textile-seed yarn was its position, which changed regularly as a result of its maintenance. The radicles and coleoptiles thus changed the direction of their growth several times, affecting the expression of the yarn and creating an understanding of how the growth of sprouts and plants can be influenced using the flexible characteristics of textiles.

The components of the textile material are important parameters due to the fact that they shape how the tube reacts to the swelling and germinating of seeds, which in turn occurs due to moisture. Thus, the seeds change shape and characteristics through their uptake of water, and wool and cotton – in the form of tubular knitted materials, as well as warp and weft materials – are transformed by moisture, changing colour saturation, expanding and contracting, or becoming glossy, weaker, or stronger. The materials used also determine whether and how rapidly moisture is absorbed and evaporates, which affects how frequently maintenance must be carried out. Other factors that influence the seeds during their transformation include the thread strength and the density of the structure, while the size and shape of the seeds determine how they can be inserted and their position in relation to the diameter and density of the tubular knitted material. Seeds such as alfalfa and broccoli have smooth surfaces and are very small, and so can fall through the knit if the loops of the structure are sufficiently large, while sharp seeds such as grass seeds can easily puncture the structure and so fall out. Seeds with sharp and fibrous hulls, however, often stick to the yarns, preventing this.

All of these parameters, along with colour, constitute how seeds can be used within textile design processes, as well as their expressions on a textile surface in passive and active states. However, for exploring yarns on a larger scale and in relation to industrial weaving processes, an automated production technique is required, and the yarns have to be compatible with industrial weaving looms in order to be fed into them as new weft materials.

Textile	**+**	**Seed**	**+**	**Maintenance**	**->**	**Transformation of the expression**
Material: Rose cotton		Material: Corn		Light: Indoor light		The seeds swelled, the tube expanded, and the radicles and coleoptiles permeated and even cracked the knitted structure. More roots grew, and folded leaves appeared.
Technique: Tubular knit		Shape/size: Droplet-shaped, yellow		Time: 8 days (Dormance and Growth)		
Construction: Medium		Position: Inside the tubular knit		Temperature: Room temperature		
Position: Variable in space				Nutrition: -		
				Humidity: Through rinsing and draining		

Table 1: The parameters that defined the passive and active expressions of the cotton-corn yarn.

3

Day 7

Figure 34: The cotton-broccoli seed yarn in its sprouting phase.

Exploring a Cotton-Broccoli Seed Yarn

This example involved the production of a cotton-broccoli seed yarn using industrial processes; to be further developed and tested in industrial weaving looms such as those at Svensson AB. Industrial yarn production opens up for exploring seed textiles on a larger scale and with regard to designing more complex dynamic patterns on a Jacquard loom to investigate different patterns, bindings, material combinations, and treatments.

Setup

In collaboration with Professor Nawar Kadi at the Department of Textile Technology at the University of Borås, the insertion of seeds within a conventional yarn-spinning process was explored in order to develop a yarn that can be used in industrial looms.

Therefore, the filaments of 27 mm cotton (Grade 2, from Izmir, Turkey) were untangled and carded to clean and intermix the fibres in order to produce a continuous web. During the drawing process, the fibres were aligned in parallel and the sliver evenness was improved. Modifications during the process led to an open sliver in which broccoli seeds, due to their small size, were inserted and translated into circular roving. The last step was the twisting, which was performed without drawing in order to avoid damage to the seeds. Figures 36 and 37 show the thick, untwisted yarns which seeds were inserted into prior to the drawing process. The textile was watered in order to ascertain the number of intact seeds in the yarn and how the seeds behaved and transformed the yarn. Having been soaked for 6-12 hours, the textile was then rinsed and drained twice per day.

Figure 35: Inserting the broccoli seeds.

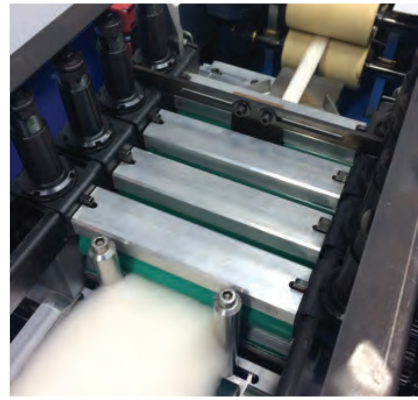


Figure 36: The drawing process.

Figure 37: A thick, untwisted yarn with broccoli seeds.

1 Day 1

Figure 38: The cotton-broccoli seed yarn, which was activated by soaking it in water.

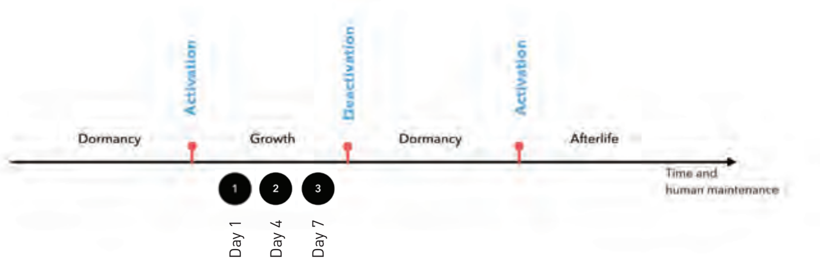


Figure 39: A diagram that illustrates which parts of the life cycle the Figures belong to.

; as this process changed the position/ arrangement of the yarn, the seeds had to constantly adapt to this (Figures 35 and 41).

Transformation of the Expression

As a first foray into industrial methods for producing textile-seed yarns, the cotton-broccoli seed yarn was very strong and had a low twist in order to avoid the mechanical processes damaging the seeds insofar as possible. The dry material was inelastic, soft, fluffy, light, and ductile, with a regular texture that was smooth but somewhat rough due to the cotton fibres, and so had a certain sticky quality. Its off-white colour was matte, opaque, and smooth. Due to the cotton's reaction to moisture, the yarns aligned and the material became stronger, slimmer, tougher, and heavier during activation, and appeared to be glossier as a result of the fact that the moisture reflected light. The seeds germinated as a result of the soaking and the roots became entangled both with the cotton fibres that they were integrated in and with the yarn itself, creating a bundle joined by growth (Figure 40) – contrasting with a more common bundle created through random knots and entanglements. Through germination, the small seeds revealed themselves and became visible. The development of the roots was subtle due to their downward and horizontal orientation, white colour, and fibrous characteristics. The stems that supported the seed leaves were difficult to see at first, but fundamentally altered the expression of the yarn when the embryonic leaves unfolded and turned green (Figure 43). As a result of the daily rinsing and draining procedure, the position of the yarn often changed, and the orientation of the sprouts along with it. With increasing root intersections, the maintenance and handling of the bundle of yarn became easier (Figure 40), and seven days after activation the sprouts had developed and were ready to be harvested (Figure 34).

2 Day 4

Figure 40: The growing roots connected the cotton-broccoli seed yarn to the surface on which it was placed.

Day 7

Figure 41: Roots built connections in the yarn bundle, fixing their positions.

Day 7

Figure 42: The fine roots, and the seed coats that fell from the unfolding seed leaves.

Broccoli seeds germinate above ground (epigeal germination). As germination takes place, the radicle develops and the embryonic root and the stem push the seed coat up so that the embryonic leaves can unfold. In contrast to hypogeal germination, the seed coat becomes visible on the surface, which in this example was outside the yarn. As broccoli seeds are a dark brown colour, they were very visible in relation to the white cotton fibre and roots and the light green stems and deep green leaves (Figure 34). Through the roots, the seedlings had a strong connection to the cotton fibres; their stems reached out at a right angle, but were bent because of the changes in the direction of their growth as they adapted to the changing positions of the textile-seed yarn. The moisture kept the roots fresh, and so both the roots and the cotton fibres had a shimmering, glossy expression. Some of the seed coats that fell when the leaves unfolded stuck to the yarn as the moisture created a certain stickiness.

Reflections

This sample illustrates the idea of integrating seeds within a common mechanical process for spinning yarn. Its scope is somewhat broad for use in industrial weaving processes, but further improvements are currently in development. These include investigating whether finer yarns that are suitable for use with industrial weaving machines are able to contain seeds during the process of producing and weaving. The investigation highlighted several important parameters that should be considered: The most important of these are the size and durability of the seeds, as they, together with the textile fibres, must undergo mechanical processes that can damage them or cause them to fall out of the textile. Furthermore, the textile-seed yarn must be possible to process using industrial weaving looms, which poses limitations as regards size and irregularities. Another factor is the type of seed in terms not only of size but needs, e.g. temperature, light, and nutrients, and expressions such as colour and the forms of roots, stems, and leaves. The germination processes of seeds are also of importance, as these define how the seeds interact (e.g. their ability to push out of the textile structure) with the materials and structures, e.g. fibres, knitted tubes, pocket-weaves, that they are enclosed in and part of. As is shown in Figure 33 the distances between the seeds, seed size, and strength and diameter of the yarn are important. When designing a spun yarn containing seeds, the material – i.e. the fibres – is important, as is the twist of the yarn due to the fact that this affects how well the seeds are contained within the textile.

Exploring the transformations of hybrid yarns themselves helps us to understand their expressions in woven cloth. The process of rinsing and draining the yarns twice a day, as well as the provision of airflow, prevented any mould from forming and kept the sprouts healthy and the textile material clean. The roots, in a fresh state, were similar to the cotton fibres. As they grew out of the yarn in search of water and nutrition, and to stabilise the position of the seedling, they connected to adjacent parts of the yarn, creating a bundle that was easy to handle with regard to rinsing and washing due to the position of the sprouts being stable, preventing damage to the seedlings. Organising the threads horizontally through weaving therefore would organise the seeds and simplify the maintenance of their development.

Textile	+	Seed	+	Maintenance	->	Transformation of the expression
Material: 27 mm cotton (Grade 2, from Izmir, Turkey)		Material: Broccoli		Light: Indoor light		The yarn thinned and became stronger, and white roots developed and connected to the yarn to form a bundle. Seed coats were pushed out of the yarn during epigeal germination, embryonic leaves unfolded, the seed coats fell, and the leaves turned green.
Technique: Spinning		Shape/size: Small, dark brown		Time: 7 days (Growth)		
Construction: Thick, soft twist		Position: Inside the yarn		Temperature: Room temperature		
Position: Horizontal as a bundle				Nutrition: -		
				Humidity: Through rinsing and draining		

Table 2: The parameters that defined the passive and active expressions of the cotton broccoli yarn.

DYNAMIC SURFACES

Exploring Textile Seed Surfaces

The following examples illustrate the methods and techniques used to create textile surfaces that embody a potential for transformation through growth and decay. Five approaches were explored: Textile-seed yarns as weft materials in hand-weaving (Figure 43); textile-seed yarns as crocheting surfaces, or for crocheting an application onto a surface (Figure 44); the integration of seeds in the process of wet-felting (Figure 45); the integration of seeds into three-dimensional knits; the integration of sprouts in the process of hand-weaving.

Hand-weaving was used to explore seed yarns two-dimensionally, with a focus on plain weave in order to concentrate on the textile and biological expressions of the materials and their transformations. The base was a white cotton warp, and the seed yarn was used as a weft. As in the previous experiments, the seeds that were inserted into the yarn belonged to edible plants in order to allow harvesting and eating to take place, as interactions with the hybrid, in an early stage of the plants' growth. The explorations investigated a close-to-the-object perspective in order to observe the impact (visual and haptic) of using seed yarns as a weft material, and the interaction (aesthetic and functional) between the seeds/sprouts and the weave. Activation was primarily based on watering, whereas the examples that used corn reacted to water or temperature.

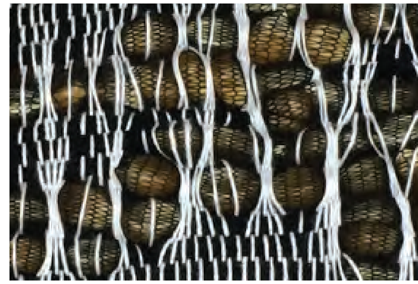


Figure 43: A textile-seed yarn that was used as a weft material.

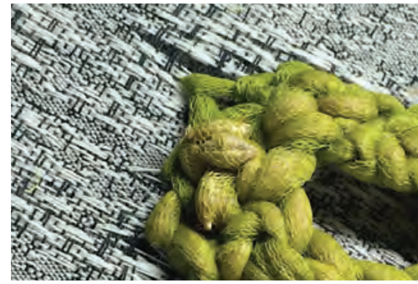


Figure 44: A textile-seed yarn that was used to crochet an application onto a woven surface.

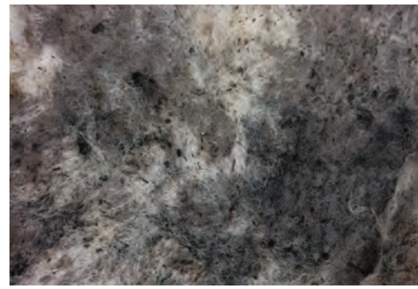


Figure 45 - The integration of seeds and soil in the process of wet-felting.

Maintaining Growth

After activation through watering, continuous maintenance was necessary to ensure that the growing process took place. Light, temperature, and airflow were dependent on the interior spaces in which the textile-seed hybrids were placed. The watering was carried out using a spray can for smaller objects and surfaces, and a watering can for larger objects.

The expressions of the textiles and their colour, feel, weight, and the amount of water that leaked out provided information regarding the amount of moisture that was contained or required. The textiles were placed on solid surfaces to ensure that the roots were always moist and could only expand horizontally, to extend the two-dimensionality of the textile seed surfaces.

Deactivating Growth

After an arbitrary length of time, the supply of water was cut off to explore the textile-seed hybrids in a transformed but passive state, in which the textiles re-gained their original expressions to an extent. In their passive states the examples did not need maintenance as they were no longer active, although reactivation was possible if they e.g. contained not-yet germinated seeds, meaning that there was the possibility of an 'afterlife'.

Initiating an Afterlife

'Afterlife' in this context is understood to be another process of growth in the life of a textile-seed hybrid, and means that it returns to a passive state after its transformation has taken place. The potential of the textile-seed hybrids for reactivation and biodegradation was explored in order to investigate an alternative life cycle for interior textiles, and so they were watered once, placed into glass jars filled with perlite substrate (a mineral substrate that is sterile, white, granulated, absorbs and stores water, and is very lightweight) for reactivation, and sealed in order to create a micro-climate that required no additional maintenance (similar to outdoor conditions with rain and a substrate for the hybrids to root in).

Figure 46: The experiments were conducted in glass jars to create micro-climates.

3 Min 5

Figure 47: A woven cotton-corn cloth that was activated using the heat of a microwave oven.

Exploring a Cotton-Corn Surface

This example explored a cotton-corn yarn that was woven into a piece of cloth and activated using heat to investigate the expressional changes that occurred due to the popping of the corn. A plain weave binding was used here, and the corn was held in place by knots in the cotton-corn yarn.

Setup

In order to explore the passive and active aspects of hybrid yarns and textiles, environmental changes in the micro-climate around the hybrids, influenced by forms of human management (e.g. applying heat or moisture) were used. As corn has a clear response to both heat and moisture, it was used to explore contrasting transformations in relation to textile surfaces, which were activated by a heat gun or microwave oven.

The dark blue cotton tube was filled with corn seeds using a straw. The seeds were first roughly positioned in the tubular knit and then, beginning at one end and working to the other, placed close to one another and fixed in place using knots (Figure 48). The cloth was then woven on a shaft handloom using plain weave and was activated using a microwave oven, being covered by a lid and then heated at a medium temperature until a couple of the corns popped. This process took a total of three minutes, with two breaks of a couple of seconds each in order to prevent the textile from burning.

Figure 48: The dark blue cotton corn yarn with fixing points, woven into a cloth.

1 Min 0

1 Min 0

Figure 49: The cotton-corn yarn, which was used as a weft material. The warp material, an off-white wool yarn, was also used as additional weft (shown in the upper part of the image).

Figure 50: A diagram that illustrates which parts of the life cycle the Figures 52, 54-57 belong to.

Transformation of the Expression

The woven cloth exhibited a contrast between the fine, dark blue knitted structure surrounding the corn seeds and the rough expression of the white woollen warp. In other examples, seeds were moved within the tubular yarn by the friction between the seeds and the warp. As the corn seeds in this example had a fixed position inside the tubular yarn, they could not move and were therefore regularly spaced. The size of the corn, diameter of the tubular yarn, and tight and close juxtaposition of the seeds and knots, as well as the yellow colouring, which contrasted with the dark blue tubular knit, visually stressed the fact that the knitted mesh was under tension and revealed its fine structure of loops. At this stage, the mesh was only interrupted by the sharp end of the droplet-shaped corn seeds that penetrated it. The expression of the plain weave was relatively arbitrary as the expression of the pattern was not heightened by the binding, but by the characteristics of the seeds that tended to displace the warp (Figure 49). In addition to these more visible qualities, the corn added a certain weight and rigidity to the overall textile, although it did not affect its pliability.

Figure 51: The woollen warp was pushed aside by the corn seeds.

1 Min 0

Figure 52: The tubular cotton material contained and stabilised the corn seeds, although sharp edges often protruded from or even damaged the knit.

1 Min 0

2

Min 3

Figure 53: The corn popped but remained inside the tubular knit.

Two stages can be described with regard to the activated cloth: popped (Figure 53) and popped and detached (Figures 47, 54). In the former, the corn expanded and extruded through the knitted structure, while in the latter the force of the popping corn destroyed the knitted structure and the popcorn became partially or entirely detached from the textile.

Contained in the strong seed coat of corn kernels is the endosperm, which is not only starchy but hard. If the water inside the endosperm is heated to the point that it becomes steam (>100°C), the hull must withstand a sharp increase in pressure. At the same time, the starch inside the corn softens and, if the pressure exceeds the ability of the hull to contain it (which occurs at c. 180°C), the kernel breaks and the foam within expands by 20-50 times the size of the original seed.

The foam is termed a 'flake' in the popcorn industry, which furthermore distinguishes between 'butterfly' (which have 'wings') and 'mushrooms' (which are generally ball-shaped and therefore less fragile) (CornPopper, 2018). The popped kernels that remained in the tubular knit were ball-shaped and similar in form to mushrooms. The white foam pressed against the seed coat and the knitted loops, expanding the tubular knit. The white colour of the foam created a visual connection to the white warp threads (Figure 53).

The corn that extruded through the knitted yarn was primarily butterfly-shaped. Some were kept in place by threads in which they became entangled, while others detached from the surface. The fully popped corn had fewer visible connections to the surface expression of the cloth, and appeared to have been placed there rather than integrated. Regardless of the state of the popped corn, its smell and the soft component of the foam added to the expression of the surface of the cloth. In contrast to growing corn, the popped corn did not exhibit directionality to light or moisture but temperature. The important parameters for the popping of a kernel are its internal moisture which is related to e.g. its freshness and the temperature to which it is heated.

Figure 54: The popped corn damaged the tubular knit and partially or entirely became detached from it.

3

Min 5

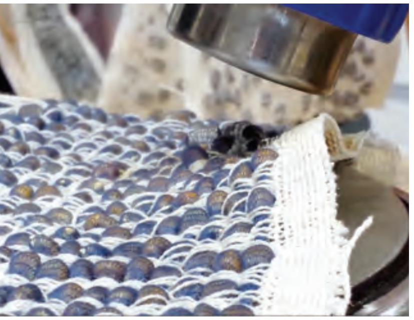


Figure 55: Another method of activating the corn was to use a heat gun.

Reflections

This example illustrates how a cotton-corn cloth can be activated and its surface expression changed. The two states that were observed are here referred to as 'popped' and 'popped out', and the terms 'mushroom' and 'butterfly' describe the two ways in which a kernel can expand. In relation to the textile in which the corn was integrated, the popped corn was shaped by the space that was available for its expansion. When the tubular knit was too narrow or the force too great, the knitted structure broke and the popped corn became detached.

The specific way in which corn reacts to heat and its transformation from hard to soft opened up for a range of possibilities with regard to textile design practice. The three-dimensional expansion and transition from hard to soft are interesting transformations with regard to upholstery textiles, providing hard and soft qualities in the same surface and using the same material. The process of upholstering could constitute the act of activating a textile in the desired areas, and can be undertaken with greater precision using a heat gun (Figure 55). The kernels that pop out of the textile surface can also be eaten or composted, and the smell adds another dimension to the sensory perception of the textiles.

Textile	**+**	**Seed**	**+**	**Maintenance**	**->**	**Transformation of the expression**
Material: wWhite wool, dark- blue tubular cotton knit		Material: Corn		Light: -		The seeds were heated, a few popped and became white/ yellow-brownish and fluffy, they began to smell, expand the tubular knit and thus the three-dimensionality of the cloth through the flexibility of the knit. Some of the popped corn remained in the textile, some was extruded and became detached.
Technique: Hand-woven		Shape/size: Droplet-shaped, yellow		Time: 3 minutes (Activation)		
Construction: Plain weave		Position: Juxtaposed, fixed by knots		Temperature: Medium power for 3-5 minutes (covered)		
Position: Horizontally draped				Nutrition: -		
				Humidity: -		

Table 3: The parameters that defined the passive and active expressions of the cotton/wool corn surface.

Figure 56: The activated cloth after it had been heated in a microwave oven.

Exploring a Cotton Corn Weave

As in the previous example, this example took the form of a cotton-corn weave that transformed not through growth but through popping corn and explored the resulting changes in expression. Furthermore, and in contrast to the previous example, the focus was on expansion, and so a very flexible, tubular knit was chosen and the corn not separated by knots, to allow unrestricted expansion, and a waffle binding was used to enhance the three-dimensionality of the extruded corn in relation to its placement.

Setup

In this example, the cotton-corn yarn was used to weave a waffle binding on a shaft handloom with an off-white cotton warp. The same material was used in the weft to stabilise the cotton-corn weave and make obvious the differences in expression between the two materials. The piece of cloth was then placed in a microwave and covered, and heated at a medium temperature for three minutes.

Figure 57: The cloth on a plate and under a cover in a microwave oven.

Figure 58: The activated cloth on a plate after it had been heated in a microwave oven.

Figure 59: The cotton-corn yarn on the weaving shuttle.

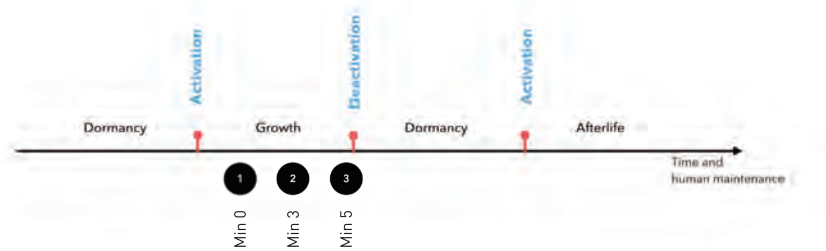


Figure 60: A diagram that illustrates which parts of the life cycle the Figures 65-67 belong to.

Transformation of the Expression

The tubular material in which the corn was integrated was very flexible. Inserting the corn was therefore easy and, even though the seeds shaped the yarn, it would have been possible to use larger seeds. The woven cloth exhibited an irregular sequence and seed interval, with irregular groups of corn wherein no pattern was visible but a sense of three-dimensionality was evident (Figure 61).

Only a few of the corn seeds popped, and most of these exhibited the 'butterfly' shape. Due to the flexible characteristics of the tubular material the corn did not break through the structure, but remained inside the tube and expanded the cloth's three-dimensionality (Figure 62). The waffle binding enhanced the three-dimensional alignment and expression of the textile (Figure 63).

Figure 61: The light blue cotton corn yarn in a waffle binding before activation.

1 Min 0

Figure 62: The cotton-corn weave after activation; the corn popped but remained in place.

2 Min 3

Figure 63: The activated cotton-corn; the three-dimensionality of the weave is obvious.

3 Min 5

Reflections

This example explored the expansion of a cotton-corn textile using heat. The tubular material was the foundation for the corn and supported its expansion due to the fact that the seeds were mobile, in contrast to the previous example (Figure 59). Thus, the number, density, and diameter of the seeds, along with the degree of stretch of the tube and duration of the application of the heat, affected the thickness of the cloth, which was also influenced by the long float and three-dimensional structure of the waffle binding (Figures 62, 63). Due to the seeds not being specifically positioned, they were not extruded as in the previous example. In contrast to the examples that transformed through growth, the transformation in this instance did not follow a specific direction, and the duration of the transformation as a result of rupture took very little time – minutes instead of days – and required a single form of maintenance (heat, and not moisture, light, and nutrients). As no moisture was needed and cotton is not strongly affected by heat, no premature degradation occurred. The activation by heat had other positive effects: the seeds became edible and developed a pleasant smell, creating an interesting perspective on interior textiles and their life cycles. Through the use of seeds that pop/burst, the expression can change from hard to soft, expand in certain places, become lighter in relation to its dimensions, change colour, and become edible. A combination of 'sprouting' and 'extruding' can also be achieved.

Textile	+	Seed	+	Maintenance	->	Transformation of the expression
Material: Off-white cotton warp, light blue tubular cotton knit		Material: Corn		Light: -		The seeds were heated, a few popped and became white/yellow-brownish and fluffy; they began to smell, expand the tubular knit and thus the three-dimensionality of the cloth through the flexibility of the knit. The popped corn remained in the textile.
Technique: Hand-woven		Shape/size: Droplet-shaped, yellow		Time: 3-5 minutes (Activation)		
Construction: Waffle binding		Position: Formed groups of 5-10 in the yarn		Temperature: Medium power (covered)		
Position: Horizontally draped				Nutrition: -		
				Humidity: -		

Table 4: The parameters that defined the passive and active expressions of the cotton- corn weave.

Figure 64: The cotton-corn surface in a state of degradation, with small grains of perlite entangled in the textile structure at the right.

Exploring a Cotton-Corn Surface

This example explored the visual effects of weaving with a cotton-corn seed yarn in which the seeds were mobile. The example disrupted the plain weave structure with a random arrangement of seeds and the process of germination and decay, particularly as regards changes in colour.

Setup

The foundational material in this example was a cotton yarn, which was knitted into a black tube that corn seeds were inserted into using a straw. A random quantity of seeds was distributed throughout the length of the yarn (Figure 65), which was then used in a plain-weave binding (Figure 66).

The woven textile was then watered and placed in a glass jar that was filled with perlite to initiate and manage the germination process, and sealed to create a micro-climate.

Figure 65: The black cotton-corn yarn used in the weaving.

Transformation of the Expression

The random placement of the seeds in the yarn contributed to the pattern of the cloth due to the varying distances between each (Figures 66, 67). The size and shape of the seeds distorted the plain weave pattern, pushing aside the warp threads and creating a gap akin to a running stitch in a knitted fabric (Figure 66). The seeds partially or fully extruded through the threads, but were held in place by the knitted yarn in which they were entrapped. This resulted in a dual expression of weave and knit, as the tube was stretched over the corn, making visible the knitted structure (Figures 66, 67). The quantity of and distances between the seeds affected the cloth's three-dimensionality, pliability, and weight (Figures 66, 67).

Figure 66: The arrangement of the corn seeds, showing how they affected the expression of the weave.

1 Day 0

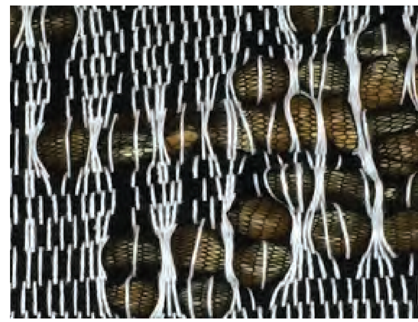


Figure 67: The expression of a dense arrangement of corn seeds within a plain weave structure.

1 Day 0

Figure 68: The random pattern that appeared when the black cotton corn yarn was woven with a plain weave. The white stripes separated the different sections.

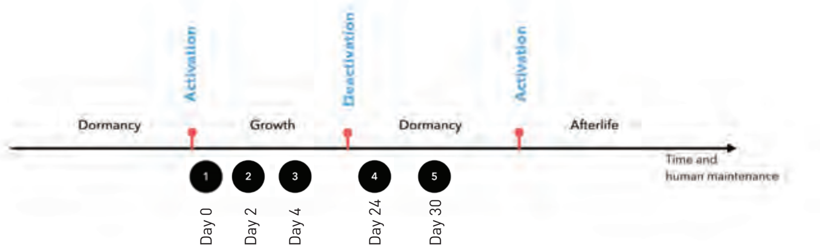


Figure 69: A diagram that illustrates which parts of the life cycle the Figures belong to.

Two days after activation, the first coleoptiles emerged. As the cloth was vertically positioned with the warp in a horizontal orientation, they became oriented upwards (against gravity), whereas the radicles grew downwards (with gravity). The coleoptiles were yellow-green, and the radicles had a colour gradient between white and red. Due to a lack of moisture, some dried out and lost a third of their former thickness, becoming of a similar thickness to the warp threads (Figure 72).

During the germination phase, the cloth became infected with mould and began to smell earthy and damp. Blue-green and white furry mould covered some of the seeds and their surroundings (Figure 64). The soft and furry layer of mould had a textile expression similar to that of a flock print, and bound the seeds into a more unified surface. However, the colours of the coleoptiles and radicles faded, and some developed a brownish colour (Figure 72). The overall impression of colour changed over time, and was much richer for the activated state than the passive cloth. To prevent decomposition and preserve the textile, the cloth was heat-dried in an oven. The example developed an overall brownish colour and all of the components merged into one another, resulting in a 'crispy' and more rigid piece of cloth (Figure 73).

Day 2
2

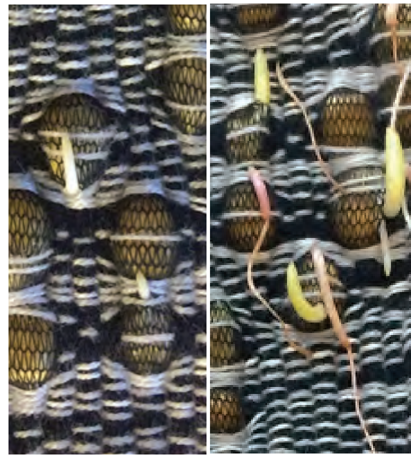


Figure 70/71: The coleoptile emerged first, followed by the radicles.

3
Day 4

Figure 72: An example on which green and white mould grew.

4
Day 24

Figure 73: The cloth was dried in an oven to stop the transformation process.

5
Day 30

Reflections

This example explored the effect of corn seeds on a weave across three phases. The expression of the cloth in its passive state – the dormancy – was determined by the size, distance between, and position of the corn seeds in the yarn, and involved a disruption of the regularity of the plain weave structure: The corn displaced the warp threads, and the seeds distorted the structure and extruded through the weave, connecting the weave and the tubular knit (Figures 71-73). When the cloth was activated, dynamic expressions such as changes in colour, dimensionality, surface characteristics, and smell occurred and developed in a unique manner over time (Figures 75-77). Through heat-drying, the process of transformation/growth was stopped (Figure 78), initiating another dormancy wherein the textile once again became dormant.

Textile	**+**	**Seed**	**+**	**Maintenance**	**->**	**Transformation of the expression**
Material: Off-white cotton warp, black tubular cotton knit		Material: Corn		Light: Indoor light		The seeds swelled, green coleoptiles and red radicles appeared, and fluffy green and white mould covered several areas on and around the seeds. The cloth turned brownish as a result of the drying, and the surface colour, dimensionality, and overall expression were affected by the textile becoming a 'crispy' piece of cloth.
Technique: Hand-woven		Shape/size: Droplet-shaped, yellow		Time: 30 days (Dormancy, Growth. Dormancy)		
Construction: Plain weave		Position: Formed groups in the yarn and the weave		Temperature: Micro-climate in a jar		
Position: Vertically draped				Nutrition: Perlite substrate		
				Humidity: Micro-climate in a jar		

Table 5: The parameters for designing and manufacturing the cotton-corn cloth.

Figure 74: The leaves of the alfalfa sprouts, which unfolded directly below the surface of the knitted structures.

Exploring a Viscose-Alfalfa/Barley Surface

In this example, alfalfa seeds were explored within a three-dimensional knit in order to investigate how they interact with a knitted surface in horizontal and vertical positions during the process of germination. The resulting expressions were compared to a similar experiment conducted using barley grass seeds. As both seeds undergo different forms of germination and vary in size and expression of growth, the focus was on how each alters the surface of textile structures.

Set–up

Barley grass seeds and alfalfa seeds were inserted into a white, three-dimensional knit consisting of a grid of circles with a layer of viscose, a layer of nylon, and a filling yarn between the two. The tension created by the nylon layer of the structure led to the viscose bulging, with the puffy yarn enlarging and creating a padded expression on the textile surface (Figure 78).

Barley grass seeds were inserted by hand or using scissors, which were used as a 'pincer', into small openings that were cut into the nylon structure at the rear of the textile in order to fill some of the circles with seeds. A paper funnel was used to insert 5-10 alfalfa seeds into each compartment (Figure 76). Once watered, the textiles were placed in a glass bowl at an angle so that they could be positioned horizontally and vertically at the same time (Figure 77).

Figure 75/76: The barley grass seeds were inserted using scissors (top), and the alfalfa seeds were inserted using a paper funnel (bottom).

Figure 77: The textile watered and positioned in a glass bowl.

1 Day 0

Figure 78: The uppermost layer of viscose of the three-dimensional knit.

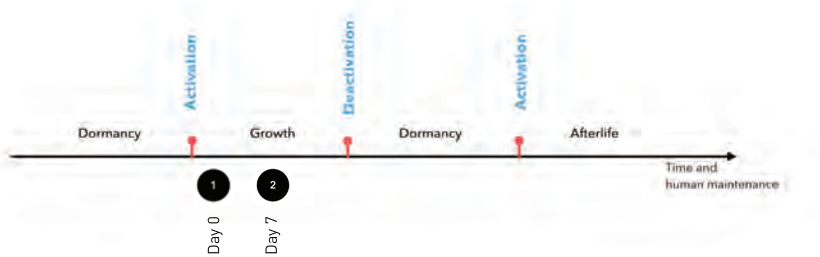


Figure 79: A diagram that illustrates which parts of the life cycle the Figures 85, 87-92 belong to.

Transformation of the Expression

The vertical part of the alfalfa knit changed its expression in displaying patches of an additional colour – brown – in the first row, fading in intensity in the lower ones. The seeds were inserted into the vertical middle rows of the fabric; those in the upper row germinated and grew out of the openings that were cut in the fabric, and so did not interact with the textile structure but grew towards the light and in the opposite direction to gravity (Figure 80). As alfalfa seeds germinate above ground, the embryonic stem pushes the seed leaves and seed coat upwards, where the two embryonic leaves unfold. Figure 80 shows leaves that remained unfolded within the seed coat at the upper right. Alfalfa seedlings that unfolded within two chambers instead of breaking through the textile structure are visible at the bottom of the image.

The rear of the three-dimensional knit remained white, but a number of seedlings grew out of the cuts through which they were inserted as seeds (81). No seedling interacted with the structure itself, and instead all chose this path of least resistance and grew against gravity. The roots, however, grew through the dense nylon structure, following gravity (81).

Figure 80: The surface expression of the vertical part of the three-dimensional alfalfa knit.

2 Day 7

Figure 81: The rear of the three-dimensional alfalfa knit.

2 Day 7

2 Day 7 **Figure 82:** The front of the horizontally aligned three-dimensional alfalfa knit.

2 Day 7 **Figure 83:** The back of the horizontally placed alfalfa 3d-knit.

The horizontally aligned part of the fabric had contrasting expressions, with the white pattern of circles disrupted by green stains. Here, the seedlings germinated and unfolded their two embryonic leaves directly under the viscose knit, inside the chambers in which they were planted as seeds. Due to the pressure exerted by the fabric, the leaves did not fully unfold in many cases and were compressed in different stages of unfolding (Figure 74, 82).

The rear of the fabric was expanded by roots growing in a serpentine fashion in search of water and nutrients. In contrast to the vertically growing roots, these grew towards the bottom of the glass vessel and, when this was reached, changed direction several times – resulting in a spiral, abstractly floral expression (Figure 83). Some of the seedlings grew out of the holes through which the seeds were originally inserted, with the embryonic stems pushing out and the leaves unfolding. Figure 83 shows seedlings, wrapped in dark brown seed coat and unfolding fresh, green dicots.

In contrast to the alfalfa, the sprouts of the barley grass, with their strong embryonic stems and one leaf, poked through the textile structure like a needle. The Figures 84 and 85 show the process of the seeds sprouting through the textile and the spicy expression of the grass-sprout when viewed from the front (Figure 85).

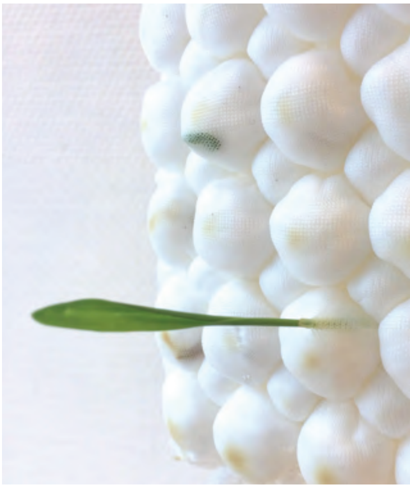


Figure 84: The front of the horizontally aligned three-dimensional alfalfa knit. 2 Day 7

Figure 85: The front of the horizontally aligned three-dimensional alfalfa knit. 2 Day 7

Reflections

This example explored how the type of seed germination and orientation of a textile can affect the interaction between seeds and a textile structure. The alfalfa seeds that grew towards the light did not have the energy or physiology to force their way through the textile structure, and so unfolded within the textile surface in the hope of accessing light and nutrients in order to continue their growth. A seed's properties and germination are therefore important factors to consider when designing surface expressions for seed textiles. The alfalfa sprouts had a more complex expression than the barley grass sprouts, even though they disrupted the physical structure of the textile less. The leaves that unfolded below the surface created a pattern of green dots in the white, circular chambers. This dynamic pattern was influenced by the number of seeds in each circle and in which circles in the grid they were placed.

The orientation of the textile had a strong influence on the germination. In a horizontal position, the sprouts developed vertically and this added dimensionality in both vertical directions. In a vertical position, the sprouts also developed vertically, but followed and extended the knitted structure in both directions. The direction of growth is therefore influenced by how the textile is oriented in relation to light and gravity.

The example also illustrates the value of the textile structure in relation to the type of seed and its growth. The alfalfa sprouts were not strong enough to break through the knitted viscose structure in the horizontal orientation, unfolding their leaves directly below the surface in order to absorb light. However, the alfalfa roots pushed through the denser rear of the textile without a problem due to their shape, which is both more streamlined and allows them to apply more force. The strong barley grass shoots made their way through the structure and were essentially not hindered in their growth.

The example also shows that sprouts prefer to grow through looser parts or holes in a structure in the interest of efficiency. Consequently, the direction of growth and the interaction between the seeds and the textile can be determined by the textile construction and thus by the designer.

Textile	+	**Seed**	+	**Maintenance**	->	**Transformation of the expression**
Material: 3d-knit face: Viscose Filling yarn back: Nylon		Material: Alfalfa		Light: Indoor light		The seeds germinated and the stems and leaves tried to find ways through the structure; some were successful, while some unfolded inside the structure. The roots grew and moved freely.
Technique: Knitting		Shape/size: Small, brown		Time: 7 days (Dormancy, Growth)		
Construction: Dense structure, creating a tension between the layers		Position: Inside the chambers of the three-dimensional structure		Temperature: Micro-climate in a jar		
Position: Horizontal and vertical				Nutrition: Perlite substrate		
				Humidity: Micro-climate in a jar (watered then sealed)		

Table 6: The parameters for designing and manufacturing the viscose-alfalfa surface.

86 - The dried cloth with merged cress plants in a PVA weave.

Exploring a PVA-Cress Surface

This example illustrates the interaction between PVA as a weft material and integrated cress seedlings in relation to watering. PVA stiffens and dissolves based on the amount of water applied, and so the experiment investigated the relationship between plants and the textile when material characteristics not only contrast with but are damaging to each other. The main interest here was thus exploring the potentials and expressions of this non-supportive combination of materials.

Setup

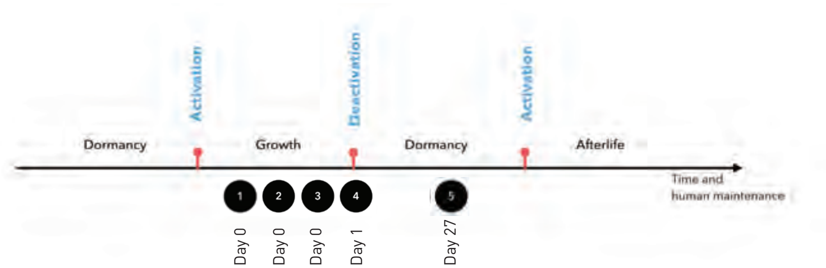
PVA was used as a weft yarn on a shaft-loom with a cotton warp, which was used for hand-weaving the textile. The cress seedlings were inserted by hand as an additional weft material, with the roots facing down and the embryonic leaves facing upwards. Two rows of cress sprouts were inserted in a plain weave structure. The cloth was then placed on a plate and watered once before being left to dry.

Figure 87: The integration of the cress sprouts during the weaving process.

1

Day 0

2
Day 0
Figure 88: The cress seedlings were integrated in the process of weaving with a PVA yarn on a shaft loom with a cotton warp.



89 - The diagram illustrates which part of the lifecycle the following images belong to.

Transformation of the Expression

During the weaving process, the tension of the warp threads held the cress in an upright position (Figure 88), they collapsed when the fabric was removed from the loom (Figure 90). By watering the cloth on a plate, the PVA began to shrink and dissolve, turning the material into a slimy gel. Due to the static placement on the plate and the overall shape of the material, the texture of the weave remained. During the drying process the sprouts began to degrade and turned the area surrounding them a brownish colour. The stems and leaves shrank, collapsed, and were left clinging to the sticky weave (Figure 91), with which they slowly merged.

Figure 90: The fabric after watering, at which point the PVA began to slowly dissolve.
3
Day 0

Figure 91: The fabric after one day; the cress had begun to degrade.
4
Day 1

Day 27

Figure 92: This photograph of the dried and rigid cloth was taken 27 days after its production.

The piece hardened while drying and became a stiff textile which had entirely lost its durability and textile expressions, aside from the visual ones. The plain weave structure condensed and became impenetrable, and the formerly three-dimensional green cress lay flat – as if ironed – on the textile, surrounded by colour gradients of yellow and brown originating from the biological process of degradation.

Reflections

This example shows that textiles and plants do not need to support one another in order to create an interesting expression. The temporal process by which the two materials interacted and merged gave rise to new expressions and design processes. The PVA-alfalfa hybrid, with its floral imprint, looked as if the plants had been pressed into its surface – even though the textile was not flat, but kept its draped shape. Thus, the process of degradation in a textile-plant hybrid can be part of a textile design process in which degrading plant parts collapse and merge into a textile surface as part of an application in which a three-dimensional life becomes a two-dimensional afterlife. Thus, sprouts can be grown in a textile, integrated as a pattern, and merge with the textile during the process of degradation similar in expression to a floral print.

Textile	**+**	**Seed**	**+**	**Maintenance**	**->**	**Transformation of the expression**
Material: Warp: cotton weft: PVA		Material: Alfalfa sprouts		Light: Indoor light		The Alfalfa collapsed, the textile shrank and became sticky, the Alfalfa started degrading, coloured the textile and both materials melted together
Technique: Hand-weaving		Shape/size: Green and ca. 5-7 cm long		Time: 27 days (Activation, Growth, Dormancy)		
Construction: Medium plain weave		Position: In two rows		Temperature: Micro-climate in a jar		
Position: Flat position on a plate				Nutrition: Perlite substrate		
				Humidity: Through a watering can		

Table 7: The parameters for designing and manufacturing a PVA-Alfalfa surface.

Figure 93: The alfalfa seeds were contained in the blue tubular weft, from where they grew out..

Exploring a Cotton-Alfalfa Surface

This hand-weaving example explored expressional changes in terms of three-dimensionality and colour-change in a striped pattern. The seeds were invisible in the passive cloth due to their size.

Setup

A piece of plain cloth was hand-woven on a shaft loom with an off-white cotton in the warp and as the main weft material. Blue stripes were woven with a cotton-alfalfa yarn with a diameter of 5-10 cotton wefts. During the process of filling the tubular knit, which took place during the weaving process and by moving the piece, some of the seeds fell out. Consequently, every movement decreased the number of seeds in the textile. The piece was placed horizontally on a piece of grey waxed cloth and water was applied regularly using a spray can.

1 Day 0

Figure 94: The plain weave on the loom; the seeds that are visible have fallen out of the textile – this was the only time they could be seen, as those integrated in the textile were completely hidden in the structure.

Figure 95 - The diagram illustrates which part of the lifecycle the Figures belong to.

Transformation of the Expression

The white weave with its blue cotton alfalfa yarn stripes appeared to be a normal piece of cloth, with only the tiny seeds on the surface that had fallen out of the yarn suggesting that another material was involved in its creation (Figure 93). After three days of regular watering, the off-white cotton material took on a yellowish tone and the blue stripes in the middle of the piece darkened and became more three-dimensional. At the corner of a stripe consisting of two wefts, several alfalfa seeds began germinating. The embryonic stem pushed the seed leaves and seed coat through the textile structure (Figure 96).

After another four days, most of the integrated seeds had fully germinated and almost all of the embryonic leaves had shed their seed coats. The sprouts had grown towards the light, although some at the outer edges had tilted slightly due to a lack of support (Figure 97). Roughly five sprouts germinated on the rear of the fabric; their leaves were light green, whereas those on the other side were a deep green. The roots grew out of the fabric's rear (Figure 98), and their colour, diameter, and thread strength was similar to that of the cotton used in the warp and weft. The direction in which they grew, however, disrupted the expression of the plain weave, which was based on right angles, and its two-dimensionality. The stems and leaves expanded the dimensions of the textile surface, through the outgrowing stems and as did the embryonic roots on the rear.

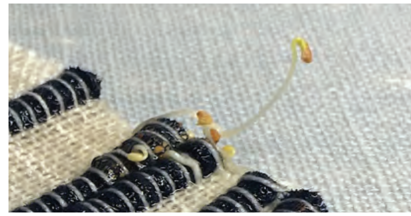


Figure 96: The wet cloth in which several alfalfa seeds germinated.

2 Day 3

Figure 97: After 7 days, the sprouts built a deep-pile in one area of the cloth.

3 Day 7

Figure 98: The rear of the textile was partially covered in white roots and several sprouts that were searching for light.

3 Day 7

Reflections

The cotton-alfalfa surface explored the transformation of a hybrid surface; one in which seeds are largely invisible to one that is fundamentally changed in terms of colour and vertical dimensionality. Consequently, seeds in textiles can be used to change surface expressions through the colour of their stems, leaves, and roots. Their colour, shape, size, and strength defined whether they adapted to or contrasted with the expression of the textile structure, yarn strength, colour, bindings etc. The direction in which the sprouts grew was dependent on the position of the textile in space in relation to gravity and physical restrictions such as a solid surface, as well as the availability and direction of the source of light. Furthermore, the orientation of the alfalfa, (a dicotyledon that undergoes epigeal germination) was related to where in the structure the leaves were able to push through . The pattern of growth varied based on how the sprouts grew, the density of the seeds within the tubular material, and how many were lost during the process of weaving and handling the cloth. The thickness of the pattern related to the seeds and time, and the overall expression was somewhat similar to that of a deep-pile rug.

Textile	+	Seed	+	Maintenance	->	Transformation of the expression
Material: Warp: cotton weft: blue cotton (filled with Alfalfa seeds)		Material: Alfalfa		Light: Indoor light		Application of water triggers colour-change of textile, fragile stems with seedleafs in their seedcoat emerge, the leaves unfold and add the colour green as well as organic threedimensionallity to the surface expression, the threedimensional expression on the back is shaped by white roots
Technique: Hand-weaving		Shape/size: Very small and brown		Time: 7 days (Dormancy, Growth)		
Construction: Plain weave		Position: Woven in stripes		Temperature: Micro-climate in a jar		
Position: Horizontal placement				Nutrition: Perlite substrate		
				Humidity: Through a spray can		

Table 8: The parameters for designing and manufacturing the cotton-alfalfa surface.

Figure 99: A cotton-chickpea surface in a second sleep phase, having been dried in an oven.

Exploring a Cotton-Chickpea Surface

The effect of degradation on colour and pliability of a cotton-chickpea surface is illustrated in this example, wherein a densely filled cotton-chickpea yarn was woven into a piece of cloth and partially activated. The example also investigates whether a textile can be partially (rather than fully) activated in order to directly compare the different expressions that result.

Setup

The cloth was woven on a shaft handloom with a white cotton warp and light blue cotton-chickpea yarn weft (Figure 100). Chickpeas were inserted in such a density that they touched one another, resulting in a material with a diameter equal to that of the peas, a certain rigidity, opacity, heft, and a beige colour that complemented the light blue knit. This density of the material fundamentally affected the expression of the plain weave structure (Figure 101). A white cotton yarn used in the weft to frame the ´chickpea weave`stabilised the borders of the weave, preventing the cloth from falling apart when handled. The cloth was placed in a glass bowl with perlite, with half of the textile hanging vertically over the edge of the bowl while the other lay on the substrate. The half that was in contact with the substrate was watered once, and the bowl was then sealed (Figure 102).

Figure 100: A close-up of a cotton-chickpea yarn.

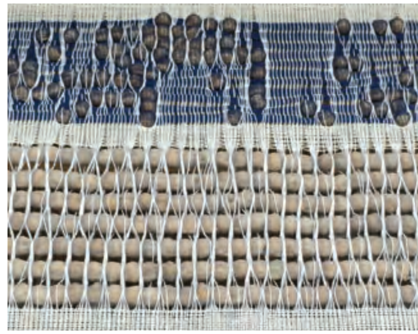


Figure 101: Different hybrid yarn spacings affected the pattern.

Figure 102: A close-up of a cotton-chickpea yarn.

1 Day 0

Figure 103: The weave, after it had been removed from the loom. The warp threads that were woven between the chickpeas during the hand-weaving were relaxed when this photograph was taken.

Figure 104: A diagram that illustrates which parts of the life cycle the Figures belong to.

Transformation of the Expression

On the loom, the weave had an open expression, with the large, round chickpeas spaced at regular intervals. During the weaving process, the chickpeas moved the warp threads, which collected between the peas. As each weft moved the warp threads, some of the th-reads were displaced to between or on top of the peas, creating a varied pattern that ranged from a clear grid to various crossed structures (Figure 105). The passive cloth was quite heavy and pliable to a certain extent, depending on the distance between the chickpeas within the tubular knit. The beige chickpeas and white cotton warp dominated the overall expression.

The uptake of water resulted in the swelling of the peas (which also developed a transparent slime) and thus the stiffening and reduction in pliability of the textile. Mould started to grow on the slimy parts of the peas and the cloth. After drying, there was a clear difference in colour between the not-activated (Figure 106, top) to and deactivated (Figure 106, bottom) parts of the piece.

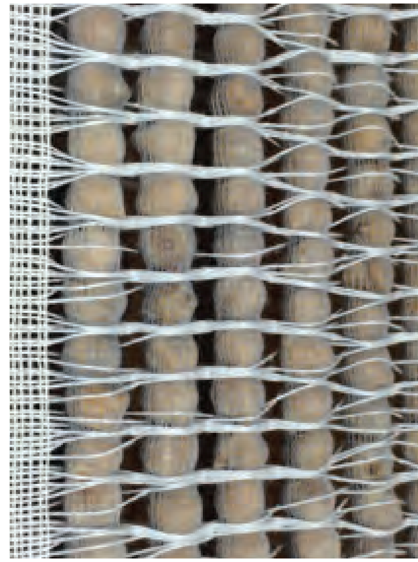


Figure 105: The cloth on the loom shows the effect of the cotton chickpea yarn on the white cotton warp.

1 Day 0

Figure 106: The difference in expression between the not-activated (top) and deactivated (bottom) parts of the cloth.

2 Day 27

Day 0

1 **Figure 107:** A close-up of the relaxed, not-activated weave.

Day 27

2 **Figure 108:** A close-up of the deactivated part of the cloth, showing its change in colour.

The difference between the not-activated and deactivated parts of the cloth is shown in Figures 107 and 108. Whereas the warp threads of the weave under tension on the loom were stretched, moving and separating the chickpeas, the relaxed warp threads retained their positions but were more closely spaced (Figure 105), defining the pliability of the piece in warp and weft direction.

The chickpeas in the deactivated part of the cloth were much closer to one another due to the swelling that occurred. The slime covered and connected the components of the surface in the manner of a gluey coating and dried, connecting the components (the chickpeas, knitted tube, and warp threads). All of the components changed colour; the chickpeas from beige to brown, the tubular knit from light blue to light grey, and the white warp threads from off-white to beige and brown. In addition, the fluffy layers of dried mould changed from white to grey and grey-green, and covered some of the chickpeas. The brown coating glued together some of the warp thread bundles and, as a result of this and the increased size of the peas through their swelling, the structure had a tight and rigid expression (Figure 108). The formerly pliable structure thus became turned into a rigid composite (Figure 109).

Day 27

2 **Figure 109:** The difference in pliability between the not-activated and deactivated parts of the cloth.

Reflections

This exploration ascertained that the density of the seeds in the knitted envelope fundamentally influenced the characteristics and behaviour of the yarn, and consequently that of the woven cloth. The plain weave, as a stable construction, created a surface that was durable and pliable to an extend that was defined by the density of the peas. The germination phase was skipped and the textile proceeded directly to degradation, evidenced by the development of slime and mould. These products of decay served as a coating or filler, gluing together the seeds and the textile and thus creating a rigid composite and aesthetic hybrid through the material connection and alignment of the colours. Thus, mould can be seen as a coating that joins textile and biological material into a hybrid entity and, moreover, stiffens a structure.

Textile	**+**	**Seed**	**+**	**Maintenance**	**->**	**Transformation of the expression**
Material: Warp: Off-white cotton weft: light blue cotton (filled with Chickpeas)		Material: Chickpeas		Light: Indoor light		Seeds swell, got covered in gelatinous liquid, seeds developed mold, colour-change, deactivation stabilizes and stoppes the transformation (molding), colour-change, passive state
Technique: Hand-weaving		Shape/size: Big and round		Time: 27 days (Dormancy, Growth, Dormancy)		
Construction: Plain weave		Position: All over as weft material		Temperature: Micro-climate in a jar		
Position: In an angle: vertical and horizontal position				Nutrition: Perlite substrate		
				Humidity: Once watered then sealed		

Table 9: The parameters for designing and manufacturing the cotton-chickpea surface.

3

Day 7

Figure 110: The cotton-grass surface.

Exploring a Cotton-Grass Surface

This example was crocheted using a cotton-grass yarn, and illustrated the changes in colour and shape of a flat circular surface during the stages of its life cycle. In particular, it investigated the similarities between degraded plant parts and textile expressions.

Setup

The surface was crocheted using rose-coloured cotton-grass yarn. In comparison to barley and corn, the grass seeds used here are generally sown in gardens and thus are thinner, softer, and do not grow to be as tall. The crochet work began with a small circle that expanded with each row. The structure was placed horizontally on a piece of waxed, grey cloth. Activation and further maintenance were carried out using a spray can, with the piece being watered 2-3 times daily. After a growing phase of 10 days the watering was stopped in order to initiate the degradation of the grass and observe the changes in expression, comparing the initial, active, and deactivated textile.

3 Day 7

Figure 111: The passive textile after it had been transformed during the growing process then deactivated.

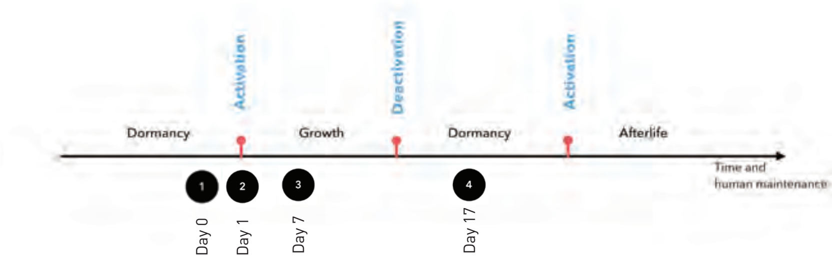


Figure 112: A diagram that illustrates which parts of the life cycle the Figures 129-130, 132-137 belong to.

Transformation of the Expression

The rose-coloured crocheted piece deepened in colour and became heavier and more pliable as a result of watering (Figure 114). The grass seeds, which were similar to barley grass seeds but thinner, smaller, and softer, collected in small groups within the tubular yarn. Some extruded from the tubular knit, but remained attached to the surface due to their fiborous hull (Figure 113). The grass germinated within 2 days and added a three-dimensional layer of green (Figure 110) to the rose colouring of the crochet work.

Figure 113: A close-up of the structure that was crocheted using cotton-grass yarn.

1 Day 0

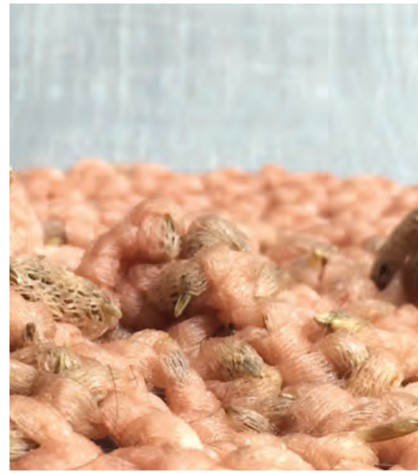
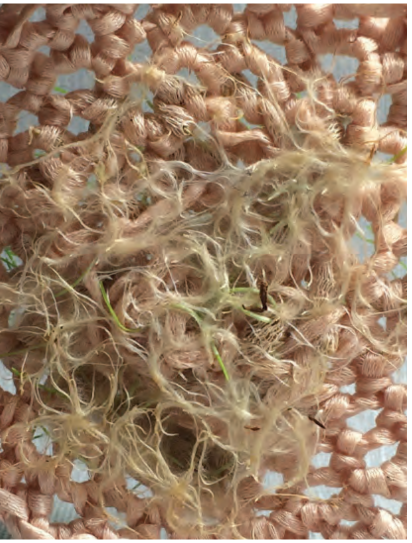


Figure 114: A close-up of the same structure, taken from the side and after watering.

2 Day 1



3 Day 7

Figure 115: The roots on the rear of the textile.

Whereas the surface of the textile was covered with green grass growing upwards, the rear was covered with white roots that grew in a serpentine fashion, forming a pattern of their own underneath the crocheted one. The root pattern covered parts of the open crocheted structure, and was flat due to the waxed cloth restricting the growth of the roots. Some light green grass grew among the roots in an attempt to reach light. The root coverage on the rear of the textile and the grass on the surface clustered around its centre, becoming thinner towards the outer edges.

As a result of the deactivation, the roots shrank and turned dark brown. This revealed the crocheted structure due to the reduction in diameter of the roots to less than that of the yarn of the tubular knit. When the textile was dried, the rose-coloured crochet lightened and returned to its initial colour. In the central areas that were covered by roots, the textile was slightly discoloured, with a yellow-brown tone.

4 Day 17

Figure 116: The dried roots.

The fresh grass sprouts on the surface of the textile (which could be considered to be 'above ground') added an intense green colour and were up to seven centimetres tall. The grass grew straight, similar to a tufted carpet with a deep pile (Figure 117). The growth of the grass was limited by the energy available in the seed as no additional nutrients were added.

By initiating a drought to deactivate the surface, the grass lost its green colour and rigidity and decreased in diameter, collapsing and becoming entangled. Just as with the roots, the grass had a textile-like expression, similar to thin, light-brown linen threads that had been tufted onto the crochet work (Figure 118).

Figure 117: Grass on the surface of the textile.

3 Day 7

Figure 118: Dried grass that collapsed on the surface of the textile.

4 Day 17

Reflections

This example explored the similarities between the expressions of plants and textiles throughout the life cycle of a hybrid. The textile expression of the passive piece was slowly superseded by the growth of the grass, although the drying process reversed this by transforming the expression of the plants such that they came to resemble textile structures such as a tufted linen yarn in terms of their colour, thickness, dullness, and reduced strength. Consequently, grass could be used as a design material in creating a living pattern for a carpet which, in fading, adapts to the surface expression and can continue to be used as a passive interior element, with an additional biological component as a new textile element.

Textile	**+**	**Seed**	**+**	**Maintenance**	**->**	**Transformation of the expression**
Material: Cotton		Material: Grass		Light: Indoor light		The colour of the cotton yarn intensified when wet, green grass was extruded straight vertically upwards, white roots covered the textile surface from below which turned brown through wittering, the grass turned brownish and collapsed.
Technique: Crochet		Shape/size: Medium / sharp		Time: 17 days (Dormancy, Growth, Dormancy)		
Construction: Open but stable construction		Position: Mostly centered		Temperature: Room temperature		
Position: Horizontally placed				Nutrition: -		
				Humidity: Through a spray can		

Table 10: The parameters for designing and manufacturing seed yarns.

2
Day 3

Figure 119: The cotton-barley grass application in a stitching frame.

Exploring a Cotton-Barley Grass Application

This example illustrated an application on a Jacquard weave, which was crocheted with a cotton-barley grass yarn to investigate changes in expression. The focus was combining a three-dimensional structure and a flat surface, creating the potential for a three-dimensional change that could be activated at will, was subtle, and when deactivated allowed the textile to be used as usual.

Setup

The foundation for the crochetwork was a Jacquard weave with a black warp and white weft. The pattern consisted of contrasting bindings that were open or very dense. The open parts of the structure were penetrated with a crochet hook to crochet directly onto the weave, and so a green cotton-barley grass yarn was used (Figure 120). The finished textile was then fixed onto a stitching frame to simulate an interior textile under tension (e.g. upholstery) and to allow the handling and maintenance of the piece (Figure 119). Once positioned horizontally (at a slight angle), it was watered with a spray bottle 2-3 times per day. After eight days, a drought was initiated to deactivate the example and to preserve in a passive state.

Figure 120: The cotton-barley grass yarn was crocheted onto the open weave structure.

1
Day 0

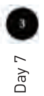


Figure 121: The textile eight days after activation.

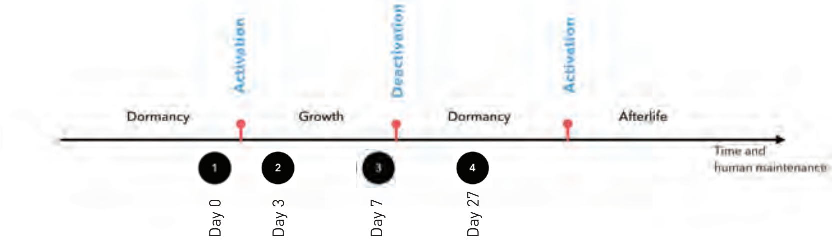


Figure 122: A diagram that illustrates which parts of the life cycle the Figures belong to.

Transformation of the Expression

Two days after activation, the first light green coleoptiles broke through the green knitted tube. As they were positioned at different angles within the tube, they aligned with one another and grew vertically upwards (Figures 121, 122). Their light green colour was very similar to the green of the tubular material, meaning that the initial changes were very subtle (Figure 123). During the process of crocheting, the seeds were squeezed in order to position them in the loops of the crocheted structure, accentuating and highlighting its organic shape (Figure 124).

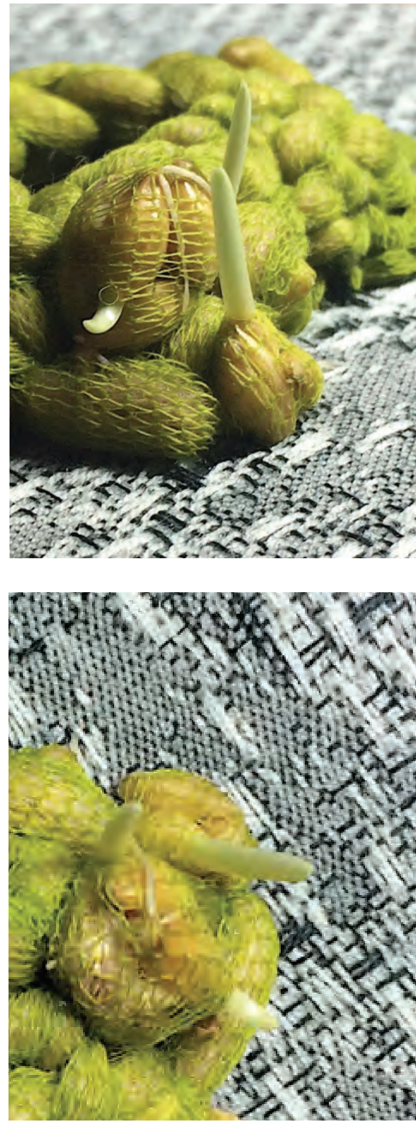


Figure 123/124: The position of the barley-grass seeds in the crocheted structure, from the front (Figure 123) and above (Figure 124).

3 Day 7 **Figure 125**: The leaves became a darker green and stood out from the green crochet work.

4 Day 27 **Figure 126:** The withered leaves, which dried and turned light brown, nestled around the crochet work.

As the coleoptiles developed and theur leaves unfolded, showing a dark green in relation to the crocheted structure, the transformation became more visible and three-dimensionally extended the application with its isolated sprouts (Figure 125).

After eight days of growing, the initiated drought caused the stems and leaves to wither. They collapsed, wrinkled, turned a light brown, and stiffened, but remained attached to the seed coat and roots (Figure 126). Some seeds developed white and grey mould that spread and covered parts of the hybrid yarn like a fibrous coating. Due to its colour, it created a link between the Jacquard weave and the application. The strong green of the wet cotton barley grass yarn became yellowish-green and thus connected with the brown-yellow of the dried grass straws that nestled around the crochetwork.

4 Day 27 **Figure 127:** The deactivated application and a quantity of mould, which visually connected the weave and the crocheted application.

Reflections

The cotton-barley grass textile involved an application which was manually croc-heted onto an industrially produced Jacquard weave using the open binding that characteritzed parts of its weave construction. The pattern of the loose binding influenced the shape and position of the application. Its three-dimensionality was expanded by the growing of the grass, but was subtle due to the similarity in colour of the two. Applications are a common means of highlighting and embellishing a relatively neutral textile. In the field of smart textiles, textile applications are often used to integrate sensing and actuation materials, which generally feature electronic components, with a piece of cloth. The example utilised the sensing and actuation capabilities of barley grass seeds, and reacted to moisture and light in its environment. The subtle quality of the change in expression resulted from simila-rities in colour, as that of the seeds, sprouts, and dried grass were similar to the green of the tubular material, visually integrating the biological material into the textile application during all of the stages of its life cycle. Due to its limited size and isolated placement, the maintenance of the application did not affect the rest of the piece of fabric, which would be an important factor if the example were to be placed on an upholstery textile that was used for a piece of furniture. Thus, the context of use and the use of colour in relation to the development of the seed are important factors for designing textiles using seeds as a material for textile design.

Textile	+	**Seed**	+	**Maintenance**	->	**Transformation of the expression**
Material: White cotton warp, black cotton weft, green knitted cotton tube		Material: Barley grass		Light: Indoor light		Coleoptiles that were the same colour as the tubular knit grew through it, became a deeper green and, unfolded leaves. White mould developed on the yarn/seeds, the textile dried out, and the leaves collapsed, turned light brown, became dry, and nestled around the application.
Technique: Jacquard weave, cro-chet		Shape/size: Medium / sharp		Time: 27 days (Dormancy, Growth, Dormancy)		
Construction: Weave with loose and dense con-struction		Position: As seed yarn applied onto the weave		Temperature: Room tempe-rature		
Framed and horizontally positioned				Nutrition: -		
				Humidity: Through a spray can		

Table 11: The parameters for designing and manufacturing a cotton barley grass applica-tion.

4 Day 12

Figure 128: The corn seeds, positioned at the outer rim of the crochet work, created a fence of shoots and roots.

Exploring a Cotton-Corn Crochet

This example offers a somewhat architectural perspective on integrating corn seeds in the outer part of a crochet work. The roots stabilised the textile and connected it to the ground, while the stems and leaves built a fast-growing fence. Furthermore, the example explored the internal energy of seeds, as no nutrients or substrate was added.

Setup

A certain part of a tubular white cotton knit was filled with corn seeds and crocheted into a round object. The placement of the seeds in the end of the knitted tube and the crocheting technique starting from a loop and adding circles enlarging the construction horizontally resulted in their positioning in the outer rim of the surface (Figure 128). For activation, the piece was placed on a water-repellent waxed cloth and watered regularly with a spray can. No substrate or nutrients were added.

Figure 129: The crocheted surface before it was activated.

1 Day 0

Figure 130: The surface two days after activation.

2 Day 2

Transformation of the Expression

The cotton tube and corn seeds swelled as a result of the watering. The knitted structure became smooth as the fibres aligned. Two days after activation, 1-2 cm-long white radicles developed, pointing in different directions but reaching down, following gravity. The coleoptiles were light green, and their tiny (less than 0.5 cm) tips pointed upwards (Figure 130).

Due to the solid surface on which the textile was placed, the radicles expanded horizontally underneath the textile and beyond its edges (Figure 131). The light green stems retained a light green colour. During the process of growth, the edges of the crochet work curled at two sides, causing the roots to first grow vertically and then to the sides (Figure 128).

The roots and some of the stems took on a red colour, while the leaves unfolded and turned a deeper green. Thus, the initial colour palette of white and yellow was expanded by different tones of red and green. With the growth of the corn, some of the seeds were infected with a green mould that covered the seeds

Figure 131: The sprouting corn expanded the textile upwards and to the sides.

3 Day 5

1 Day 0

Figure 132: The bottom of the crocheted surface; the corn seeds are visible in the curled rim.

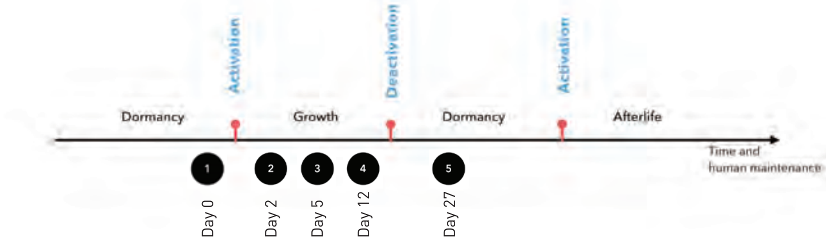


Figure 133: A diagram that illustrates which parts of the life cycle the following images belong to.

and surrounding fabric. A drought was initiated after Day 7 to interrupt and stop this process and explore whether the crochet work, which had expanded vertically, could return to its previous expression. The object was dried in an oven to speed up this process (Figure 135). The white cotton took on a light brown colour and the leaves collapsed, stiffened, and also turned brown. The original form of the surface thus reappeared, having been overgrown. The corn seeds in the rim took on a dark brown expression colour.

Reflections

This example illustrated that seeds, when positioned in a specific area of a textile, can create a three-dimensional expression in order to e.g. connect it to the surface on which the textile is placed or tie it closely to a specific area. The textile-seed hybrid did not need a direct connection to the surface for this connection to be established, as the roots automatically grew in the direction of gravity and thus bridged this gap. The roots and shoots also created a spatial and visual vertical boundary, which was defined by the position, distance between, type, pattern, and speed of growth of the seeds, as well as the colour of the resulting shoots. This barrier was temporary and dependent on the life cycle of the plants and support of the environment. As corn is an annual plant, its life cycle takes place over the course of a year. However, as it is a grass and therefore very fast-growing, it can reach up to three meters in height and thus has an architectural dimension.

The example shows that a process of degradation resulting from e.g. a drought can reverse a transformation and create an expression that is similar to that of an not-activated state. Here, the relationship between the dimensions of the textile, the seeds, and the environment is fundamental.

Figure 134: The sprouting corn affected the dimensions and colour of the cotton corn crochet.

4 Day 12

Figure 135: The drying process returned the cotton- corn crochet to its original dimensions.

5 Day 27

Textile	+	Seed	+	Maintenance	->	Transformation of the expression
Material: White knitted cotton tube		Material: Corn		Light: Indoor light		The textile became glossy and the seeds swelled; radicles appeared and grew downwards, and coleoptiles grew upwards. The surface was expanded upwards, before the drying process caused everything to collapse and the plant material to turn brown, shrink, and become dry. The surface reverted to its flat state.
Technique: Crochet		Shape/size: Droplet-shaped, yellow		Time: 27 days (Dormancy, Growth, Dormancy)		
Construction: Medium construction		Position: Outer rim		Temperature: Room temperature		
Horizontal position in space				Nutrition: -		
				Humidity: Through a spray can		

Table 12 - Important parameters for designing and manufacturing cotton-corn yarn.

DYNAMIC SHAPES

Exploring Textile Seed Shapes

The following section shows the developed methods and techniques in relation to three-dimensional textile 'plant containers'. The handmade dynamic materials were used to create the examples, and aspects of the dynamic surface examples were also utilised. Crocheting and tubular knitting were the primary textile techniques used; the crocheted structures were placed on a stable surface, while the knitted structures were suspended.

The first crocheted examples consisted of empty textile vessels to which no substrate or nutrients were added, whereas the subsequent ones were filled with soil as a substrate. Soil was also used for the knitted structures, which were filled with seeds and substrate to form chambers using knots. The principle of the tubular knits thus followed that of the seed yarns, albeit on a larger scale. The crocheted objects were watered with a watering can, and the suspended structures with a watering can, spray can or dipped into a bucket filled with water. The crocheted objects explored multi-purpose designs in relation to an alternative life cycle of a textile object, and were designed to allow plants to be handled in alternative ways, and to gather information about thesem. The positioning of the seeds was also a particular focus.

The suspended structures exemplified vertical approaches to organising seeds, plants and substrate. Exploring the effects of growth and decay was a goal in relation to the creation of both types of example.

Figure 136: Watering a textile-seed hybrid.

Figure 137: The feel, weight, and leakage of dust of the hybrids provided information regarding the amount of moisture they contained.

3
Day 7

Figure 138: The woolmix-corn shape on Day 7.

Exploring a Wool Mix Corn Shape

This experiment explored the concept of partially integrating seeds into a textile object and observing how this affected the expression of the section of the textile where the seeds were integrated, as well as the overall appearance.

Setup

Yellow corn seeds were inserted into the first section of a fine tubular woolmix knit and crocheted into a three-dimensional vessel, featuring a bulky bottom and upper section that was similar to the neck of a bottle. As the corn was situated in the first part of the tube and the bottom of the object crocheted first, the seed filled yarn constituted the bottom of the object and weighed it down. The fine material and relatively open structure of the tubular knit highlighted the colour and shape of the corn and was subtle in relation to it, whereas the area in which the tubular material created a crocheted structure and that had not been filled was grey, fluffy, and dense. Thus, there was a strong contrast between the two parts of the object. It was placed on a glass surface (later a waxed cloth), and water was applied using a spray can 2-3 times per day to activate germination and maintain growth. After 12 days a drought was initiated and accelerated by drying the piece in an oven.

5 Day 24

Figure 139: The dried woolmix-corn shape with a nest of stems, leaves, and roots, photographed from above.

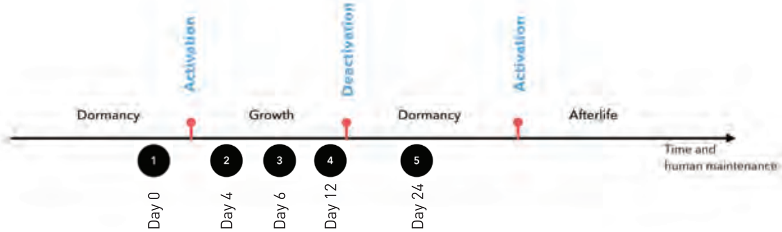


Figure 140: A diagram that illustrates which parts of the life cycle the Figures belong to.

Transformation of the Expression

The intuitive process of creating three-dimensional textiles using crochet technique resulted in a design process that in dialogue with the material – the seed yarn – produced a vessel-like object that was weighted down and stabilised by corn, which also provided a visual contrast. The fine net of the tubular material which held the corn in place was subtle but noticeable. The overall shape was bulky, and coloured light grey at the top and light yellow at the bottom (Figure 141).

The application of water changed the expression, making it dark grey and strong yellow, stiff, and thinner (Figure 142). The wool contracted and the yarns of the crochet and knitted structure became indistinct and fuzzy. The contrasting change in shape – the thinning at the top and swelling at the bottom – and increased colour contrast produced a change in expression that was at first dominated by the reaction of the wool to the water. The corn responded to the activation by sending radicles in search of water (Figure 142), which positioned, stabilised, and enlarged the textile vessel towards the ground and horizontal.

After the development of the roots, the first shoots – strong, light green hypocotyls – appeared, pointing straight upwards (Figure 143). While the network of roots expanded, the stems continued to grow and pushed up a green leaf, which unfolded; some also turned dark red. The root system was a dense network that surrounded the object horizontally due to its being located on a hard surface instead of substrate. The roots and shoots developed a red colouring that was most intense near to the seeds, and the stems and leaves grew beyond the top of the vessel, expanding its expression in all directions.

Figure 141: The crocheted structure dominated the object's top section, while the tubular knit holding the corn is visible below this.

1 Day 0

Figure 142: The upper part of the object became thinner while the lower part swelled.

2 Day 4

With increasing growth, the seeds developed mould (Figure 144). 12 days after germination had taken place, a drought was initiated and the decay was sped up by drying the object in an oven. The deactivated object lost all shades of green and red and returned to its original height, as the stems and leaves shrivelled and collapsed to the sides. Due to the drought, all of the colours disappeared and the leaves and roots entangled so as to be no longer distinguishable from one another. The object decreased in weight, lost its pliability, and became an almost entirely rigid object (Figure 145).

3 Day 6

Figure 143: The coleoptiles reached upwards; the crocheted object is still clearly visible.

4 Day 12

Figure 144: The stems and leaves grew to be twice as tall as the object. A dense network of roots reaches off to one side.

5 Day 24

Figure 145: The deactivated, passive object, which had lost its colour but gained additional material that supplemented its original shape.

Reflections

The woolmix-corn shape illustrated changes in expression in an object in which seeds were partially integrated, and investigated the nature of these changes in relation to its life cycle. The object expanded horizontally through the development of roots and vertically through the growth of stems and leaves, adding colours to the original expression (Figure 144). Although such biological developments are not reversible, many expressions that change fundamentally through processes of growth can be partially reversed through processes of decay: The added colour disappeared and the vertical expansion collapsed, revealing the original shape and height of the object (Figure 145). The two passive states – the not-activated and the deactivated – differ in terms of the expression of the lower part of the object. That of the not-yet-activated shape was characterised by the yellow corn, while that of the deactivated shape was characterised by the dried, brown leaves, stems, and roots. The upper part changed colour, but largely maintained the same shape. As in the previous examples, the expressions of decay were aesthetically more interwoven with the textile expression than the aesthetics of growth, which tended to outshine the original. The aesthetics of growth, however, added new expressions, such as three-dimensional expansion, colour, and scent. Thus, the aesthetics of decay blurred the boundaries between textile and plant, creating an aesthetic hybrid.

The combination of textile three-dimensionality and forms of plant development was rich in potential and created a dialogue between the materials, expressed by their intertwining throughout the process of transformation. Two terms can be used to describe this transformation; 'imposing', which relates to processes of growth, and 'accentuating', which relates to processes of decay. Whereas the original expression of the textile seed hybrid often cannot compare to that which results from the growth of seeds (i.e. the expression created by the activation), decay accentuates the textile through the alignment of the textile and biological expressions, and can thus be seen as a 'glue' or design material for aesthetic plant-textile hybrids. Furthermore, the open nature of the expressions created stimulate interpretation and thus which makes them suitable for discussion.

Textile	**+**	**Seed**	**+**	**Maintenance**	**->**	**Transformation of the expression**
Material: Grey wool/polyamide		Material: Corn		Light: Indoor light		The seeds swelled and the object contracted and darkened. The knitted construction became subtle, radicles reached out to one side, and light green coleoptiles reached upwards and darkened. Leaves unfolded and turned deep green, while roots and stems became red; the roots shrank and, the leaves collapsed, turned brown and revealed the woollen object.
Technique: Crochet		Shape/size: Droplet-shaped, yellow		Time: 24 days (Dormancy, Growth, Dormancy)		
Construction: Vessel-like object		Position: Lower part		Temperature: Room temperature		
Position: Upright				Nutrition: -		
				Humidity: Through a spray can		

Table 13: The parameters for designing and manufacturing wool mix corn yarns.

Figure 146: The image shows the empty textile envelope and the chickpea-yarn that was used to crochet its funnel-shaped rim.

Exploring a Wool Corn Object

This example explores how the positioning of corn seeds in a rim around a woolen crocheted container and the availability of nutrience in form of soil, which it is filled with, affects the transformation of the shape in a dynamic way.

Setup

The bulbous shape is a crochet work from a white wool-mix and has a rim from cotton-corn-yarn. The container has a quite open construction and a small opening in the top, through which the soil was filled and water for the activation and maintenance applied with a can. Then it was placed on a concrete windowsill. After five weeks the watering was stopped to initiate a drought in order to deactivate the sample. Throughout this processes the object was physically explored and the explorations recorded to document the expressions of changing material behaviour of the stages within the different life-cycle of the object. To explore the concept of reactivation, the object was planted into a bowl with perlite substrate, was watered and then sealed to create a micro-climate for which no further maintenance was necessary.

Figure 147: The colour palette of the plant parts ranged from white and pink to tones of green.

2 Day 3

Figure 148: Sprouting corn has one embryonic leaf and thus belongs to the monocotyledon group.

3 Day 7

1 Day 2

Figure 149: The emergence of the first coleoptiles that permeated the crocheted woollen envelope, which was filled with soil.

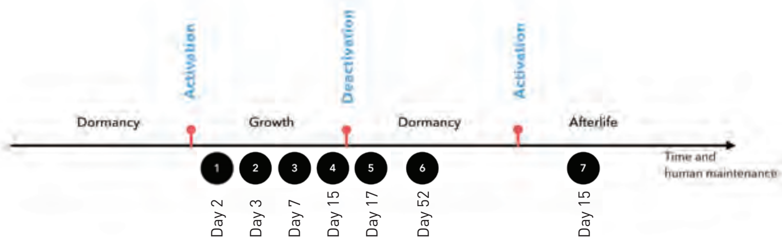


Figure 150: A diagram that illustrates which parts of the life cycle the Figures belong to.

Transformation of the Expression

Regularly watering the object initiated the growing process, which was evidenced by the first coleoptiles (Figure 149). Through its weight and soft shape the object was pleasant to hold, and could be squeezed or manipulated in ways that added an element to the transforming object, allowing sensorial exploration (Figure 147).

The shoots framed primarily the rim of the object (Figure 148), although some interacted with the open structure of the crochet work by permeating and deforming it. Despite the fact that nutrients and water were available within the object, most of the roots grew between the container and the concrete surface. They were relatively thick and strong, and had a colour gradient ranging from white to pink (Figure 155).

In the later stages of their growth, the roots formed a dense network underneath the object, becoming brownish and thinner than the fresh white roots that grew after the event of activation (Figure 156). The small coleoptiles became strong stems of dark red that grew out of the crocheted object, slowly fading into a strong green colour that led up to the leaves. Although the corn seeds were attached to the side of the object in the manner of a belt, their plants grew close to the centre of the object. White mould developed around the corn seeds, forming a layer around them and the knitted cotton tube in which they were inserted. The woollen envelope was not affected.

As soon as the watering was stopped, the leaves softened and collapsed, and were beginning to lose their colour (Figure 152). After a couple of days, the object had completely dried out and thus lost much of its weight, colour, and vitality (Figure 153). The leaves were brownish and rustled when touched, creating a stiff tangle around the object and being oriented down,

Figure 151: The stems grew upwards, whereas the leaves bent to the sides and downwards.

4 Day 15

Figure 152: The once-strong and straight corn collapsed due to a lack of water.

5 Day 17

6 Day 52

Figure 153: A photograph taken on Day 52 (the drying process was completed on Day 25).

7 Day 15

Figure 154: Some of the seeds that did not germinate during the first activation process later began to grow.

in opposition to the growth phase. Several corn seeds that had not activated before began to germinate and grow (Figure 154). The textile object began to mould and degrade, although the investigation showed that hybrid objects can have an extended lifespan through reactivation (planting).

Reflections

The wool-corn object opened up for a more physical way of interacting with plants and textiles, encouraging users to touch and hold it in order to feel the textile qualities and observe the development of the plants from all angles and with all senses. The physical experience of the object also provided information regarding its weight and moisture levels and the stability of the plants in relation to movement, leading to knowledge of the plants' wellbeing and needs. Thus, a different perspective on textiles was provided, as generally there is no need to water, expose to light, feed and harvest, and cut away or remove parts of textiles.

As in the previous examples that did not use soil, the roots expanded to the sides, here remaining close to the object due to the nutrients and water being located within it. As the water moved downwards, a dense network of roots was located on the underside of the object. Thus, the location of the water and soil had an effect on the direction in which the roots grew. The grass stems grew around the object in the manner of a belt; some emerged from the inside, growing through the open structure or penetrating and deforming the crocheted envelope. As in previous examples, the dried grass had a textile-like expression, and so it can be seen that degradation aligns textile and biological expressions.

As the substrate for the seeds was inside the object, the object was mobile and not fixed in a certain place. However, it was capable of positioning itself in order to access moisture and/or nutrients, as was the case when the dried object was watered and planted on perlite to reactivate it. The reactivated example showed that textile-seed hybrids can have another life-cyclelife cycle after a second dormancy, i.e. an afterlife. This concept describes the use of a textile after its activation and growth, and can involve e.g. another activation after a dormancy (as in this example) or planting it outdoors so that it decomposes, as a natural form of disposal.

Figure 155: The roots, which had a white to dark pink colouring, gathered underneath the object.

3 Day 7

Figure 156: The roots formed a dense network underneath the object and turned brownish.

4 Day 15

Textile	**+**	**Seed**	**+**	**Maintenance**	**->**	**Transformation of the expression**
Material: Rim: Black cotton Body: White wool/polyamide		Material: Corn		Light: Indoor light		Green stems and white roots appeared; the stems expanded, dark green leaves unfolded, collapsed, lost their colour, and turned brownish then black. Soft, new stems appeared, although these were fewer than in the first cycle of growth.
Technique: Crochet		Shape/size: Droplet-shaped, yellow		Time: 15 days (Growth, Dormancy, Afterlife)		
Construction: Open but stable		Position: Lower rim		Temperature: Room temperature		
Position: Horizontal placement				Nutrition: Soil		
				Humidity: Through a watering can		

Table 14: The parameters for designing and manufacturing wool-corn object.

Figure 157: The textile plant container, featuring a rim crocheted with a cotton-chickpea yarn.

Exploring a Wool-Chickpea Container

This example illustrated how seeds integrated in a textile object can change its expression over time through human maintenance, and how the positioning of the seeds affects the passive and active states of the object. Furthermore, the example was used in its passive (dormancy) and active (growth and afterlife) states, and so explored its life cycle.

Setup

The object was a crochet work, consisting of a bulbous shape made from wool and polyamide. Its opening consisted of a funnel-shaped rim made from a black cotton-chickpea yarn. This was later filled with soil, and the textile object was activated and maintained with water and regularly watered via the seed-framed opening (Figure 158). A drought was initiated to begin the process of decay and, once the object had fully dried, it was planted in a glass bowl on perlite substrate to investigate the possibility of reactivation. This involved watering the object once and sealing the glass bowl to create a micro-climate and to leave the object to itself (Figure 159).

Figure 158: Watering the textile-seed hybrid.

Figure 159: The object in a sealed glass bowl.

1 Day 0

Figure 160: The empty textile envelope and the chickpea-yarn that was used to crochet its funnel-shaped rim.

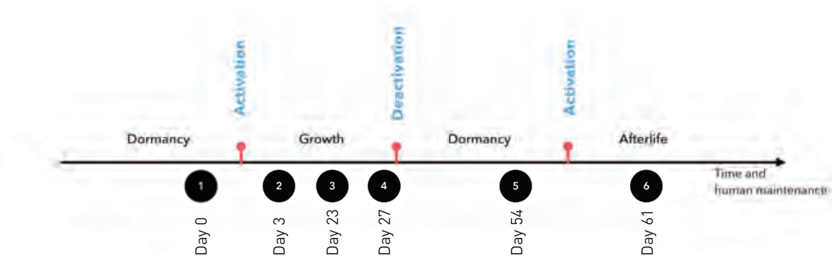


Figure 161: A diagram that illustrates which parts of the life cycle the following images belong to.

Transformation of the Expression

The body of the textile seed container consisted of a soft envelope that was possible to deform and manipulate in various ways (Figure 162). The tight structure of the rim, which was crocheted using a cotton-chickpea yarn, had a certain stability that contrasted with the soft body (Figure 160). Watering into the opening caused the chickpeas to swell, stretching the tubular yarn to its elastic limit and resulting in the yarn either cutting into the chickpeas or tearing (Figure 163). Following the swelling, which caused the rim to stiffen, the radicles grew, following gravity, and so connected the rim with both the woollen body and the soil (Figure 164). The germinating chickpeas were located near to the funnel-shaped opening and the intersection with the woollen body, in the most moist section of the textile after the watering had been conducted. The downwards growth of the radicles and roots into the soil-filled body of the object caused the opening to become increasingly blocked.

Figure 162: The textile vessel was filled with soil, and was soft and easy to manipulate and deform.

1 Day 0

Figure 163: The swelling chickpeas were constricted by the knitted cotton tube. The first radicles are also visible in this image.

2 Day 3

Figure 164: The radicles grew downwards, into the soil-filled woollen envelope.

2 Day 3

SERIES I – DYNAMIC SHAPES

3

Day 23

Figure 165: The woollen vessel was very soft, and when this photograph was taken there was space within it for more soil to provide additional support.

4

Day 27

Figure 166: Having filled the object with additional soil, it took on a more distinctive visual appearance, and the plants were more supported.

As the body was woollen and half-filled with soil, it was flexible and soft (Figure 165). To alter this expression and provide the plants with more nutrients and substrate, the object was fully filled with soil (Figure 166), stretching the crocheted structure and giving it a bulging shape. Traces of soil altered the colour of the wool and stabilized the position of the upper rim. The overall expression changed as a result of the filling, and the object became more stable and easy to position in relation to light sources and the growth of the stems and leaves (Figure 166).

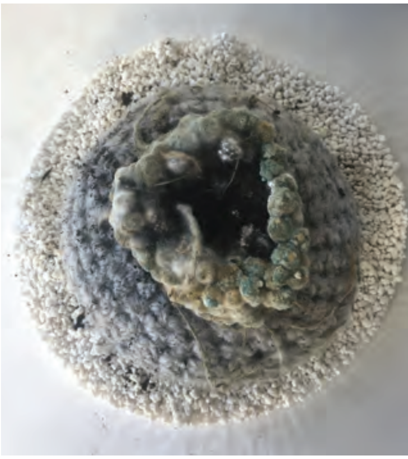
To initiate the dormancy phase, the watering was stopped. The young chickpea plants collapsed, shrank, crumpled, and shrivelled, losing their colour and thickness. This change also caused dry soil to fall away from the crocheted structure (Figure 167).

In order to explore the concept of afterlife, the object was placed in a glass container that was filled with perlite substrate, watered once, and sealed to create a micro-climate. However, some of the chickpeas that had not been activated began to mould rather than germinate. This mould covered the rim with a thick, flock-like coating in tones of white, yellow, and green, overlaying the expression of the chickpeas (Figure 168).

5

Day 54

Figure 167: The drying process caused the plants to wither and collapse.



6

Day 61

Figure 168: The chickpeas moulded instead of germinating following the re-activation process.

Reflections

This example explored the concept of a living material that can be activated and deactivated by watering, which is a form of human maintenance. The textile object came to life and developed the plants that it contained, causing a change in expression, which was determined by the amount of substrate and the state of growth. The soft container contained soil and water, flexible enough to be expanded by additional soil, and was discernible due to its weight and the feel of the wool when touched (as wool only feels wet when it has absorbed 30% of its weight in water). The object consequently opened up for a more embodied interaction with plants based on interior textiles and questioned concepts such as durability, washability, and – in particular – life cycles that are shaped by static applications, static expressions, and disposal. Due to its function as a container, the object was flexible and able to adapt to the growth of plants or be planted in another location (e.g. outdoors) to continue its growth. The object could be buried when no longer needed and thus decompose, expanding its biological life cycle.

'Afterlife' is a concept that aims to open up the design process and usage of interior textiles, which are usually designed for indoor use and with a specific purpose in mind, bringing in a more holistic perspective that includes designing textile interiors so that they undergo multiple phases of development. These not only lengthen the lifespan of a textile but provide several options as regards use and placement, and ensure that the experience of the product involves continuous physical and visual transformation during the active phases (growth and afterlife).

Textile	**+**	**Seed**	**+**	**Maintenance**	**->**	**Transformation of the expression**
Material: Rim: black cotton, body: grey mix of wool and polyamide		Material: Chickpeas		Light: Indoor light		The seeds swell, stiffened the rim, and germinated; the plants grew rooted in the object body and below; terminating the watering led them to collapse, and crimple; planting the object into a jar and watering it led to a second phase of germination and growth, accompanied by mould, a sign of degradation that soon also affected the plants.
Technique: Crochet		Shape/size: Big and round		Time: 61 days (Dormancy, Growth, Dormancy, Afterlife)		
Construction: dense construction body: medium		Position: Upper rim		Temperature: Room temperature		
Position: Variable position in space				Nutrition: Soil		
				Humidity: Through a watering can		

Table 15: The parameters for designing and manufacturing a wool chickpea container.

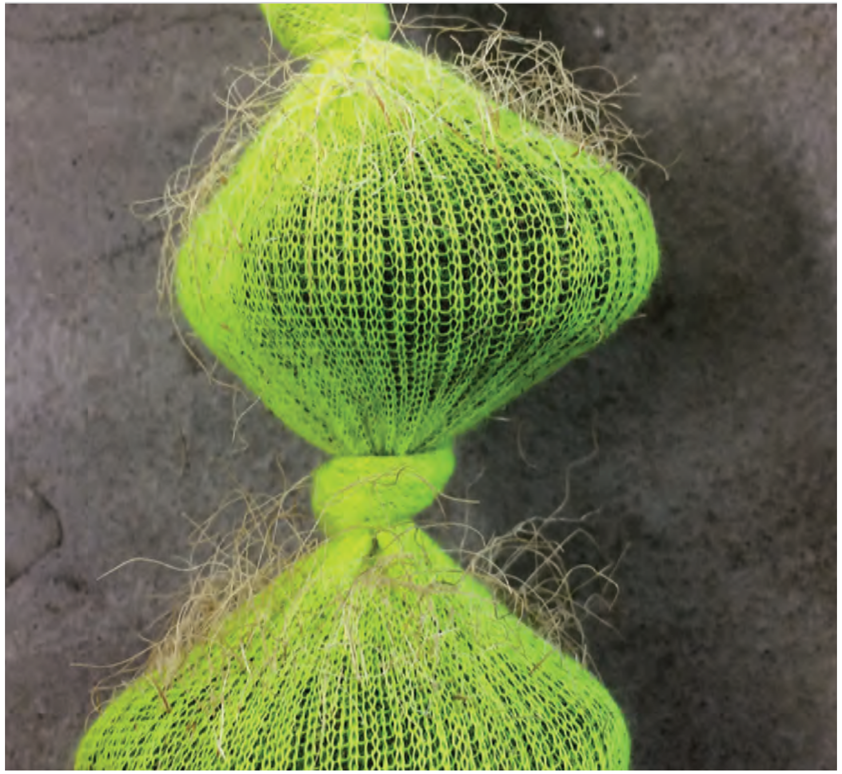
Figure 169: The knitted grass structure and its compartments, which separated the substrate and provided space for the grass to grow.

Exploring a Polyester-Grass Structure

This example explored the dynamics of growth and colour using grass that was integrated in a neon-yellow knitted polyester tube. The transformation of the grass created an expression similar to fur and, over time, its growth and decay resulted in various expressions involving furriness and colour.

Setup

For this example, neon-yellow polyester tubular knit was fabricated in the Knitwear Lab at the Swedish School of Textiles. The tube was filled with a mixture of moist soil and grass seeds, which were pressed into bead-like shapes and separated by knots. This was done to 'highlight the distinct forms of a seed yarn in a larger scale. The structure was vertically suspended, and watered by dipping it into a bucket of water and using a spray can.



5 Day 153

Figure 170: Six months after the structure had dried out, the grass lost its colour and turned beige.

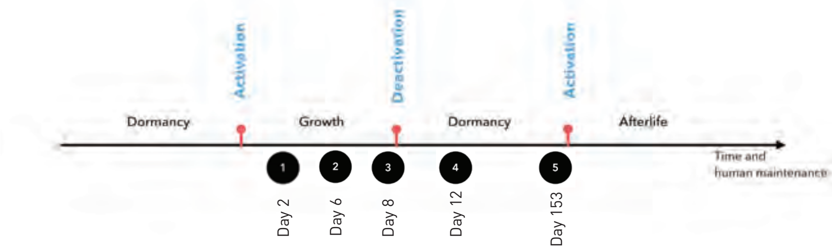


Figure 171: The diagram illustrates which part of the lifecycle the following Figures belong to.

Transformation of the Expression

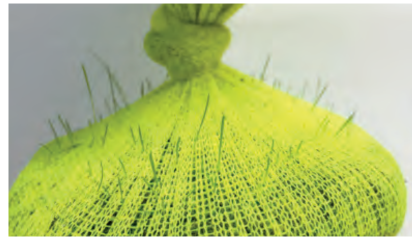
On the second day of watering, thin stalks of bright green grass grew through the tubular knit on the upper areas of the soil spheres (Figure 172). These changes in the surface expression were subtle, as the grass was very fine and its colour did not contrast strongly with the neon-yellow knit, which had been darkened by water and damp soil.

In the following days, the grass coverage became denser (Figure 173). The young grass, which was bright green, grew densely and vertically from the soil-filled compartments, each of which was separated by a knot. In contrast to previous examples, no roots were visible during the period of growth. The thin stalks of grass were oriented directly upwards, and their thickness was comparable to that of the yarn used for the tubular knit. As a result of the number and length of the stalks, the contrast in colour became more visible (Figure 174).

After two days without water, the grass withered, turned dark green, became fuzzy, and stood out in all directions, increasing the contrast between the green tones and creating a textile ´yarn-like`expression through the crumpled grass straws (Figure 175).

After six months, the grass had entirely lost its colour and turned beige, the crumpled stalks took on the appearance of fur or a bunch of threads (Figure 169).

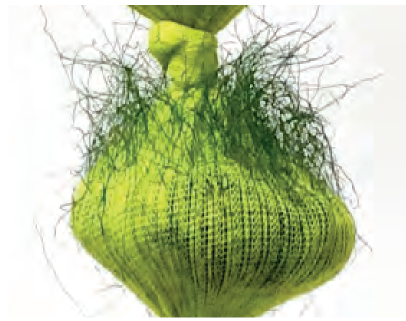
Day 2 2



Day 6 3

Day 8 4

Day 12 5



Figures 172-175: The development of the grass over a period of twelve days.

Reflections

The effects of change in colour resulting from growing and withering – i.e. expressions of growth and decay – were explored in this example. While the polyester-based material did not lose its expression, the grass underwent constant changes, observed daily in the process of early growth, that later slowed. The withering of the grass took place quickly, while the change in colour of the already-dry straws took place over the course of several weeks. Changes in maintenance and environmental parameters thus appear to trigger a rapid response, whereas stable conditions support more constant expressions.

In this example, a static material – the neon-coloured tube – was combined with a dynamic one – grass – which changed shape and colour (from light to bright, to dark green and beige). When designing a textile-seed hybrid and its life cycle, the dynamic expressions of the materials need to be considered; this is in contrast to designing textiles, where the combination of materials and textile techniques creates a static expression. Consequently, time is a variable that is not frequently used when designing textiles but crucial when designing textile-seed hybrids, as it allows colours and structures to be designed to display a series of expressions over time. The interplay between the textile and the seeds defines the overall expression of the object, creating an aesthetic hybrid in which it is difficult to distinguish in between the textile and the plant. A hybrid could thus be designed and used to exhibit phases where at certain times biological and textile expressions oppose or blend.

Figure 176: The dried knitted grass structure.

Textile	**+**	**Seed**	**+**	**Maintenance**	**->**	**Transformation of the expression**
Material: Polyester		Material: Grass		Light: Indoor light		Bright green grass grew with increasing density on the upper sides of the soil-filled compartments. The, soil dried out, the structure became lighter, the grass became less stiff, whithereds, turned dark green then, beige. The, expression of the textile envelope is difficult to distinguish between the textile and the plant.
Technique: Circular knit		Shape/size: Small, long, sharp		Time: 153 days (Growth, Dormancy)		
Construction: Medium		Position: In compartments mixed with soil		Temperature: Room temperature		
Position: Suspended				Nutrition: Soil		
				Humidity: Through a watering can		

Table 16: The parameters for designing and manufacturing the knitted grass structure.

SERIES II

Textiles as Alternative Perspectives for Indoor Gardening

The immersive examples of Series II explored the integration of biological materials and pocket-weave in order to organise plants. They were produced at Svensson AB using an industrial Jacquard loom, so as to explore the interactions between seeds and textiles - and in relation to people in a full scale interior scenario at a later point. The examples have been categorised into three groups: 'Dynamic Stripes', 'Dynamic Circles' (both of which consider the woven pockets to be patterns), and 'Dynamic Interiors'; a full-scale installation which was exhibited at the Textile Museum of Sweden in Borås. Its 'traditional' aesthetic centred on a scenario, with a table, a carpet, curtains, and seating that were intended to introduce visitors to the concept of *On Textile Farming*.

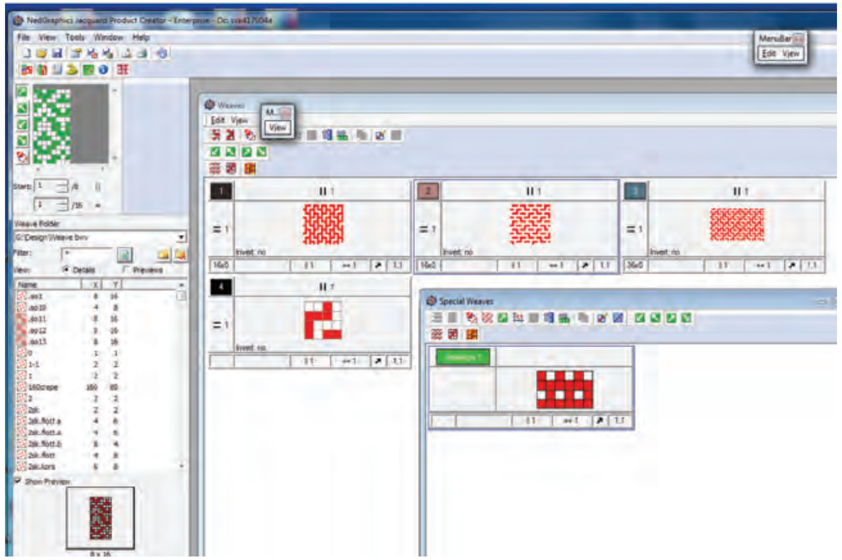


Figure 177: The bindings in the NedGraphics Jacquard software package.

Materials and Constructions

The examples described in this section were produced at Svensson AB. The warp material used 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 the warp is usually used to produce an upholstery collection called 'ACCESSOIRE'. For the samples described here, an organic combed 24/2 cotton or the white warp material were used in the weft. The NedGraphics Jacquard software package (Figure 177) was used to estimate, calculate, simulate, and prepare for the loom (here a Picanol Jacquard loom) doubleweave constructions. Four contrasting bindings were used for the examples, as well as two additional ones for the selvedges that were intended to either prevent the fabric from loosening at the edges or allow openings to access to the horizontal channels (Figure 178).

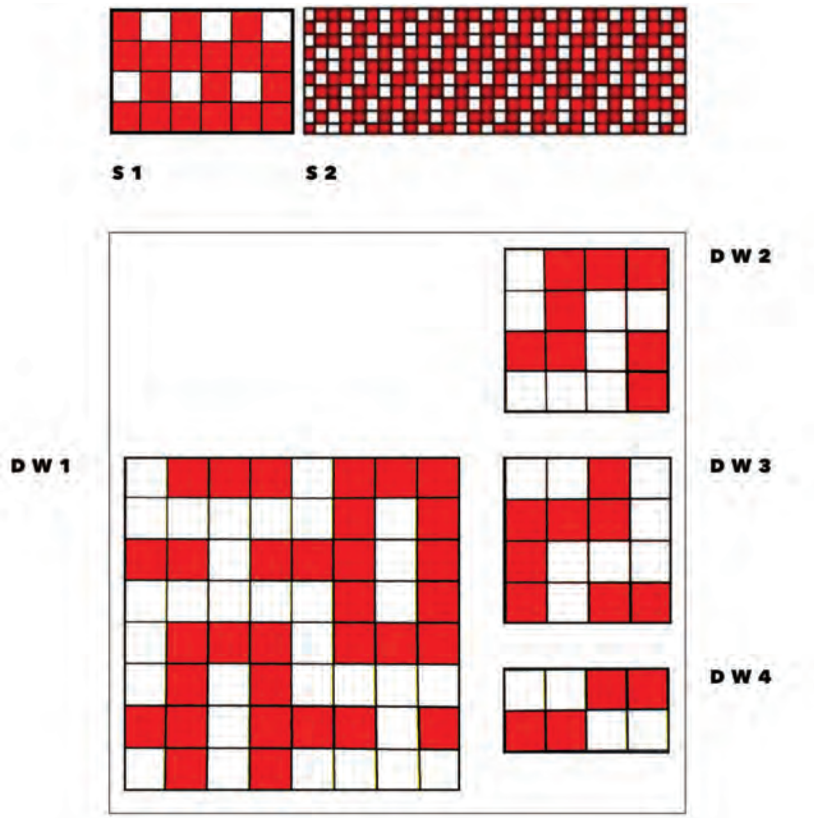
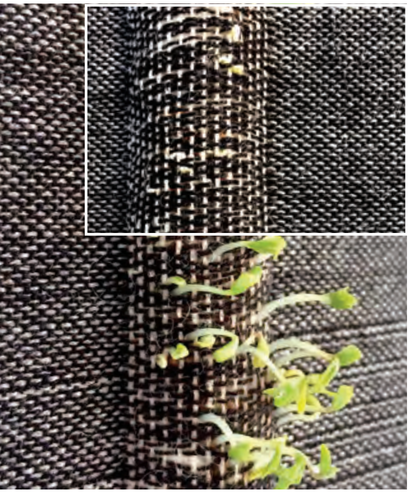


Figure 178: The bindings that were used in the fabrics that were woven at Svensson AB. The top row shows the selvedges, and below this are the doubleweave structures.

Series II

Textiles as Alternative Perspectives
for Indoor Gardening



Dynamic Patterns - Stripes

An industrial Jacquard loom was used to produce double cloth with different types of channel to explore stripes as a basic pattern in textile design. This was conducted in relation to organising plants in full-scale interior textiles, their possible spatial arrangements, and the relationship between growth and the position of a structure.

Figure 179: Channels in a doubleweave that was filled with padding and seeds which transformed over time.

Dynamic Patterns - Circles

These examples investigated circles as a basic pattern in textile design; specifically, how seeds and substrate can be integrated into circular pockets and how they then interact with structures throughout their life cycle. Combining stripes and circles allowed the potential of integrating watering systems to be explored, where the channels were used to guide water into the seed-containing pockets.

180 - A circular pattern of pockets transforms over time due to sprouts and their life-cycle.

Dynamic Interiors

This section explored full-scale interior scenarios, and is based on an installation at the Textile Museum of Sweden in Borås. Here, the pocket-weaves produced at Svensson AB formed a spatial experience and opened up for complementary ways of organising and living with plants in interior spaces. The flexible textiles constituted alternatives to static, vertical gardens, and their patterns provided different environments

Figure 181: A visitor waters the installation at the Textile Museum of Sweden in Borås (from Jan Berg, 2017)

DYNAMIC PATTERNS

Stripes

Stripes are a fundamental concept within textile design practice and education, particularly with regard to weaving, where interlaced yarns at right angles form the warp and weft and thus a grid that promotes geometrical patterns. The fabric described in this section was designed to explore stripes using differences in width, distance, and direction, and formed channels to investigate how seeds and substrate can be integrated; how seeds can be activated, and growth maintained in relation to the pockets they were placed in and the structure of the weaves; and how plant growth affects surface expressions. This chapter presents the approach to and setup for designing and producing the examples, wherein a stripe was filled with seeds and substrate and its transformation was monitored over the course of 12 days.

Figure 182: The filled channel, from which alfalfa sprouts grew.

Exploring a Striped Doubleweave

This example illustrated a striped doubleweave construction; here, channels containing alfalfa seeds were used to investigate the seeds' process of germination and adaption to the piece of cloth and its weave construction.

Setup

This example, a striped pocket-weave, consisted of horizontal channels running in the weft direction that varied in depth and distance (Figure 183). The white warp threads were bound in a 2/2 pattern to create an open structure, while the black warp threads were bound in a more dense 1/1 pattern. Both layers were joined using a 2x4 structure (Figure 183). An open binding (S1) for the selvedge was used to allow easy access to the channels from the side in order to place the seeds and substrate.

The example explored cotton padding and alfalfa seeds, which were inserted into a narrow channel where the fabric was bound in an open fashion and densly bound where the two warps were joined together. The textile was framed and positioned vertically, with the front facing a light source and the rear to a wall (Figure 184) in order to explore how this affected the pattern of growth.

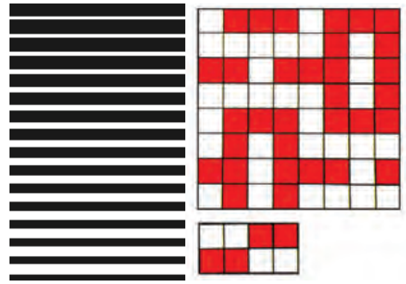


Figure 183: The design of the stripes and their binding.

Figure 184: A narrow channel was framed and filled with padding and alfalfa seeds, which germinated.

1 Day 0

Figure 185: The empty textile envelope and the chickpea yarn that was used to crochet its funnel-shaped rim.

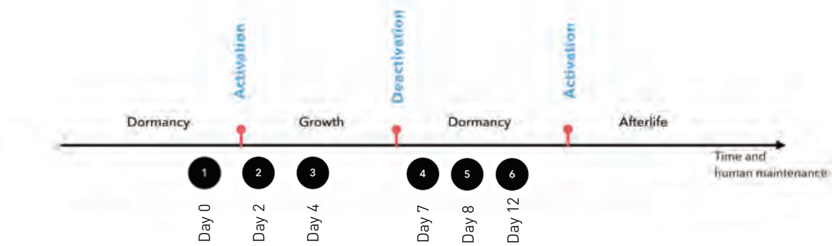


Figure 186: A diagram that illustrates which parts of the life cycle theFigures belong to.

Transformation of the Expression

One day after activation using a spray can, the first pale sprouts pushed through the binding (Figure 187) and the first roots made their way through the open structure at the back. No roots appeared on the front of the textile, and only two sprouts appeared on the rear. The alfalfa seeds lost their seed coats while pushing through the weave structure (Figure 187). Thus, the brown hulls stayed inside the padded fabric, whereas in other examples they appeared on the surface, providing an additional colour and shape to the overall expression. The sprouts broke through the fabric within a day of activation, then unfolding their leaves in search of light and turning a deeper green. As the piece was oriented vertically, perpendicular to the light source, the sprouts were primarily oriented horizontally, with a slight alignment upwards, against gravity (Figure 188).

Figure 187: The coleoptiles broke through the weave construction, losing their seed coats in so doing.

2 Day 2

Figure 188: The pale sprouts unfolded their embryonic leaves.

3 Day 4

4 Day 7

Figure 189: As the water was affected by gravity, the effects of the drought were felt first by the plants at the top.

4 Day 7

Figure 190: The effect of the drought seen from the side.

5 Day 8

191 - The images shows all sprouts collapsed as a response to the drought.

The initiated drought initially affected the upper section of the piece, where the sprouts began to collapse (Figure 189). As the moisture moved downwards due to gravity, it collected in the lower part of the textile and the sprouts there maintained their upright positions for longer. As the piece continued to dry out, these too collapsed and so the piece again took on a consistent aesthetic expression. The collapsed sprouts shrivelled and lost their rigidity, but were still pliable and flexible (Figures 189-191).

After additional two days, the sprouts lost their flexibility and became brittle as a result of the drying process. Their stems took on a yellowish expression, while the embryonic leaves remained dark green but lost their colour saturation. While the sprouts originally had smooth edges and slight bends in their stems and leaves, the withering resulted in a wrinkled and sharp expression (Figure 192).

Figure 192: The collapsed sprouts dried out, becoming brownish and crisp to the touch.

6 Day 12

SERIES II – DYNAMIC PATTERNS: STRIPES

Reflections

In this example, alfalfa sprouts adapted to their positions in a channel that hung vertically. The cotton padding served as substrate and absorbed the added water, creating a suitable environment for the seeds to germinate and position themselves within. The contrasting light conditions and permeability, porosity, and openness of the plain weave caused two distinct areas of growth: stems and leaves on the front, roots on the rear.

Although the cotton padding helped to absorb, store, and distribute the added water, this evaporated very quickly and so the sprouts withered soon thereafter. This process caused the sprouts to collapse, moving from a horizontal position with an upwards tendency to pointing downwards, following gravity. The behaviour of the alfalfa sprouts therefore clearly showed the presence and location of water within the stripe, which can thus be seen as a type of indicator. The change in the directionality of the sprouts also showed their state, i.e. whether they were active or passive (deactivated). Expressions of growth showed a clear directionality, which got lost during the process of withering.

The degree of water accessibility in the vertical stripe opens up for designing planting patterns that take into account the moisture requirements of different plants; those that need drier environments could therefore be sown 'higher', and those that need more moisture could be sown 'lower'.

growth shows clear directionality while withering disturbs this expression

Textile	**+**	**Seed**	**+**	**Maintenance**	**->**	**Transformation of the expression**
Material: Warp: 1:1 black and white 32/2 mix of wool (85%) and polyamide (15%) Weft: White warp material Substrate: Cotton padding		Material: Alfalfa		Light: Face: indoor light (mix of natural and artificial light) back: shadow (position on the wall)		Alfalfa sprouts broke through the weave construction and unfolded their leaves at the front and expanded the roots at the rear. With stopping the watering, the upper sprouts collapsed and withered, followed by the once in a lower position.
Technique: Industrial jacquard weaving		Shape/size: Small and brown		Time: 12 days (Dormancy, Growth, Dormancy)		
Construction: DW1, DW4, S1		Position: Inside the channel		Temperature: Room temperature		
Position: Vertically positioned				Nutrition: -		
				Humidity: Through a spray can		

Table 17: The parameters for designing and manufacturing the striped dynamic double-weave with seeds.

Circles

Another fundamental pattern in textile design and doubleweave structures is circles. This section presents an example that featured more complex circular patterns that were filled with seeds and substrate to create dynamic textile patterns. As closed curves, circles create two regions: an interior and an exterior. In this research, circles were used as pockets in a doubleweave to create a hollow interior in which substrate and seeds were placed. Different bindings were chosen to create dense and open areas; the former held the seeds and substrate in place and prevented them from being permeated by growing sprouts, while the latter were used to create openings for inserting seeds and substrate, and also let through more air and light, promoting the growth of the sprouts and thus interactions with the textile structure. The design of this example, wherein several pockets adjoined one another, facilitated a range of different experiments. The following section describes how the fabric was designed and manufactured, and how elements were prepared and activated to create a dynamic circular pattern.

Day 5

Figure 193: Part of the pattern. The dark grey and white sections are pockets, while the grey area connects both warps.

Exploring Circular Enclosures with Alfalfa

This example illustrated the transformation of expressions of pockets within a circular pattern in a doubleweave structure. The example investigated how the insertion of substrate and alfalfa seeds and the growth of sprouts changes the shape and adds colour and dimension to the pockets within the pattern.

Setup

This example was inspired by the three-dimensional application on a plain weave that was transformed by the growth of sprouts, and explored the expressions that resulted from partially filling and altering the fabric, i.e. inserting seeds and substrate and activating the process of transformation. The pattern consisted of simple circular and elliptic shapes (Figure 197). The pockets differed in terms of their construction, and together they formed a graphical expression. A robust foundational weave suitable for upholstery was created using DW4 to interweave the two warps, and DW1 and DW1-3 were used to create the enclosures. In contrast to DW2/3, DW1 has an open binding on the front and a dense binding on the rear (Figure 194). Open-binding DW1 was used to create openings by separating the warp and weft threads (Figure 195). The cloth was manufactured using a Picanol Jacquard loom at Svensson AB (Figure 196) with an organic combed 24/2 cotton in the weft. Parts of the pattern were filled with cotton padding and alfalfa seeds, which also highlighted the visual contrast by adding three-dimensionality to the pattern. The examples were then framed and positioned vertically, with one side facing a light source and the other thus in the dark. The pieces were dipped in water to activate them, and regularly sprayed with water mist.

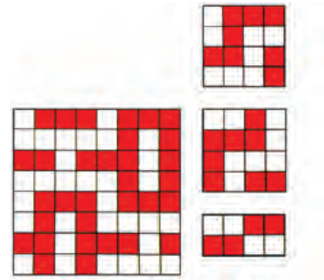


Figure 194: The bindings used in this example: DW1 (left column) DW2-4 top to bottom, right column).

Figure 195: The parts with the loose bindings could be opened.

Day 0

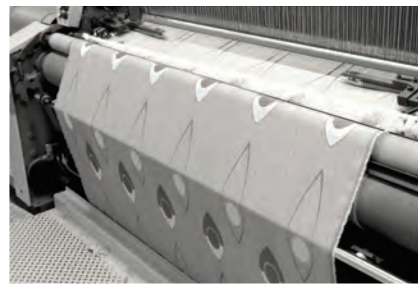


Figure 196: The production of the example using a Picanol Jacquard loom at Svensson AB.

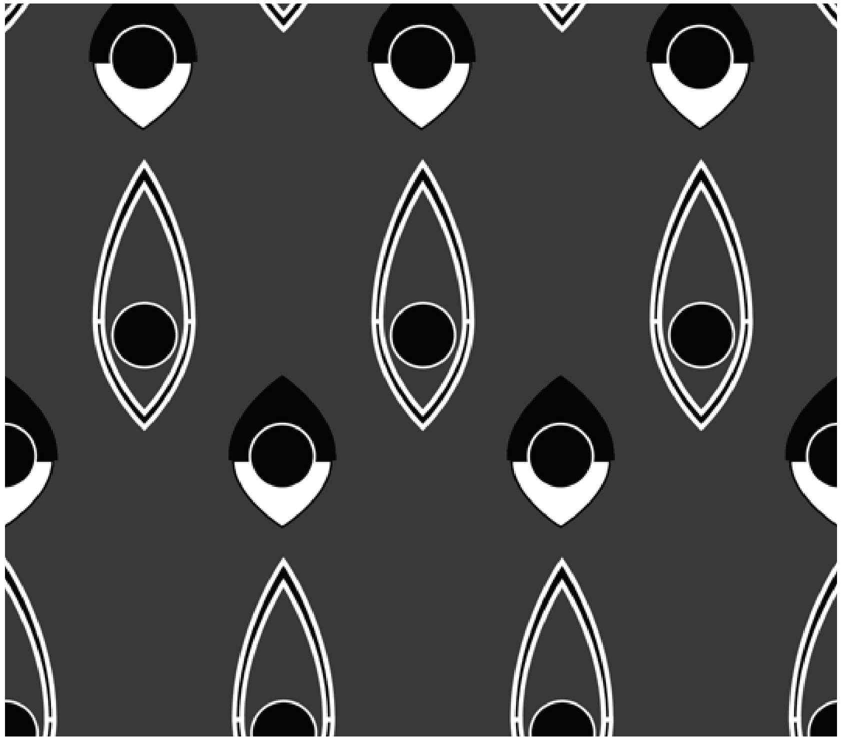


Figure 197: Part of the pattern. The dark grey and white sections are pockets, while the grey area connects both warps.

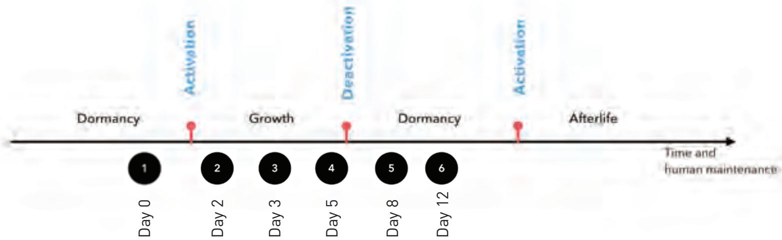


Figure 198: A diagram that illustrates which parts of the life cycle the Figures belong to.

2
Day 2

Figure 199: A pocket that was stuffed with cotton padding and alfalfa, which germinated.

3
Day 3

Figure 200: The coleoptiles and several roots broke through the dense structure of the front.

Transformation of the Expression

One day after activation, the hypocotyls pushed through the structure, losing their seed coats during this process – as occurred with the example presented in the 'Dynamic Stripes' section. The stems pushed the folded, light green leaves through the weft and warp threads in search of light, initially growing horizontally and with their embryonic leaves still folded (Figure 199). Several roots grew out of the front of the fabric (Figure 200), but the majority grew from the rear, facing the wall and thus the darkness (Figure 201).

3 Day 3

Figure 201: White roots permeated the rear of the pocket and its open structure.

3 Day 3

Figure 202: Coleoptiles pushed through the dense binding on the front of the fabric.

The structure of the rear of the fabric was relatively open, and the white padding inside the pockets blended with the white roots and structure, interweaving the warp and weft (Figure 201). The roots were initially thick and white, but became thinner and yellowish as a result of a lack of moisture, outside the microclimate of the pockets (Figure 201).

By Day 3, some of the sprouts had pushed through the surface and oriented themselves towards the light and against gravity (Figure 202), while others were still in the process of pushing through the weave, their stems and folded leaves growing between the interlaced threads.

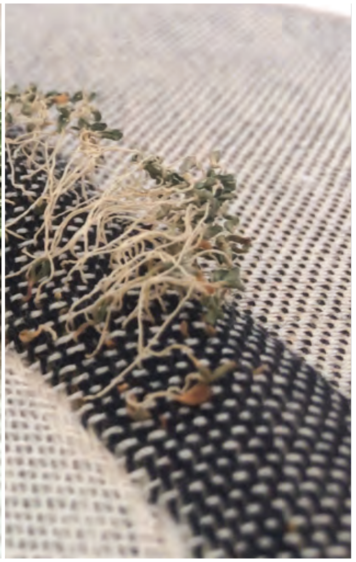
Figures 203-204: The stems expanded and grew towards the light, against gravity.

4 Day 5

Within another two days, the stems had grown by approximately two centimetres and oriented themselves horizontally, towards the light and against gravity. The embryonic leaves had mostly unfolded at this point in time, but were not entirely open. They had, however, changed from yellowish-green to a deep, matte, shimmering green that contrasted strongly with the white stems, which were visually connected to the white weft. This created a contrast between the sprouts and the matte, fine-pored texture of the black warp. The sprouts caused the stuffed pockets to become densely overgrown islands, wherein the embryonic leaves added colour to an otherwise black and white cloth (Figures 203-204).

Figure 205: The sprouts withered, wrinkled, and lost both their colour saturation and upright orientation.

5 Day 8

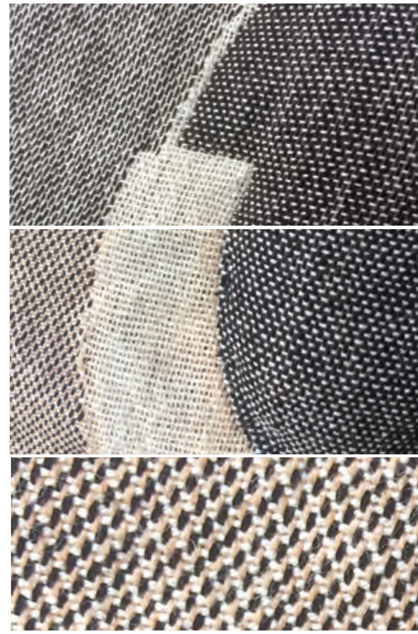


5 Day 8 **Figure 206:** By Day 8, the withered sprouts had collapsed, lost colour saturation, and turned crispy.

6 Day 12 **Figure 207:** The withered sprouts changed colour and turned brown.

An initiated drought caused the sprouts to wither and, eventually, collapse due to gravity and shrivelling. By Day 8, they had changed from being flexible to brittle, wrinkled, and stiff (Figures 206, 207) and had lost their saturation and brightness of colour (although this was still present to an extent). After four more days the withered sprouts had not changed in terms of shape, but turned brown. The stems were beige, and some of the leaves were curry yellow, ochre, or mud-brown (Figure 207). The withering of the roots on the rear of the cloth caused them to thin and change colour, from white to a mixture of beige, yellow, brown, and red. They did not collapse as the stems and leaves did, but became tangled and retained their rigidity (Figure 211).

The watering caused the black warp to lose some of its colour, and caused the white warp to take on a salmon hue. Thus, the black and white fabric received additional colouring and a colour gradient at the edges, where the black and white warps, which were woven separately, met. The areas in which both warps were interwoven were evenly discoloured (Figures 208-210).



Figures 208-210: The white woollen warp turned a light salmon colour.

Reflections

This example showed that pockets filled with cotton padding and alfalfa seeds are able to host the growth of sprouts, which extended the pattern of the cloth in a dynamic way and disrupted the woven structure of both faces. The sprouts added three-dimensionality and colour to the black and white cloth, and its maintenance – the application of water using a spray can and the dipping of the textile in water – caused the discolouration of the woollen warp, although the cotton weft remained unchanged (Figures 208-210). Thus, the interplay between the maintenance of the plants and the reaction of the textile material could be emphasised and designed with transformation in mind in future work.

The deactivation – the stopping of the water supply – initiated the transformation of the textile back into a stable, passive state, where the expression of growth was still visible but had been adapted to the textile's expression. The duration of the sprouting process was an important parameter in relation to the height, colour saturation, and direction of growth of the sprouts. Other important factors included light, moisture, and the position of the cloth. The pattern, orientation, and direction of growth of the sprouts was affected by the

Figure 211: The withering of the roots caused a light brown colouring. 6 Day 12

Figure 212: Roots and sprouts that grew in both directions.

Figures 213-214: Roots and sprouts that grew in the same direction.

position of the textile and direction of the light. By utilising a specific placement, the direction of growth of the roots, stems, and leaves was influenced; by changing this, the orientation of the sprouts was confused, leading to both the roots and embryonic leaves appearing on both sides (Figures 212, 214). However, the expression and development of the growth can also be guided by the openness of the cloth, which is defined by its binding. If a dense binding is used, the textile materials' reaction to moisture together with the tension of the fabric, will cause an increase in the resistance that the sprouts must overcome in order to push through it. If this resistance is too high the sprouts adopt a different approach, depending on the environmental conditions and stimuli. This behaviour affects the expression such that roots and sprouts develop in the same direction, or the embryonic leaves unfold within the pockets (as illustrated in the Viscose-Alfalfa Knit example).

Textile	+	Seed	+	Maintenance	->	Transformation of the expression
Material: Warp: 1:1 black and white 32/2 mix of wool (85%) and polyamide (15%) Weft: White warp material Substrate: Cotton padding		Material: Alfalfa		Light: Face: indoor light (mix of natural and artificial light) back: shadow (position on the wall)		Most of the coleoptiles pushed through the light-facing weave, and the roots through the back. The maintenance was challenging as the water pearled off the cloth and evaporated quickly. Most coleoptiles lost their hull on the way through the weave construction. They were light green, then turned dark green. The cloth discoloured through the watering process. Once stopped, the sprouts withered, lost their colour saturation and their curvy shapes.
Technique: Industrial jacquard weaving		Shape/size: Small and brown		Time: 12 days (Dormancy, Growth, Dormancy)		
Construction: DW1, DW4, S1		Position: Inside the channel		Temperature: Room temperature		
Position: Vertically positioned				Nutrition: -		
				Humidity: Through a spray can		

Figure 18: The parameters for designing and manufacturing dynamic circular patterns with seeds.

DYNAMIC INTERIORS

Textiles as Alternative Perspectives on Indoor Gardening

A full-scale interior scenario, which took the form of an installation at the Textile Museum of Sweden in Borås, is presented in this section. The installation illustrated the pocket-weaves produced at Svensson AB in an interior scenario; here, the weaves formed a spatial experience and opened up for new ways of organising and living with plants in interiors. The flexible textiles opened up for an alternative to static vertical gardens, and their patterns provided different environments for the plants.

Exploring Textiles as Plant Containers

An Installation at the Textile Museum of Sweden, Borås

A spatial installation at the Textile Museum of Sweden in Borås investigated the series of pocket-weaves produced at Svensson AB in the context of alternatives to indoor gardening and plant organisation using woven textiles. The five fabrics – Geometrical Stripe, Organic Stripe, Connected Circles, Geometrical Circles, and Organic Circles – were designed and produced on a larger scale to investigate the potentials of stripes and circles in relation to plant organisation and interior textiles. These five fabrics were presented as examples, each of which focused on a type of interior fabric: a ceiling, a curtain, a carpet, a seat, and a tablecloth. The integration of substrate and seeds in textiles and activation and maintenance of the examples were investigated. The conceptual explorations and spatial experience of the installation led to a range of scenarios, which are discussed in the sections that reflect on each of the pieces.

Figure 215: The installation at the Textile Museum of Sweden in Borås.

Intermediary Spaces
Where Places of Living and Growing Intersect

The scenarios described in the following sections create connections between indoors and outdoors, and therefore refer to the Naturhus and ReGen Villages projects described in the 'Hybrid Environments' chapter. These hybrid environments were created through e.g. a greenhouse that extends our understanding of living zones, intersecting architecture and nature as well as areas of living and growing. Figure 309 illustrates such a scenario, and how it creates an intersection between interior and exterior spaces. It is used to illustrate, document, and describe the life-cycle of the examples across the different areas (interior, intermediary space, exterior).

The diagram shows an outline of a house, which represents the interior space. This is surrounded by another outline –the extended living space – which in Naturhus is the greenhouse that partially or fully surrounds the common living area. The left of the two dashed lines is the transition between the zones that is to be facilitated by the hybrid textiles.

A scenario usually begins indoors, exploring the hybrid textile in a passive state; the textile is activated and undergoes a transition to the space in between, where it transforms and the germination and growing processes take place. In some cases the onset or initial changes through growth take place indoors, which is illustrated by a sequence of interior spaces. These sequences refer to the same space, and represent the changes that occur over time. The right of the two dashed lines on the way to the outdoor space marks another transition, which is either a deactivation that leads to another cycle within the interior or extended interior, or results in the textile moving to the outdoors, where it can grow towards maturity or degrade. Both transitions constitute the afterlife of the hybrid interior textile. The diagram can also be interpreted more abstractly, with the space between the indoors and outdoors standing in for various places in which living and growing intersect, e.g. indoor gardening systems.

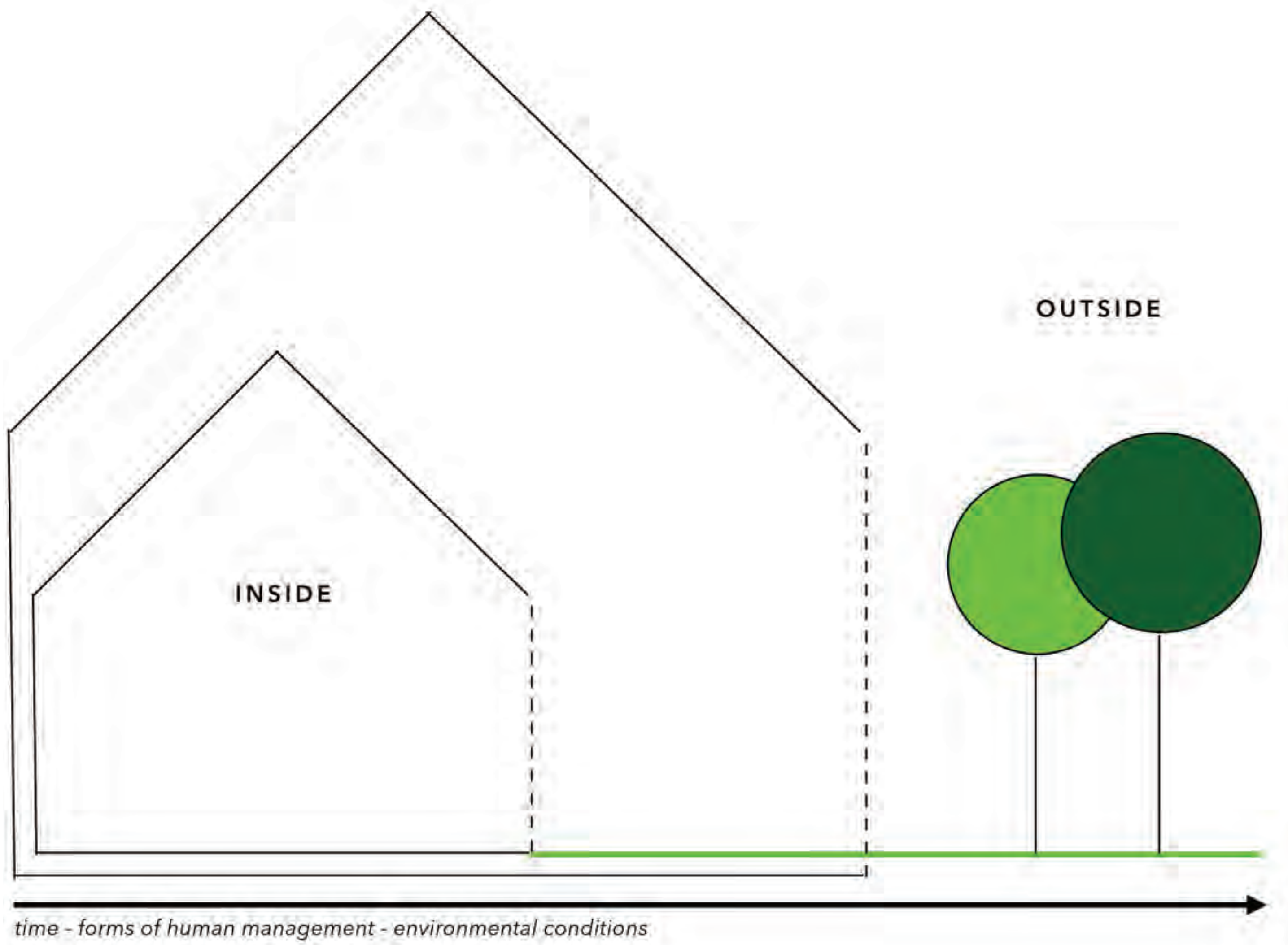


Figure 216: 'A diagrammatic representation of the concept of 'intermediary space' that is at the heart of *On Textile Farming*.

Figure 217: The Geometrical Stripes pocket-weave in use as a textile ceiling.

Exploring a Textile Ceiling

The concept of a textile ceiling was explored through the Geometrical Stripes fabric, which investigated how stripes, as channels, can host and organise plants, and how a flexible textile ceiling can affect the ways in which we live with and organise plants in interiors.

Setup

The Geometrical Stripes fabric was suspended from a metal frame in the manner of a textile ceiling. The fabric was relaxed and formed a curve, held in place by the frame above and at both sides.

Lettuce-seed tapes were inserted into the channels of the open structure of selvedge S1. The tapes, which were adjustable in terms of length, were relatively easy to insert and contained seeds at optimal intervals for planting and growth. The white warp dominated the upper face of the channels and had a 2/2 binding to create an open structure, whereas a more dense 1/1 binding was used on the underside (DW1). Both layers were joined using a 2x4 binding (DW4). The seed tapes were visible from both sides due to the open binding on the upper face (218) and the translucency of the underside of the structure in the back, when observed against a lightsource.

Figure 218: A close-up of the structure and inserted lettuce-seed tapes, photographed from above.

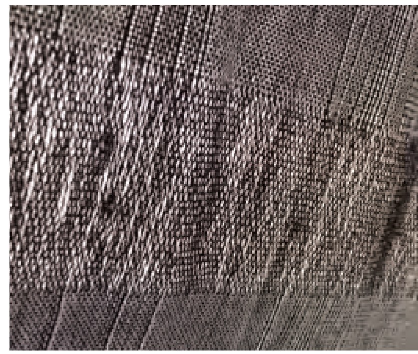


Figure 219: A close-up from below, facing a light source. The fabric has a certain trans-lucency, allowing the seeds to be seen.

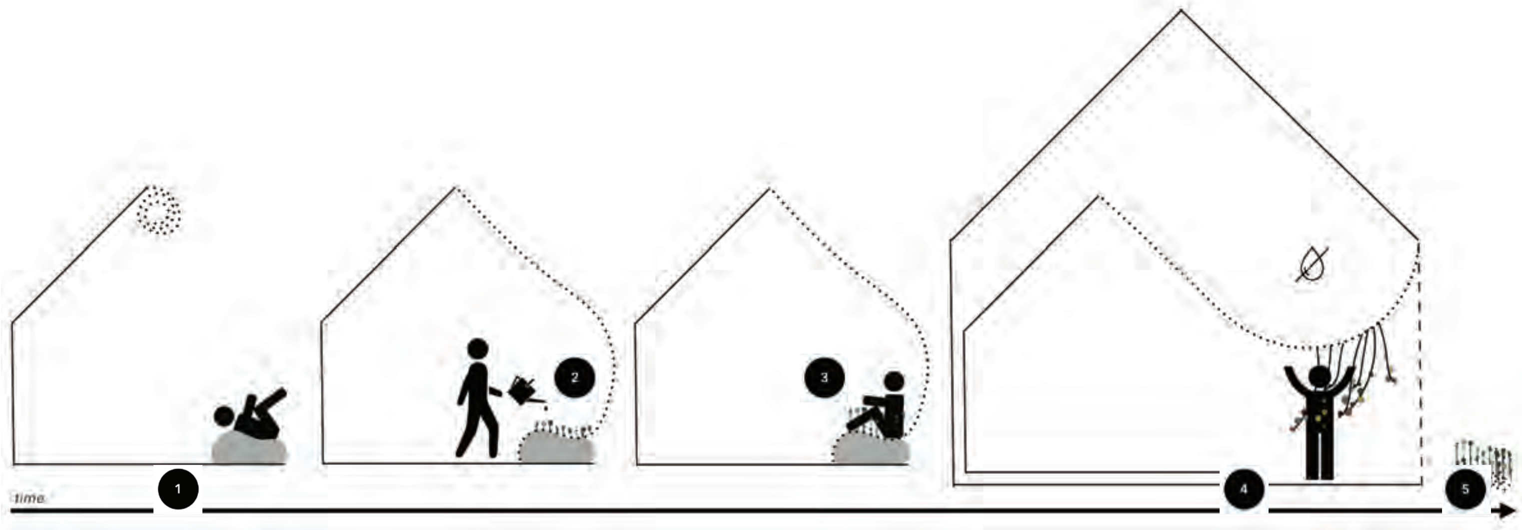


Figure 220: A scenario in which the Geometrical Stripes fabric is used as a dynamic ceiling that transforms spatial experiences over time.

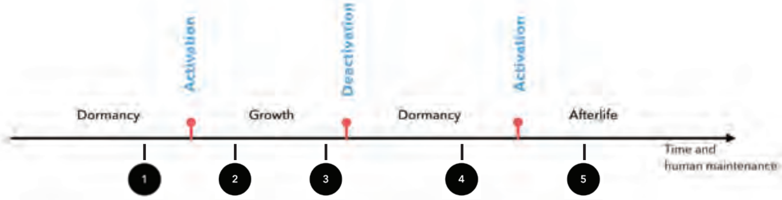


Figure 221: A diagram that illustrates which parts of the life cycle the Figures belong to.

Scenario

The first point is an open space in which a textile-seed weave can be unfolded to create a flexible spatial divider (220, Point 1-2). The pictured seat is filled with substrate and covered by part of the ceiling and watered to initiate the germination and growth of the seeds in the desired areas (220, Point 2). The inserted seed tape would determine the horizontal distance between the plants, whereas the vertical distance is influenced by the stripes of the weave. Thus, the pattern of growth is a result of both the inserted material and the textile design. The development of roots would anchor the textile to the seat, which could still (depending on the type of plant) be used (220, Point 3). As the textile is flexible, it could also be detached from the seat and draped and fastened in a different way, e.g. as a ceiling. In this configuration, the plants would dry out, adding a curtain of dried stems and leaves to the expression of the space, the specifics of which are determined by the pattern of growth (220, Point 4). The biodegradable nature of the textile-seed weave would allow it to be disposed of outside outdoors at any time (220, Point 5).

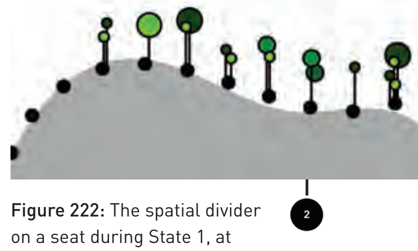


Figure 222: The spatial divider on a seat during State 1, at which point it is activated.

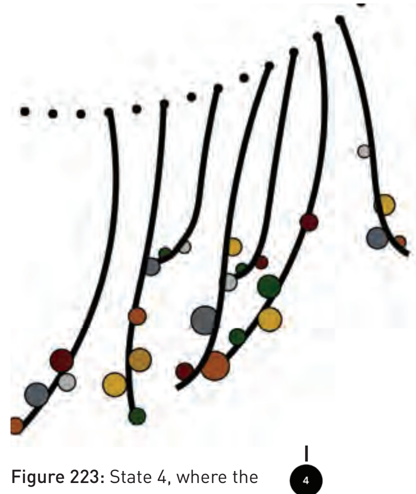


Figure 223: State 4, where the dried herbs are suspended.

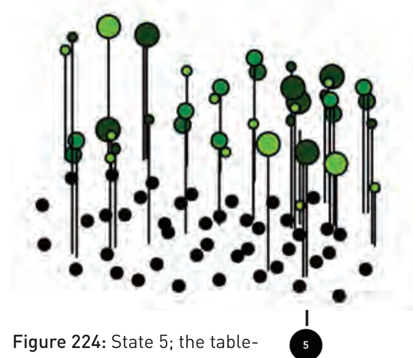


Figure 224: State 5; the table-cloth is planted in a garden to allow the plants to thrive fully.

Reflections

The explorations of the Geometric Stripes pocket-weave in a spatial setting resulted in a scenario that redefines the concept of a space-dividing textile. Using the textile pattern to integrate and organise the seeds, the potential of their growth is integrated into the textile design, which thus determines the pattern of growth. The flexibility of the structure opens up for spatial explorations, i.e. the draping and arranging of the cloth to transform and separate spaces, connecting interior and exterior expressions. These changes can be undertaken in several steps over time, and are enhanced by the dynamic surface expressions that the textile-seed structures enable. Bringing biological processes of growth and decay into textile design practice thus introduces biological life cycles to those of textiles, opening up for new perspectives on designing, managing, using, and disposing of interior textiles. Their dynamic nature is a fundamental characteristic, and must be considered in the early stages of design processes; thus, a more holistic approach than is commonly adopted is required.

The presence of biological expressions also brings new perspectives to interior design practice, wherein spatial transformations are a result of recombining, styling, and exchanging furniture rather than transforming the furniture or the textiles of a space. Consequently the flexible ceiling and its integrated seeds open up for new ways of living with textiles and plants over time.

Figure 225: The Organic Shapes pocket-weave in use as a ceiling.

Exploring a Curtain

This example explored the Organic Shapes fabric, investigating larger enclosed spaces in relation to larger plants and water containers. This was undertaken with the aim of creating a watering system that was visually integrated into the overall textile expression.

Setup

The balloon-like pockets were connected via a channel in the warp direction. The structure is based on DW2-3, and so the textile was designed to create enclosures and tunnels (the dark grey sections in Figure 226). The organic shapes partially consisted of DW1 (the light grey colour areas in Figure 226) to allow openings being created by separating warp and weft. In this way pipes for water supply, balloons for water storage, and substrate to accommodate seeds and plants could be inserted.

Figure 226: The pattern design of the Organic Shapes pocket-weave.

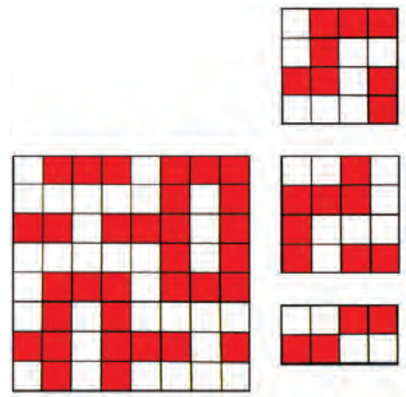


Figure 227: The bindings used in this example: DW1 (left column) and DW2-4 (top to bottom, right column).

Figure 228: The process of filling the pockets with perlite using a tube.

Figure 229: A water balloon being inserted into one of the pockets.

Figure 230: The pipes and water balloons were connected using sealing tape.

The curtain that was exhibited at the Textile Museum of Sweden consisted of a double vertical rapport pattern (Figure 225). The first row from the bottom was filled with perlite substrate. The loose binding, located in the middle of the pockets, was used to create openings through which the funnel was inserted, allowing the substrate to be added (Figure 228). Water balloons were inserted into the upper sections by creating openings in the loosely bound areas (Figure 229). The upper and lower pockets were then connected by a pipe that ran through the channel connecting them.
It was connected to the water balloons using sealing tape (Figure 230). The other end of the pipe led into the balloon containing perlite (Figure 231). The balloons were filled with water and thus expanded the upper pockets, increasing their weight, and their tension pushed the water down into the substrate.

The pressure of the balloons and gravity led to their draining quickly and thus excess water collecting in the substrate, and so the water moved through the channels that led from the perlite-filled pockets to the floor. In some areas, drops of water came through the textile structure (Figure 232), creating puddles on the floor (Figure 233).

Figure 231: The perlite-filled pockets, connected to the water supply via pipes.

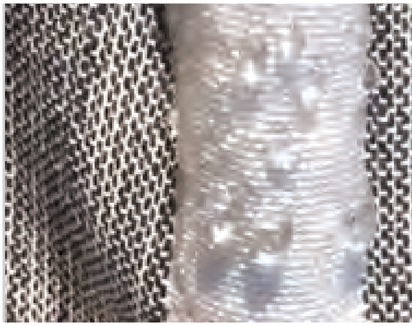


Figure 232: Water led through a channel.

Figure 233: A waste water puddle where the curtain and the ground meet.

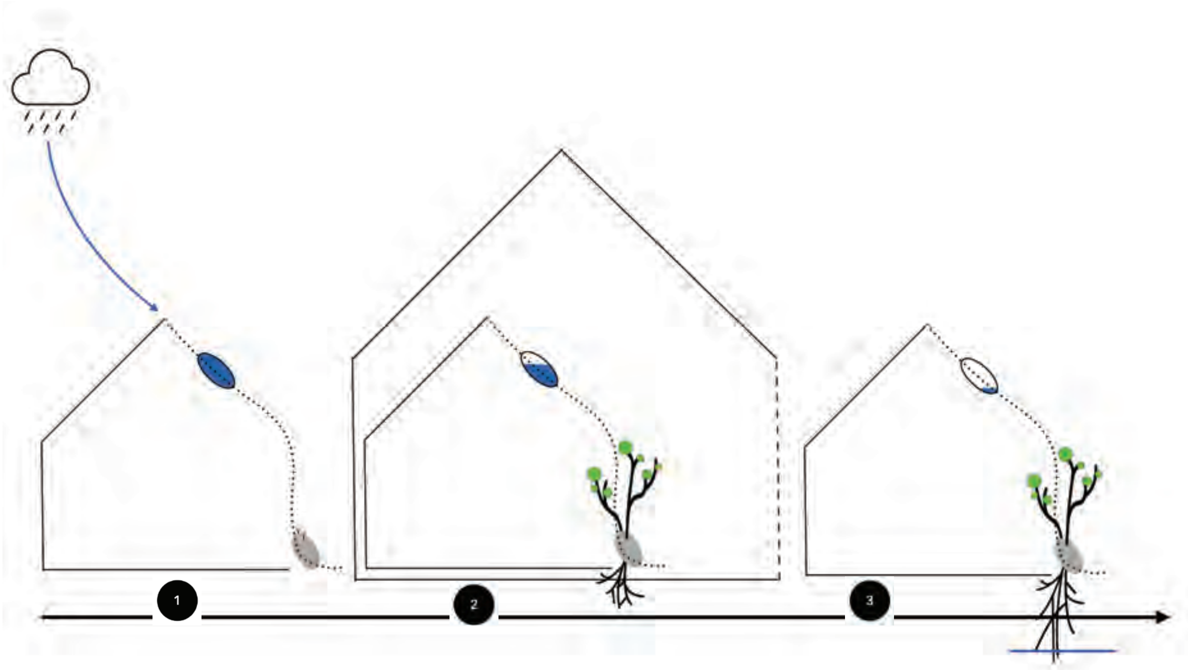


Figure 234: A scenario in which the Organic Shapes fabric is used as a dynamic spatial divider that transforms spatial experiences over time.

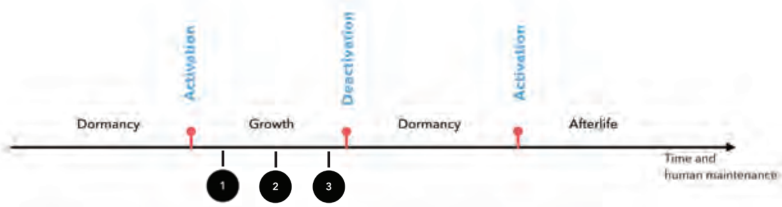


Figure 235: A diagram that illustrates which parts of the life cycle the Figures belong to.

Scenario

This scenario uses the Organic Shapes fabric as a spatial divider between the indoors, 'the intermediary space', and the outdoors, illustrating the concept of a flexible wall that is anchored by roots. The textiles are able to collect a certain amount of rainwater in their flexible tanks, which expand or contract based on the amount of water (although the expansion is limited by the size of the pocket that each tank is placed in). A valve attached to these tanks regulates the water supply, draining it to larger pockets that are filled with seeds and substrate. Through its weight, the substrate creates a flexible connection to the ground. Opening the valve allows the water supply which activates the germination of the seeds and maintains the growth of the plants. The roots of the plants have access to a permeable surface that they enter, creating a permanent and stable connection and anchoring the textile. Excess water could simply seeps into the ground.

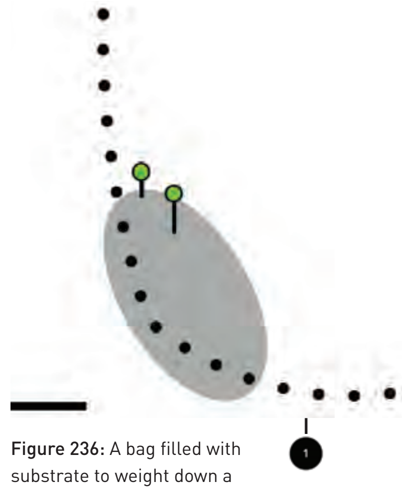


Figure 236: A bag filled with substrate to weight down a textile wall, and a young plant growing out of it.

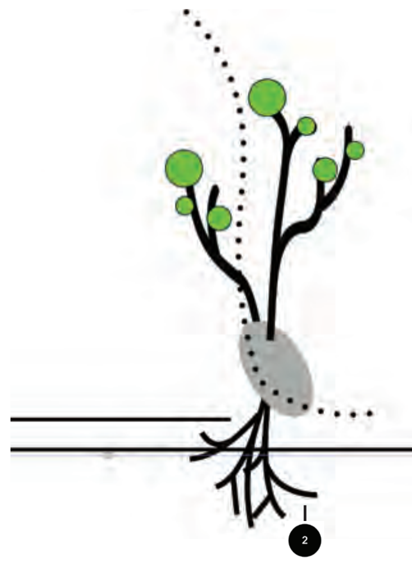


Figure 237: The plant eventually reaches maturity and stabilises the wall permanently through a thick network of roots.

Reflections

In this scenario, the pattern of the textile provides space in which elements of plant maintenance and organisation are integrated. Furthermore, it includes external ressources, in this case rain water for the maintenance of the piece, guided by the construction of the textile and according to its pattern design. The size, tension, and filling of the flexible water tanks are influenced by the size of the textile enclosures, which introduce three-dimensionality to a two-dimensional textile envelope, affecting how it drapes and falls in response to changes in dimensions. Thus, the expression of the textile is dynamically affected by the amount of water that it contains, the types of plant that are integrated as seeds, and the growth of these seeds. As the maximum possible dimensions for one pocket (in which the water container or the substrate could be integrated) in relation to the used Jaquard machine at Svensson AB could measure 150 cm by 300-600 cm (depending on the pick density), the sample could be manufactured in an architectural scale.

Figure 238: The Organic Stripes pocket-weave in use as a carpet.

Exploring a Carpet

In this example, the Organic Stripes cloth was processed into a carpet, investigating the three-dimensionality of the channels that were filled with seeds and substrate and their influence on the dynamic expression of the piece.

Setup

The pattern of the Organic Stripes fabric consisted of horizontal stripes of varying width, creating a wave-like expression (Figure 239). A DW2 binding was used on both sides, with a black and white warp to create colour contrast (Figure 240). As in the previous example, the selvedge could be opened quickly to insert substrate and seeds. The warp and weft materials were the same for this piece. The tubular wave shapes were filled with perlite, and a watering can beside the piece at the exhibition communicated the nature of the carpet and promoted speculation regarding its transformation (Figure 241).

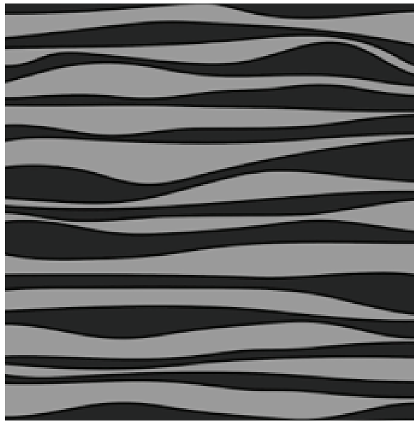


Figure 239: The pattern design of the Organic Stripes fabric.

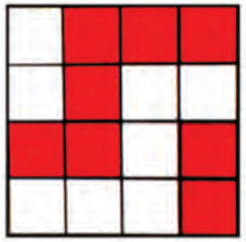


Figure 240: The DW2 binding (1/1 on both sides).

Figure 241: The installation invited participants to water the structures (from Jan Berg, 2017)

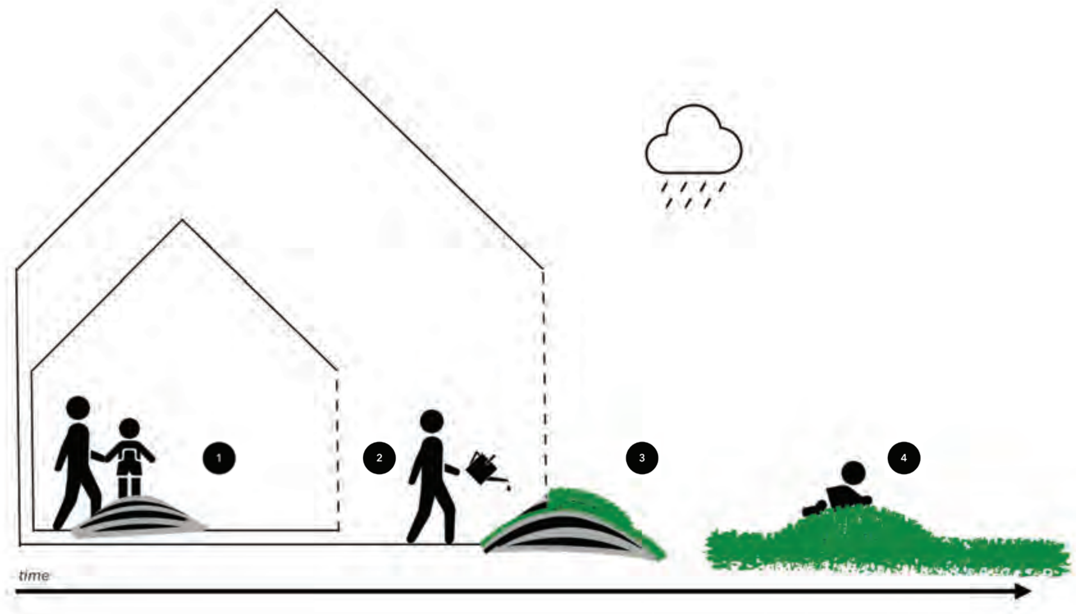


Figure 242: This scenario involves using the Organic Stripes fabric as a carpet that transforms over time when activated and maintained.

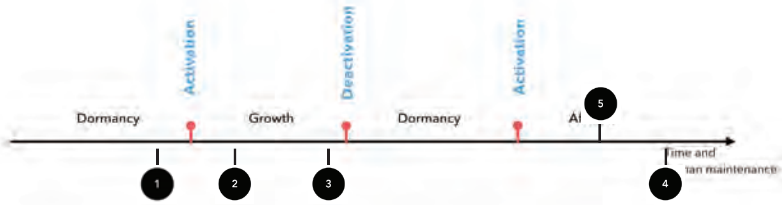


Figure 243: A diagram that illustrates which parts of the life cycle the Figures belong to.

Scenario

This scenario uses the Organic Stripes fabric as a carpet that transforms into several other three-dimensional shapes through draping. The carpet is filled with substrate and activated by watering (Figure 242, Point 2). Thus, the fabric can be used in a space in which puddles of water can be present without causing problems. The watering initiates the growth of plants, e.g. grass (Figure 242, Point 3). Through the use of biodegradable materials, the carpet has a set lifetime, it is a template and substrate for seeds to grow in interiors but would slowly degrade in in exterior conditions (Figure 242, Point 4). There, the carpet could be used to create an arrangement that would shape the landscape and, in time, become one with it. An alternative cycle is to initiate a drought and keep the textile carpet and its thick pile indoors. The surface expression of the dry grass would change over time, from green to a brownish fur-like coverage (Figure 246). Depending on its hard-wearing properties, the pile could be worn away as a result of use, leaving only the textile expression remains (Figure 344).

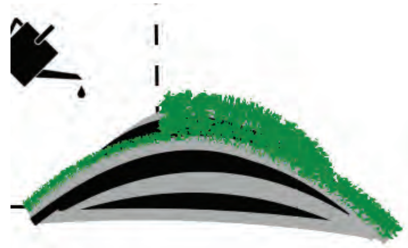


Figure 244: The transformation of the carpet as a result of its being moved to an intermediary space.

Figure 245: The afterlife of the carpet as a living part of the exterior landscape

Figure 246: The afterlife of the carpet as a passive part of the interior landscape.

Reflections

A carpet that can develop a thick pile as a result of the growth of e.g. grass and is biodegradable has a range of possible uses within its life cycle, being possible to use indoors, 'in between', and outdoors. Indoors, the structure can be draped and positioned as needed, and used as a carpet or seating. Activating it would cause the growth of the pile, and the way in which it is draped would influence the growth of the roots. As the roots follow gravity they would stabilize the drape and depending on the ground on which the carpet is placed, the roots could fix its position in a space. Managing the life cycles of structures requires participation and opens up for alternative ways of living with textile interiors and plants, with the options to decide when to trigger a change in spatial expression and experience, when to interrupt and stop them, and when to end the life cycle through composting. A biodegradable textile interior also allows choices to be made regarding the disposal of a textile, and conditions for this.

The example proposes that the textile be planted outdoors, where the carpet would initially shape the landscape before merging into it as the grass grows over its surface and the textile degrades. It therefore expresses its qualities as an intermediary object.

Figure 247: The pocket-weave with a circular pattern, in use as a tablecloth.

Exploring a Tablecloth

The tablecloth illustrates the fabric ´Connected Circles`and explores the idea of a tablecloth on which a variety of sprouts could grow. The derived scenario investigates connections between interior and exterior, the cycles of plants and their relation to the seasons and how a tablecloth could work as a mediator between them.

Setup

The textile design consisted of a pattern of circles connected by a system of channels in the warp direction. Each circle had a different diameter based on the size of the cotton pads, allowing the seeds to be integrated with the circles and inserted as composite units. Thus, 'planting discs' were prepared to insert the seeds at specific intervals and concentrations.

The weave construction of the circles on the front of the cloth was based on the open DW1 binding, through which the seeds and cotton pads were inserted. DW2-3 was used for the larger and smaller channels (the white areas and grey lines, respectively, in Figure 346). An organic combed 24/2 cotton was used for the weft.

The cloth was upholstered onto a small table to create a transforming tablecloth. A system of nozzles, activated by an integrated timer, sprayed a fine mist of water onto the seating arrangement (which consisted of the table/upholstered tablecloth and several seats) and the tablecloth to provide moisture without the need for human maintenance.

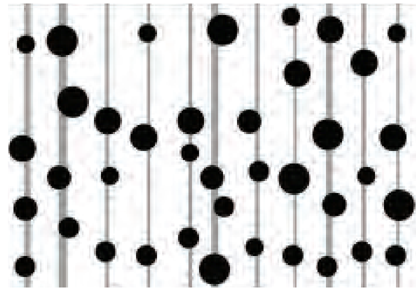


Figure 248: The rapport pattern.

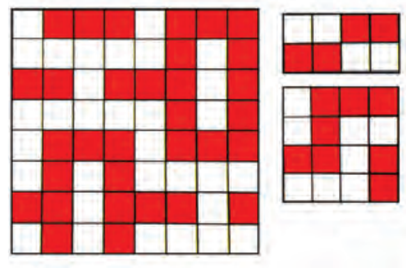
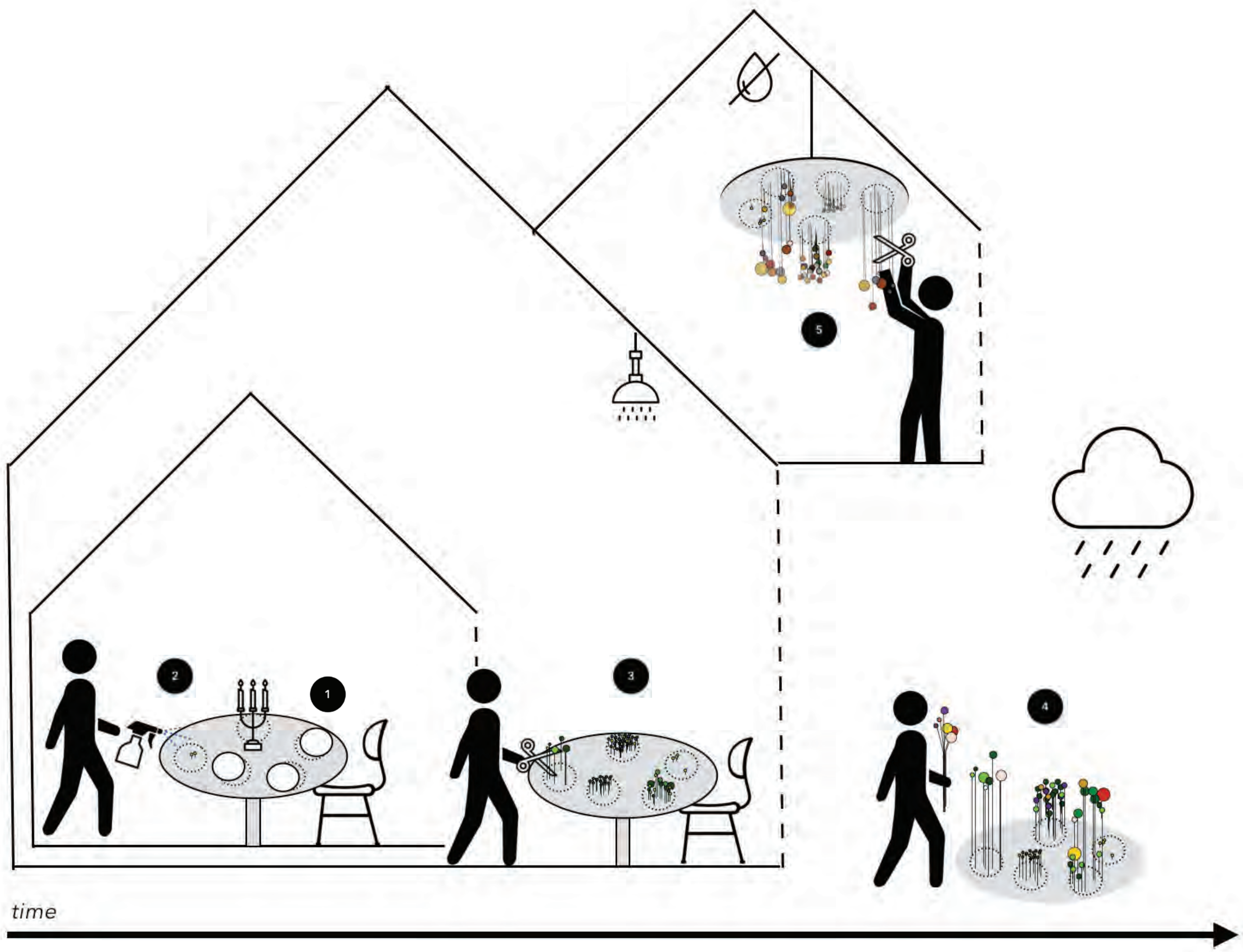


Figure 249: The bindings DW1 (left), DW4 and DW2 (top to bottom on the right)

Figure 250: A 'planting disc'.



Scenario

This scenario consists of a tablecloth with integrated seed discs that contains the seeds of e.g. herbs to be used in cooking. The textile can be used like an ordinary tablecloth indoors or be activated using water (349, Point 1). Through regular manual watering or a fine mist of water supplied by a system of nozzles, the growth of the sprouts can be maintained and the first leaves harvested (Figure 349, Point 2). To promote further growth, the tablecloth can be planted. If planted outdoors, the tablecloth would receive rainwater, sunlight, and nutrients from the soil, and thus be placed in an environment in which it could fully thrive (Figure 349, Point 3). This process can be halted by removing the tablecloth from the ground, framing it, and placing it in an interior space to dry out. The herbs, attached to the cloth, would dry and be preserved to be harvested in a dry form (Figure 349, Point 4).

Figure 251: The scenario involves using a tablecloth to grow seeds, e.g. herbs to be used in cooking. The tablecloth could also be planted in order to grow fresh herbs, or preserved in a dried state to harvest dried herbs.

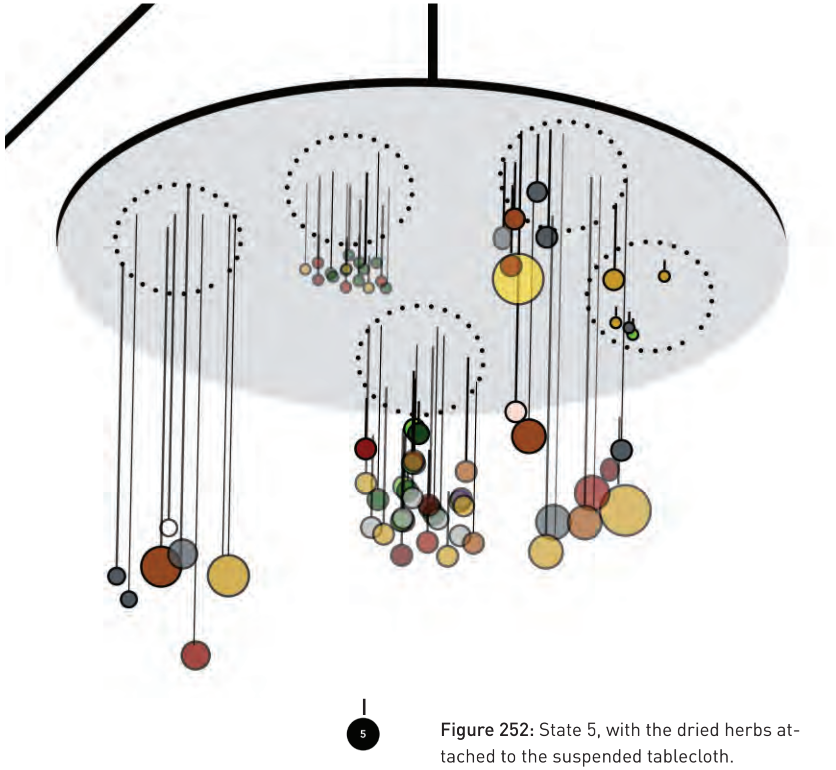


Figure 252: State 5, with the dried herbs attached to the suspended tablecloth.

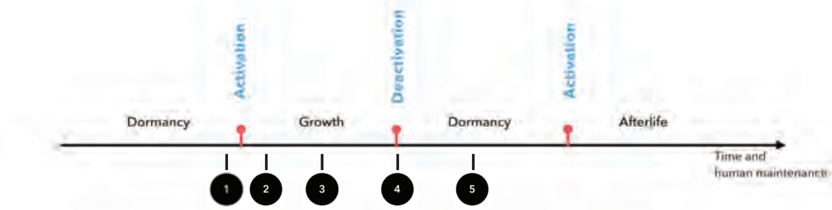


Figure 253: The diagram that illustrates which part of the lifecycle the Figures belong to.

Textile Pattern

The cloth featured pockets to host and organise seeds, e.g. basil, mint, and rosemary, in a circular pattern. The cotton-seed discs (containing a specific number of seeds that had been carefully positioned) were inserted into the pockets through the loose binding on the front of the tablecloth. The cotton also absorbed and stored water, allowing the seeds to germinate.

The cloth could be soaked or regularly watered to activate the germination (Figures 254 and 251, Point 2), and daily rinsing and draining reduces the risk of mould formation. Germination would alter the surface expression of both sides of the tablecloth, as stems and leaves would appear on the upper surface, adding three-dimensionality and colour to its expression (Figures 255 and 251, Point 3). On the underside, a network of roots would grow between the cloth and the table, and so its expression would remain flat. Consequently, the circular textile pattern would create a circular pattern of growth on both faces of the textile.

The tablecloth could be used as a 'plant nursery' by being planted, providing the plants with nutrients and a substrate to anchor in. In this way, the textile pattern would shape the expression of the bed of herbs and prevent the growth of weeds (251, Point 4). The flat network of roots would have space in which to expand and anchor the cloth to the ground, absorbing water and nutrients. During the period of growth, the herbs can be harvested. As the purpose of the textile was to grow an entire bed of herbs and be used as a tapestry, ceiling ornament, or tablecloth, it had to be resistant to environmental factors such as rain and sunlight. By the end of the growing season, the tablecloth can be moved indoors and dried, then placed to store and harvest the bed of herbs throughout over the course of a winter (251, Point 5).

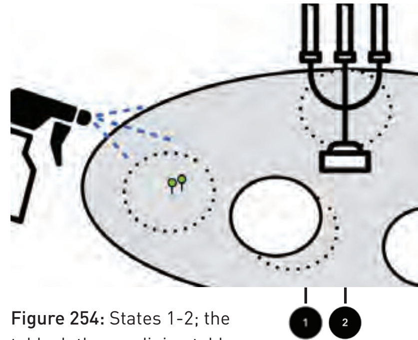
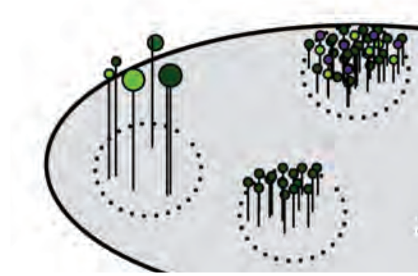


Figure 254: States 1-2; the tablecloth on a dining table, where it is activated.



Figures 255-256: State 3, wherein the sprouting herbs add three-dimensionality and colour to the plain cloth.

Figure 257: State 3, wherein the sprouting herbs added three-dimensionality and colour to the plain cloth.

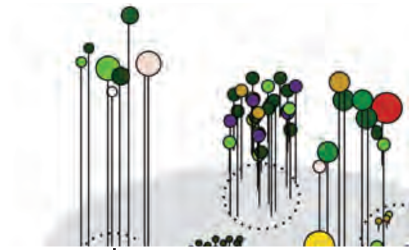
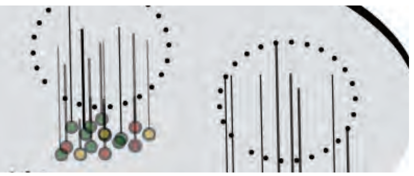
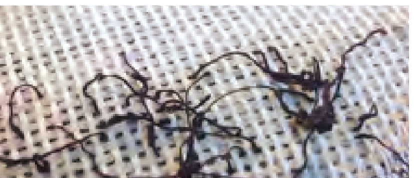


Figure 258: State 4; the tablecloth is planted outside in order for the plants to thrive fully.





Figures 259-260: State 5; the sprouts/plants dried out and hung from/collapsed on the fabric.

The former rigidity of the plants and their colours and shapes would change in response to this, from upright to drooping, from saturated to pale colours, and from round to sharper and wrinkled (compare the Figures 257 and 260).

The Tablecloth

Tablecloths are generally produced for the sole purpose of covering a dining table. They are transformed through wear and collecting stains, and disposed of when no longer aesthetic or clean. This scenario proposed the use of a tablecloth as a template for growth, wherein the textile pattern determined the pattern of growth. The time between the activating and planting of the textile is the period in which different spaces between indoors and outdoors are explored and techniques to maintain growth are investigated.

The scenario involves a passive and mobile (locally flexible) cloth becoming dynamic (transforming) and mobile (Figure 251, Point 2), then dynamic and static (251, 3), and finally passive and mobile (Figure 251, Point 4). The tablecloth consequently redefines itself by changing its positions and functions. The time until its disposal is thus shifted several steps into the future – if the growth is successful.

Reflections

In this scenario a tablecloth changes states; from passive (Figure 251, Point 1) to active (Figure 251, Point 2-3) and back to passive (Figure 251, Point 4). The textile plays a crucial role in organising the plants in all of the stages and undergoes expressional changes, ranging from the sprouts pushing through the textile structure to harvesting and the subsequent suspension of the tablecloth as a screen in order to dry and store the herbs (e.g. for the winter). In this way, the tablecloth promotes gardening practices in relation to the changing seasons. The maintenance of the textile ranges from manual human actions to possibilities relating to conditioned spaces and automated maintenance (sprinkler) and the natural environment, where the sun, rain, and soil would provide optimal growing conditions during spring and summer. Thus, the cycle and transformation of the cloth could follow the cycle of the seasons.

The textile tablecloth, as a template for growth, influences the cultivation of plants through its pattern, and so the design of the pattern creates connections and separations and promotes symbioses in organising patterns of growth in relation to requirements (dry substrate, wet substrate), principles (permaculture), and criteria (height of growth, colour).

In relation to textile design practice, designing with seeds and for alternative life cycles means designing with several dimensions in mind, and applying a holistic view to all of the phases of the design process, from pattern design to materials, bindings, etc. Consequently, the design phase must begin with a detailed scenario, from which all other design decisions can be derived.

Hybrid textiles and furniture open up possibilities for multi-use products and dynamic expressions that develop over time and through maintenance, but also involve challenges such as puddles, dust, mould, smells, and insects. The transformable tablecloth provides a template for the growth of herbs and a framework for their storage and harvesting. Consequently, it is extended to cover and protect a table and produce herbs for consumption and decoration.

Figure 261: The Geometrical Circles pocket-weave in use as a seat.

Exploring a Seat

The Geometrical Circles fabric was illustrated in this example, which took the form of a seating arrangement. Here, a pattern featuring small pockets was combined with a piece of furniture to produce seats that doubled as plant containers. The accompanying scenario investigates an alternative life cycle for this concept.

Setup

The Geometrical Circles fabric was used to upholster a seat. Prior to the upholstering process, the pockets of the cloth were equipped with soil tablets (Figure 262). This was undertaken by choosing areas that had been loosely bound (DW1), and separating the warp and weft threads using a pointed object, after which coconut-fibre tablets were manually inserted into the created holes, which were then neatly closed to hold the substrate in place and restore the structure and, thus, pattern (Figure 263).

Figure 262: A pocket in the doubleweave structure, opened by separating the threads.

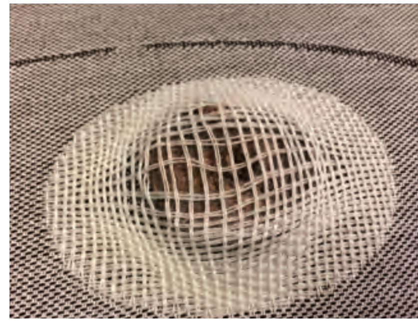


Figure 263: A pocket in the doubleweave structure that was filled with a coconut-fibre tablet.

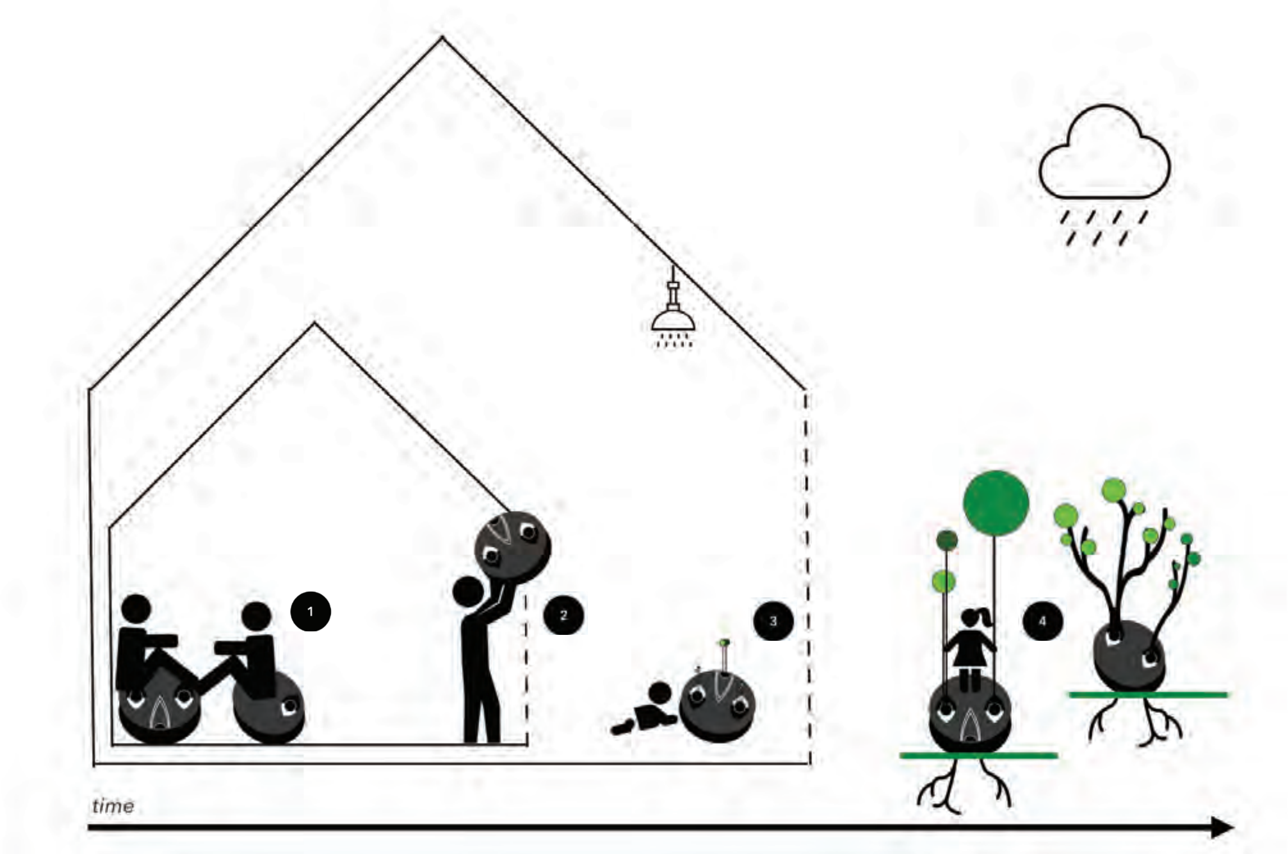


Figure 264: A seating arrangement, the seats of which can be activated. The resulting surface transformations can be observed, and the seats then placed outdoors in order to transform into e.g. a tree.

Figure 265: The diagram illustrates which part of the lifecycle the Figures belong to.

Scenario

The scenario involves seats that are intended to be sat on. These are filled with a substrate that, when dry, works well as an upholstery filling (Figure 264, Point 1). When the seat is no longer needed, it can be rearranged (Figure 264, Point 2) and watered to trigger the germination of the seeds that are integrated in the pattern of the fabric, which consists of small pockets filled with seed discs. Over time and as a result of human maintenance or an environment that supports growth through light and moisture, the seeds would germinate and permeate the weave structure (Figure 264, 266, 267, Point 3). The filling of the seat provides the growing seedlings with moisture, a permeable substrate to take root in, and nutrients. The scenario emphasises the growth of trees and bushes, which develop over a long period of time, generally outdo-ors. During the first stages of their growth, the seeds can grow on and within the seats. Later, due to the growing roots and need for further nutrients and more substrate, the seat could be moved outdoors, where the roots would anchor the young bush or tree to the ground and consequently create a permanent position for it (Figure 264, Point 4).

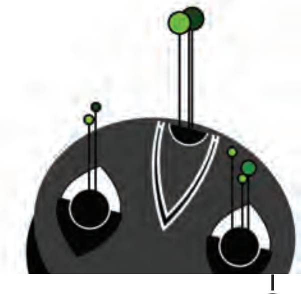


Figure 266: The seat in which the first plants are to grow. 3

Figure 267: A more dense cluster of seeds in a woven pocket. 3

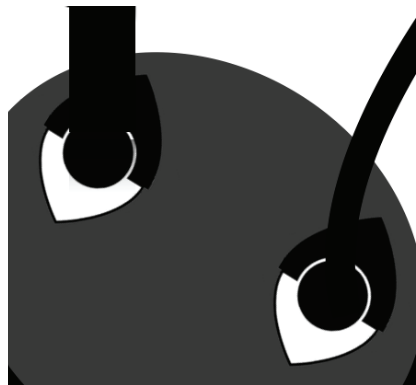


Figure 268: Two large trunks that succeeded in thriving over time and outdoors. 4

Reflections

This scenario proposed a piece of furniture that could be used as a seat in its first 'life' and as a container for a bush or tree in its second (the 'afterlife'). In contrast to the previous examples, this scenario emphasises the use of slow-growing plants such as bushes and trees, and therefore a period of growth that may span several decades. Pieces of high-quality furniture can be used for decades and even centuries, and are often passed down between generations. Textiles, however, generally expire relatively quickly. This example suggests that a piece of textile furniture can have a second life – in another form – that exceeds the former and allows subsequent generations to experience the piece.

The pattern of circular pockets serves as a container for a seed disk or soil pellet containing seeds. As the goal is not coverage of an area but the growth of a single plant, the number of seeds is lower and so the interactions between the seeds and the textile structure in the early cycles of growth are relatively small, but become more interesting as the stem widens with each year.

A BIOLOGICAL CHALLENGE

Textile Farming proposes a framework for designing dynamic surface expressions using seeds, and integrating biological life cycles in the design of textile interiors in order to open processes of textile and interior design towards botanical and horticultural practices. The framework provides a complementary perspective on living with plants indoors and promotes expressions that bridge interior and exterior spaces, man-made and natural, passive and active.

The concept of weaving, as the interplay of fibres, colour, and weave, is expanded by another factor – seeds – which provides a range of static expressions relating to e.g. shape and dimensionality, affecting the structure, pliability, and weight of a textile, and providing transformative potential with regard to e.g. colour, shape, and direction of growth. Consequently, using seeds in textile design processes opens up for the design of surface expressions that develop over time. Bacteria (Yao et al., 2015), veneer (Menges & Reichert, 2015; Scott, 2013), and other shape-changing materials and responsive textile systems (Scott, 2016; Mossé, 2014; Abel, 2014) are dynamic and transform over time and in response to external influences in a generally reversible manner. Irreversible dynamic patterns are defined by Worbin as "textile patterns that changes during use and do not come back to an initial expression, the expression is built up over time" (2010). The transformation of the textile-seed hybrids is irreversible, and comparable to recent research by Dumitrescu et al. (2013), Nilsson et al. (2011), Worbin (2010), and Talman (2015). However, seeds undergo relatively complex transformations; once activated they continuously change their expression in terms of e.g. shape, colour, and dimensionality, and pass through different stages of development, e.g. germinating, growing, blooming, and propagating. This in turn demands alternative ways of designing with and using them.

As Worbin states: *When the characteristics of textiles change, the roles of designers and users change with respect to textile products. The notion of a textile as the 'final' product will be different from what we today get out from traditional industrial textile processes.* (2010)

Thus, both the characteristics and role of the material that the textile is made of change; the material reacts to certain stimuli, but also constantly performs and transforms in complex ways in relation to its own dynamics. Consequently, *On Textile Farming* explores biological perspectives on textile design and smart textiles, where hybrid textiles are constantly affected by environmental stimuli and impart information through their response to these stimuli. Thus, the reaction of sprouts to environmental stimuli and different forms of tropism (explored by Collet in the *Botanical Fabrication* project; 2015) shape the surface expressions of textiles and provide information regarding e.g. light, humidity levels, and direction of gravity. In relation to this, Ramsgaard Thomsen and Bech describe textiles as "a technology as well as a material" (2012), using knitting in programmable systems for architectural structures. The intrinsic potential of natural materials in relation to textile design and developing adaptive structures that react to environmental stimuli has not yet been fully explored, however, particularly with regard to weaving and complex plants.

When used as living and responsive smart materials, seeds not only sense and adapt but transform and change their general character and mode of life,i.e. their structures and outward appearances, and adapt to the conditions in which they find themselves. Designing textile-seed hybrids and planning the different stages of their development and expressions requires that designers combine knowledge of textiles and botany; this, and relating these two fields to interior spaces and their environments, along with the parameter of time, leads to the adoption of a biological perspective on designing interiors. These are generally understood to be relatively static environments, the design of which involves creating contemporary expressions that serve the user and the space. *On Textile Farming* proposes an understanding of interiors that considers them to be dynamic spaces, and so the design enquiry focuses on material characteristics that cannot be expressed by new structures but are expressed through time and use, and in relation to the environment itself. Here, textiles – as highly adaptive structures – can accommodate and organise plants and be used to shape and transform space over time, working closely with the user and the environment. A framework for designing dynamic interior textiles has therefore been proposed, and includes methods of designing textile-seed hybrids, i.e. integrating seeds in textile structures. The introduced design variables relating to the textile and the seed result in a passive hybrid, whereas those relating to maintenance lead to a transformation in the expression over time. The passive and active states of the textile-seed hybrids open up for a life cycle with different phases, wherein functions, location, and expressions are influenced by the materials and structures used and human maintenance. Designing a textile that passes through multiple phases, requires a different approach to textile design, outlined in the diagram (Figure 7) that frames the life cycle of textile-seed hybrids. The three main phases – dormancy, growth, and afterlife – can be used to design, manage, and describe the life cycles of textile-seed hybrids, and question static and one-dimensional design approaches, opening up for alternative perspectives on designing interior textiles and interior design practice in general.

In relation to indoor gardening and urban gardening as a means of making cities greener and more sustainable with regard to the availability of food, textile-seed hybrids propose a complementary perspective on the rigid structures that both concepts are based on. The design of templates and patterns that incorporate seeds offers several possibilities in terms of vertical farming: Seeds can be placed in a certain pattern, i.e. the selection of seeds and their arrangement can follow the principle of permaculture, creating beneficial relationships between the plants and their environment (textile and space). Furthermore, the areas in which the seeds grow can be defined by the textile design, with e.g. the bindings being used to restrict or promote growth and so direct the development of roots, stems, and leaves. This can be undertaken with regard to the type of germination and characteristics of development of plants, and environmental influences as directed by human maintenance. Colours can be selected in order to merge or contrast (or both in different phases) with the expression of the textile, in order to create dynamic surface expressions. Accordingly, materials that support the needs of plants and store, direct, or repel water can be selected, as can textiles with different levels of durability prior to biodegradation or that change expression in different ways by environmental influences such as light, temperature, and humidity. These materials can also be engineered to provide and transport nutrients to the plants such that the textile structure serves as template, carrier, and substrate, with the structure working with the material. Furthermore, materials can be selected to provide a certain thickness and permeability. The arrangement of textile-seed hybrids in space can be chosen and changed over time, i.e. they can be positioned horizontally, vertically, or diagonally; suspended or laid flat; framing a space or dividing it; facing light or shade. In relation to their life cycle design they can be moved, and so be initially placed indoors and eventually move outdoors. Their activation can be triggered by changing environmental conditions or the user interacting with the structure, affecting the entire piece or a certain part of it. Maintenance depends on the setting and demands of the structure in the interior space; as Despommier states in relation to his concept of vertical farming:

[P]lants do not require soil, per se. What they use soil for is a solid base of operations into which they can spread their roots. In other words, the earth serves as a physical support system [...] as long as there is enough water and dissolved minerals, and a source of organic nitrogen. (Despommier, 2011)

Thus, textile-seed hybrids physically support roots and can be developed to meet the needs of plants in soil-less conditions. Through constraining or promoting their development, roots can be influenced in terms of direction, length, and density, and can replace the textile structure as parts of it gradually degrade. Thus, textile-seed hybrids are designed to grow and decompose in a predetermined way, with the structure of the textile material and choice of seeds defining the phases of the dynamic transformation. Consequently, expressions such as weathering, discolouration, puddles, and dust become part of the interior, introducing alternative values and characteristics that need to be enabled, accepted, and lived with by the inhabitants of the space. These alternative perspectives not only change the practices of designers but require the cooperation of the user in enabling and maintaining the dynamic expressions. Pinto et al. describe the new roles and relationships between designers, users, and materials: "The final product is the result of the actions of various actors: the designer who developed the system, the one who manipulates the system and the actuators that define it" (Pinto et al., 2013). There is thus a close relationship between these actors. Extending the life cycles of interior textiles means that designers must expand their palette of textile design processes and adopt more holistic practices in which textiles are understood and handled as dynamic 'fabrics of time'. Here, individual phases of life – and beyond – must be thought through and have central roles in textile design processes. As the involvement of the user is crucial in managing the life cycles of textile-seed hybrids, these must be designed, communicated, and guided by both the textile design and the designer. Designers not only design possible surface expressions, but influence the ways in which users interact with products, and so 'mediate' the design intention and the demands of the textile-seed hybrid and the user. This thesis encourages designers to explore how natural principles can impact practice, as is proposed by Collet and Foissac: "designers can begin to integrate botanical and horticultural knowledge to play with the environment of plant growth and envision production chains of a new type" (2015). They can also envision and design textile interactions of a new type, as textile-seed hybrids promote both textile and biological perspectives, which can be combined to create a biophilic approach to designing textile-seed hybrids and interacting with them in interiors. Users, as those who live and interact with textile-seed hybrids, can choose whether to act based on the information provided by the designer through the design or instructions. They can also choose to act based on a design intention of their own. They can determine the use, time of activation, and maintenance of an object, and so define the duration of phases and select where these take place. Their commitment or lack of maintenance also determines the quality of growth and well-being of the structure. Due to the importance of knowledge and commitment on the part of users, instructions and even education with regard to main working methods may be of value. However they respond to these suggestions, users are free to act in relation to their imagined scenarios and reflect on their experiences, making them investigators in their own right.

The seeds, as the actuators and drivers of transformations, respond to the intentions of the designer in relation to their selection and placement, and to the user in relation to how they are maintained and where the finished object is placed. The weave structure can consequently exhibit certain surface topographies, which are defined by fibre size and orientation, pore size and geometry, pore interconnectivity, and total porosity. These parameters influence the bio-receptivity of the textile, i.e. whether it is biocompatible with a living system – in this case seeds. By enhancing or suppressing the bio-receptivity of the textile, the pattern of growth can be influenced.

However, even if all variables have been carefully considered, the development of the seed textiles consistently exhibited a certain unpredictability that was related to a complex network of factors. This unpredictability can cause problems in maintaining the structures, but result in unique and unexpected surface expressions.

The development of the research programme was strongly influenced by the industrial context of Svensson AB, resulting in a conceptual reunification of the company's departments. This may promote discussion of developments in hybrid housing as a potential market and changing design and production practices through new materials and techniques. By combining textile thinking and indoor gardening, imaginary and practical realities are explored and sustainable, alternative modes of living with plants are investigated, following natural rhythms of transformation and the interconnectedness of plant systems. The design methods presented in this thesis suggest changes to practice, but also posit ways of designing, producing, and furnishing interiors, and living with plants. Today, the textile industry (and Svensson AB more specifically) develops highly specific products that are created for particular purposes and feature static expressions that are designed to last for as long as possible. Dynamic changes relating to e.g. the age of a textile are prevented, and perspectives on a secondary usage or the disposal of the product are not suggested or provided.

On Textile Farming proposes the inclusion of dynamic changes and considerations relating to the life cycles of plants in design processes and product development, as well as perspectives relating to multiple uses and environments. With regard to Svensson AB, this would mean that textiles that manage interiors and plants could become one and the same: Interior textiles that react to environmental changes without electronics but through changes in light, humidity, and temperature. Textile walls, floors, and ceilings could thus become green, and move from the interior and into the intermediary spaces, and from there outdoors. They would thus benefit from different forms of human maintenance and environmental conditions, influencing their transformations. These processes could be halted after sprouting in order to grow a short-pile carpet with a pattern determined by the characteristics and position of the seeds used, along with the textile structure. This in turn could be transformed into a vegetable patch through permaculture techniques, or a tree, wherein the textile provides nutrients. By living with textile-seed hybrids, people and plants can be brought together – both indoors and outdoors.

The scenarios presented in this thesis represent a speculative approach to the framework and are intended to open up for speculative design research in an industrial context as an approach to creating perspectives ahead of the next years for the company and customers, that can be used for discussions, and developing business strategies, products, and production methods.

To encourage discussion and enable alternative ways of organising, living, and interacting with plants in relation to sustainable interior textiles to be explored, a collection of interior textile prototypes will be developed in which seeds are integrated in both subtle and overt ways. They will be explored in a real scale living scenario and exhibited for being explored by the public. .

REFERENCES

Abel, J. (2014). Active Knit Actuation Architectures. University of Michigan.

Akbari, M., Tamayol, A., Laforte, V., Annabi, N., Najafabadi, A. H., Khademhosseini, A., & Juncker, D. (2014). Composite living fibers for creating tissue constructs using textile techniques. Advanced Functional Materials, 24(26), 4060–4067. http://doi.org/10.1002/adfm.201303655

Andrews, K. (2013). Pasona urban farm by Kono designs. Retrieved January 10, 2017, from http://www.dezeen.com/2013/09/12/pasona-urban-farm-by-kono-designs/

Aouf, R. S. (2016). IKEA moves into indoor gardening with hydroponic kit. Retrieved January 10, 2017, from https://www.dezeen.com/2016/05/03/ikea-indoor-gardening-hydroponic-kit-krydda-vaxer/

Archer, B. (1995). The Nature of Research. Co-Design, Interdisciplinary Journal of Design, 6–13. http://doi.org/10.1007/s10165-008-0069-5

ArcInTexETN. (2016). Research Program. Retrieved from http://www.arcintexetn.eu/research/research-program/

Aust, M. (2010). Wohnbeet. Retrieved October 14, 2016, from http://aust-amelung.com/wohnbeet.html

Bang, A. L. (2010). Emotional value of applied textiles - Dialogue-oriented and participatory approaches to textile design. Kolding School of Design, Aarhus School of Architecture.

Beatley, T. (2017). Handbook of biophilic city planning and design. Handbook of Biophilic City Planning and Design. http://doi.org/10.5822/978-1-61091-621-9

Beatley, T., & Newman, P. (2013). Biophilic cities are sustainable, resilient cities. Sustainability (Switzerland), 5(8), 3328–3345. http://doi.org/10.3390/su5083328

Beckett, R. (2018). Bioreceptive Facade Panels. Retrieved 22 March 2018, from http://www.richard-beckett.com/bioreceptive-facade-panels.html

Biggs, M. (2004). Learning from Experience: approaches to the experiential component of practice-based research. In Forskning, Reflektion, Utveckling (pp. 6–21).

Binder, T., & Redstrom, J. (2006). Exemplary Design Research. DRS Wonderground, 21.

Blaine, T. W., Dawes, A., & Snider, D. (2010). Profiling community gardeners. Journal of Extension, 48(6), 1–12.

Cache, B., Boyman, A., & Speaks, M. (2010). Earth moves: the furnishing of territories. Cambridge, MA: MIT Press.

Cairns, S., & Jacobs, J. M. (2014). BUILDINGS MUST DIE: a perverse view of architecture. MIT PRESS.

Camilleri, W., Sampaio, D., Blog, B., Winfield, A., Nash, A., & Institute, W. et al. (2018). Making an autonomous robotic ecosystem: Hortum Machina B | Robohub. Robohub.org. Retrieved 10 February 2018, from http://robohub.org/making-an-autonomous-robotic-ecosystem-hortum-machina-b/

Carlile, P. R. (2002). A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development. Organization Science, 13(4), 442–455. http://doi.org/10.1287/orsc.13.4.442.2953

Chieza, N. & Ward, J. (2015). Design in the Age of Living Technology. Proceedings of the 2nd Biennial Research Through Design Conference, 2. https://doi.org/10.6084/m9.figshare.1327971.

Clément, G., Rahm, P., & Borasi, G. (2007). Environ(ne)ment: Manières dagir pour demain = approaches for tomorrow. Milan: Skira.

Collet, C. (2012). BioLace: An Exploration of the Potential of Synthetic Biology and Living Technology for Future Textiles Studies in Material Thinking, 7(2).

Biennial Research Through Design Conference, 4. https://doi.org/10.6084/m9.figshare.1327976.v1

Collet, C. & Foissac, G. (2015). Botanical Fabrication - A research project at the intersection of design, botany and horticulture. Proceedings of the 2nd

Collet, C. (2016). Botanical factory. Retrieved March 25, 2018, from http://www.designandlivingsystems.com/botanical-factory/

Collins English Dictionary (2018). Collinsdictionary.com. Retrieved 22 March 2018, from https://www.collinsdictionary.com/dictionary/english/nature

Congdon, A. (2018). Tissue Engineered Textiles: Research. Retrieved 20 February 2018, from http://www.amycongdon.com/tissue-engineered-textiles/

Cooke, L. (2012). Utopian off-grid Regen village produces all of its own food and energy. Retrieved January 10, 2017, from http://inhabitat.com/utopian-off-grid-village-grows-own-food-in-shared-local-eco-system/

Correa, D., Krieg, O., Menges, A., Reichert, S., & Rinderspacher, K. (2013). HygroSkin: A Climate-Responsive Prototype Prject Based on the Elastic and Hygroscopic Properties of Wood.

Correa, D., Papadopoulou, A., Guberan, C., Jhaveri, N., Reichert, S., Menges, A., & Tibbits, S. (2015). 3D-Printed Wood: Programming Hygroscopic Material Transformations. 3D Printing and Additive Manufacturing, 2(3), 106–116. http://doi.org/10.1089/3dp.2015.0022

Cross, N., 2001. 'Designerly ways of knowing: design discipline versus design science', Journal of the Design Issues, 17(3), pp. 49-55.

Cross, N. (2006). Designerly ways of knowing, London, Springer, pp. 49-55.

Cross, N. (2007). Designerly ways of knowing. Basel: Birkhäuser.

Cross, N. (2007). From a Design Science to a Design Discipline: Understanding Designerly Ways of Knowing and Thinking. Design Research Now, 41-54. doi:10.1007/978-3-7643-8472-2_3

Cruz, M., & Beckett, R. (2016). Bioreceptive design: A novel approach to biodigital materiality. Architectural Research Quarterly, 20(01), 51-64. doi:10.1017/s1359135516000130

Decker, M. (2016). Matter Timed. Archit. Design, 86: 82–87. doi:10.1002/ad.2005

Desai, A., & Mital, A. (2003). Evaluation of disassemblability to enable design for disassembly in mass production. International Journal of Industrial Ergonomics, 32(4), 265–281. http://doi.org/10.1016/S0169-8141(03)00067-2

Despommier, D. (2011). Advantages of the Vertical Farm. Sustainable Environmental Design in Architecture Springer Optimization and Its Applications,259-275. doi:10.1007/978-1-4419-0745-5_16

Despommier, D. (2011). The vertical farm: feeding the world in the 21st century. New York: Picador.

Despommier, D. (2013). Farming up the city: The rise of urban vertical farms. Trends in biotechnology. 31. 388-9. doi: 10.1016/j.tibtech.2013.03.008.

Dias, B. D. (2015). Beyond Sustainability – Biophilic and Regenerative Design in Architecture. European Scientific Journal, 7881(March), 1857–7881.

Doron, G. (2005). Urban agriculture: Small, medium, large. Architectural Design, 75(3), pp. 52–59. doi:10.1002/ad.76.

Dourish, P. (2001). Where the action is: The foundations of embodied interaction. Cambridge, MA: MIT Press.

Duchemin,E. , F. Wegmuller & A.-M. Legault (2008). Urban agriculture: multi-dimensional tools for social development in poor neighbourhoods. Field Actions Science Reports. Vol. 1

Dumitrescu, A. D., Nilsson, L., Persson, A., & Worbin, L. (2014). Smart Textiles as Raw Materials for Design. In Shapeshifting Conference. Auckland University of Technology (pp. 1–20).

Ecovative (2018). Ecovative Design. Retrieved February 10, 2018, from https://www.ecovativedesign.com/

Findeli, A., Brouillet, D., Martin, S., Moineau, C., & Tarrago, R. (2008). 04: Research Through Design and Transdisciplinarity: A Tentative Contribution to the Methodology of Design Research. «FOCUSED» — Current Design Research Projects and Methods Swiss Design Network Symposium, 67–91.

Flores, H. C. (2006). Food not lawns: How to turn your yard into a garden and your neighborhood into a community. White River Junction, VT: Chelsea Green.

Fransella, F., Bell, R., & Bannister, D. (2004). A manual for repertory grid technique. Chichester, West Sussex, England: John Wiley & Sons.

Franck, K. A. (2016), Designing with Time in Mind. Archit. Design, 86: 8–17. doi:10.1002/ad.1996

Frayling, C. (1993). Research in art and design. Royal College of Art Research Papers series, 1(1).

Frearson, A. (2016). EFFEKT designs villages that produce all food and energy. Retrieved March 25, 2018, from https://www.dezeen.com/2016/05/20/effekt-designs-regen-villages-produce-own-food-energy-danish-pavilion-venice-architecture-biennale-2016/

Fredriksson, M. & Warne, B. (1993). På akacians villkor: Att bygga och bo i samklang med naturen. Partille: Warne.

Freitag. (2017). F-ABRIC IS GROWN IN EUROPE. Retrieved March 25, 2018, from https://www.freitag.ch/en/fabric/resource

Gissen, D. (2009). Subnature: Architectures other environments: Atmospheres, matter, life. New York: Princeton Architectural Press.

Goffi, F. (2016). Built Conservation and the Unfinished Fabrics of Time. Archit. Design, 86: 24–33. doi:10.1002/ad.1998

Gotham Greens. (n.d.). Our Story. Retrieved March 25, 2018, from http://gotham-greens.com/our-history

Gray, C., & Malins, J. (2004). Visualizing research: A guide to the research process in art and design. Aldershot, Hampshire, UK: Ashgate.

Greenhouse Living. (n.d.). Retrieved March 25, 2018, from http://www.greenhouseliving.se/

Gruber, P. (2009). Biomimetics in architecture – inspiration from plants, 6th Plant Biomechanics Conference – Cayenne, November 16 – 21, 2009. Retrieved 22 February 2018, from http://www.ecofog.gf/Docs/PBM2009Proceedings.pdf

Gruber, P. (2011). Biomimetics in architecture: architecture of life and buildings. Biomimetics--Materials, Structures and Processes, 245. http://doi.org/10.1007/978-3-7091-0332-6

Jensen, K. G., & Sommer, J. (2016). Building a circular future. Kobenhavn: GXN Innovation.

Hallnäs, L. (2010). The design research text and the poetics of foundational definitions. ArtMonitor, (No 8), 109-118.

Hallnäs, L., & Redström, J. (2006). Interaction design : foundations, experiments. Retrieved March 25, 2018, from http://urn.kb.se/resolve?urn=urn:nbn:se:hb:diva-3386)

Hallnäs, L., Redström, J. (2008). Textile Interaction Design. The Nordic Textile Journal, Smart Textiles special edition, pp. 105-115.

Halweil, B. (2004) Eat Here: Reclaiming Homegrown. Pleasures in a Global Supermarket, WW Norton & Company: Washington DC.

Hamann, H., Wahby, M., Schmickl, T., Zahadat, P., Hofstadler, D., Stoy, K., Risi, S., Faina, A., Veenstra, F., Kernbach, S., Kuksin, I., Kernbach, O., Ayres, P. and Wojtaszek, P. (2015) 'Flora Robotica - mixed societies of symbiotic robot-plant bio-hybrids', 2015 IEEE Symposium Series on Computational Intelligence, . doi: 10.1109/ssci.2015.158.

Harrison, A. (2002). Shared judgements: Thinking for yourself, thinking from the standpoint of everyone else, and being consistent. Working Papers in Art and Design, 2. Retrieved November 12, 2005, from http://www.herts.ac.uk/artdes1/research/papers/wpades/vol2/andrewfull.html

Hebel, D. E., Wisniewska, M. H., & Heisel, F. (2015). Building from Waste : Recovered Materials in Architecture and Construction. In Building from Waste : Recovered Materials in Architecture and Construction.

Horton, R. (2010). Roll Out Your Garden - Urban Gardens. Urban Gardens. Retrieved 20 March 2018, from http://www.urbangardensweb.com/2010/02/02/roll-out-your-garden/

Horton, R. (2013). How to Grow Your Own Food Garden With a Template - Urban Gardens. Urban Gardens. Retrieved 20 March 2018, from http://www.urbangardensweb.com/2013/07/22/how-to-grow-your-own-food-garden-with-a-template/

Hosey, L. (2012). The shape of green: Aesthetics, ecology, and design. Washington, DC: Island Press.

Howard, P. L. (2006). Gender and social dynamics in swidden and homegardens in Latin America. Advances in Agroforestry Tropical Homegardens, 159-182. doi:10.1007/978-1-4020-4948-4_10

Imhof, B., & Gruber, P. (2016). Built to grow: blending architecture and biology. Heidelberg: Birkhäuser Verlag AG.

Ingold, T. (2011). Tim Ingold. World Archaeology. http://doi.org/10.1080/00438243.1993.9980235

Ingold, T. (2015). The life of lines. London: Routledge.

Ingold, T. (2016). On human correspondence. Journal of the Royal Anthropological Institute, 23(1), 9–27. http://doi.org/10.1111/1467-9655.12541

Jonas, W. (2015). Research through design is more than just a new form of disseminating design outcomes. Constructivist Foundations.

Jones, J. C. (1992). Design methods. New York: Van Nostrand.

Jordan, P. (2000).Designing Pleasurable Products. An introduction to the new human factors. London: Taylor & Francis.

Kellert, S. R. (2012). Building for Life Designing and Understanding the Human-Nature Connection. Washington DC: Island Press.

Kretzer, M. (2018). Materiability.com. Retrieved 10 February 2018, from http://materiability.com/about/

Kretzer, M. & Hovestadt, L. (2014). Alive: Advancements in Adaptive architecture. Austria: Ambra.

Krieg, O., Christian, Z., Correa Zuluaga, D., Menges, A., Reichert, S., Rinderspacher, K., & Schwinn, T. (2014). HygroSkin – Meteorosensitive Pavilion.

Kuusk, K. (2016). Crafting sustainable smart textile services. Eindhoven University of Technology.

Louv, R. (2008). Last child in the woods: Saving our children from nature-deficit disorder. Ecology And Society. http://doi.org/1565123913

Löwgren, J., Larsen, H. S., & Hobye, M. (2013). Towards programmatic design research. Designs for Learning, 6(1-2), 80. doi:10.2478/dfl-2014-0017

Ludwig, F., de Bruyn, G., Thielen, M. & Speck, T. 2009. Plant stems as building material for living plant constructions. Sixth Plant Biomechanics Conference. Cayenne, French Guyana, France: UMR EcoFoG.

Ludwig, F., Schwertfeger, H., & Storz, O. (2012). Living Systems: Designing Growth in Baubotanik. Architectural Design,82(2), 82-87. doi:10.1002/ad.1383

Marder, M. (2012). Plant intentionality and the phenomenological framework of plant intelligence. Plant Signaling & Behavior,7(11), 1365-1372. doi:10.4161/psb.21954

Marris, E. (2013). Rambunctious garden: Saving nature in a post-wild world. New York: Bloomsbury Publishing Plc.

McDonough, W., & Braungart, M. (2002). Cradle to Cradle. Chemical and Engineering News, 80(3), 208. http://doi.org/10.1021/es0326322

McLennan, J. F., & Berkebile, B. (2004). The Philosophy of Sustainable Design the future of architecture. Kansas City: Ecotone.

Menges, A. & Reichert, S. (2012). Material Capacity: Embedded Responsiveness. Archit Design, 82: 52-59. doi:10.1002/ad.1379

Menges, A., Reichert, S., & Krieg, O. (2014). Meteorosensitive Architectures.

Menges, A. & Reichert, S. (2015). Performative Wood: Physically Programming the Responsive Architecture of the HygroScope and HygroSkin Projects. Architectural Design (Vol. 85). http://doi.org/10.1002/ad.1956

Minnich, R.A. (1983). Fire mosaics in southern California and northern Baja

California. Science 219: 1287-1294

Mody, A. (2015). Textilisations of light: using textile logics to expand the use of LED technology from a technology of display towards a technology of spatial orientation. Kbh.: The Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation, School of Architecture.

Montana-Hoyos, C., & Fiorentino, C. (2016). Bio-utilization, bio-inspiration, and bio-affiliation in design for sustainability: Biotechnology, biomimicry, and biophilic design. International Journal of Designed Objects, 10(3), 1–18. http://doi.org/10.18848/2325-1379/CGPv10i03 Myers, W. and Antonelli, P. (2014) Bio design: Nature, science, creativity. London: Thames & Hudson.

Morton, T. (2012). The ecological thought. Cambridge, MA: Harvard University Press.

Mossé, A. (2014). Gossamer timescapes: designing self-actuated textiles for the home. Ph.D. thesis, The Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation, School of Architecture, Copenhagen.

Moulds, J. (2015). Can big brands catch up on sustainable fashion?. the Guardian. Retrieved 10 February 2018, from https://www.theguardian.com/sustainable-business/sustainable-fashion-blog/2015/mar/24/composting-clothes-sustainable-materials-biodegradable

Moutos, F. T., Freed, L. E., & Guilak, F. (2007). A biomimetic three-dimensional woven composite scaffold for functional tissue engineering of cartilage. Nature Materials,6(2), 162-167. doi:10.1038/nmat1822

Mycoworks (2017). MycoWorks. Retrieved 20 February 2018, from http://www.mycoworks.com/

Myers, W. & Antonelli, P. (2014). Bio design: Nature, science, creativity. London: Thames & Hudson.

Nilsson, L., Vallgårda, A., & Worbin, L. (2011). Designing with Smart Textiles : A new research program. Nordes. Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:hb:diva-5422

Philips 90 years of design. (2018). 90yearsofdesign.philips.com. Retrieved 10 February 2018, from https://www.90yearsofdesign.philips.com/article/67

Pinto, R.; Carvalhais, M. and Atkinson, P. (2013). Generative designing with biological systems - searching for production tools aimed at individualization. In: Proceedings of the 10th European Academy of Design Conference, Gothenburg. [Gothenburg], University of Gothenburg/European Academy of Design.

Pleasant, B. (2015). Using Seed Tapes, Seed Mats and Seed Disks. GrowVeg. Retrieved 20 March 2018, from https://www.growveg.com.au/guides/using-seed-tapes-seed-mats-and-seed-disks/

Pons, O., Nadal, A., Sanyé-Mengual, E., Llorach-Massana, P., Cuerva, E., Sanjuan-Delmàs, D., . . . Rovira, M. R. (2015). Roofs of the Future: Rooftop Greenhouses to Improve Buildings Metabolism. Procedia Engineering,123, 441-448. doi:10.1016/j.proeng.2015.10.084

Portoghesi, P. (2000). Nature and architecture , Skira editore, Milan.

Radchuk, V., & Borisjuk, L. (2014). Physical, metabolic and developmental functions of the seed coat. Frontiers in Plant Science,5. doi:10.3389/fpls.2014.00510

Thomsen, M. R., & Bech, K. (2012). Suggesting the Unstable: A Textile Architecture. Textile, 10(3), 276-289. doi:10.2752/175183512x13505526964029

Ramsgaard Thomsen, M., Tamke M. (2009). Narratives of making: Thinking practice led research in architecture. Paper presented at the International Conference on Research and Practice in Architecture and Design, Bruxelles.

Redström, J. (2011). Some notes on program/experiment dialectics. Proceedings of Nordic design Research Conference 2011, June, Helsinki, Finland. The Journal of Cloth and Culture, vol. 10, no. 3, pp.276-289.

Redström, J. (2017). Making design theory.MIT Press:Cambridge(MA)

Rendell, J. (2005). Architectural research and disciplinarity. Architectural Research Quarterly, 8 (2), 141-147.

Rissanen, T., & McQuillan, H. (2016). Zero waste fashion design. New York: Fairchild Books.

Schmidttakahashi (n.d.). Circulation of Clothes. Retrieved February 10, 2018, from http://www.schmidttakahashi.de/label/concept

Savic, S., Huang, J. (2014). Proceedings of the 5th STS Italia Conference: A Matter of Design. Making Society through Science and Technology. Research Through Design: What Does it Mean for a Design Artefact to be Developed in the Scientific Context?. Issue EPFL-CONF-207787. STS Italia Publishing. p. 409-423

Scherer, D. (2016). Interwoven. Retrieved March 25, 2018, from http://dianascherer.nl/

Schön, D. A. (1983). The Reflective Practitioner: How Professionals Think in Action: Basic books.

Scott J. (2013). Hierarchy in Knitted Forms, Responsive Textiles for Architecture, proceedings of ACADIA2013 Adaptive Architecture, Waterloo, Canada, pp347-355

Scott J. (2015). Mutate: The Evolution of a Responsive Knit Design System. Proceedings of Research Through Design, Microsoft Research Centre, Proceedings of RTD2015, http://figshare.com/articles/RTD2015_05_Mutate_The_Evolution_of_a_Responsive_Knit_Design_System/1327974

Scott, J. (2016). Programmable Knitting. In: Acadia 2016 Posthuman Frontiers. Acadia Publishing Company, pp. 276-281.

Scott J (2017). Programmable Knitting, Active Matter. Mit Press.

Simard, S. W., Beiler, K. J., Bingham, M. A., Deslippe, J. R., Philip, L. J., & Teste, F. P. (2012). Mycorrhizal networks: Mechanisms, ecology and modelling. Fungal Biology Reviews, 26(1), 39-60. doi:10.1016/j.fbr.2012.01.001

Smýkal, P., Vernoud, V., Blair, M. W., Soukup, A., and Thompson, R. D. (2014). The role of the testa during development and in establishment of dormancy of the legume seed. Front. Plant Sci. 5:351. doi: 10.3389/fpls.2014.00351

Stamets, P. (2005). Mycelium Running, how mushrooms can help save the world. Ten Speed Press. http://doi.org/10.3368/er.27.2.228

Stappers, P. J. (2007). Doing Design as a Part of Doing Research. Design Research Now, 81-91. doi:10.1007/978-3-7643-8472-2_6

Star, S. L., & Griesemer, J. R. (1989). Institutional Ecology, `Translations and Boundary Objects: Amateurs and Professionals in Berkeleys Museum of Vertebrate Zoology, 1907-39. Social Studies of Science, 19(3), 387-420. doi:10.1177/030631289019003001

Stoner, J. (2016). The Nine Lives of Buildings. Archit. Design, 86: 18–23. doi:10.1002/ad.1997

Svesson AB. (2016). Climate screens installed in an innovative Hybrid House. Retrieved March 25, 2018, from http://www.ludvigsvensson.com/climatescreens/news/industry-news/climate-screens-installed-in-an-innovative-hybrid-house

Svensson AB. (2018). About us. Retrieved March 25, 2018, from http://www.ludvigsvensson.com/interior-textiles/about-us

Syn.de.bio. (2015). Bioreceptive Concrete Facade Panels by Richard Beckett and Marcos Cruz - Retrieved 22 February 2018, from http://syndebio.com/bioreceptive-facade/

Talman, R. (2015). Exploring the relationship between material and textile structure in creating changing textile expressions. In EKSIG 2015 – Tangible Means

- Experiential Knowledge Through Materials. Kolding. Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:hb:diva-8627

Taylor, M. (2016). Time Matters: Transition and Transformation in Architecture. Architectural Design, 86: 42–49. doi:10.1002/ad.2000

ten Bhömer, M. (2016). Designing embodied smart textile services. PhD Thesis. Mtbhomer.com. Retrieved 25 February 2018, from https://www.mtbhomer.com/portfolio/phd-thesis/

Toole, E. H., Hendricks, S. B., Borthwick, H. A., & Toole, V. K. (1956). Physiology of Seed Germination. Annual Review of Plant Physiology,7(1), 299-324. doi:10.1146/annurev.pp.07.060156.001503

Trewavas, A. (2005). Green plants as intelligent organisms. Trends in Plant Science, 10(9), pp. 413–419. doi: 10.1016/j.tplants.2005.07.005.

VERTICALGREEN Jardines Verticales. (2018). VERTICALGREEN. Retrieved 25 February 2018, from http://www.verticalgreen.com/index.html

Vieira, P., Gagliano, M., & Ryan, J. (2016). The green thread: dialogues with the vegetal world. Lanham: Lexington Books.

Viljoen, A., Bohn, K., & Howe, J. (2005). Continuous Productive Urban Landscapes. Continuous Productive Urban Landscapes: Designing Urban Agriculture for Sustainable Cities, 1–296. http://doi.org/10.4324/9780080454528

Wahby, M., Hofstadler, D. N., Heinrich, M. K., Zahadat, P., & Hamann, H. (2016). An Evolutionary Robotics Approach to the Control of Plant Growth and Motion: Modeling Plants and Crossing the Reality Gap. 2016 IEEE 10th International Conference on Self-Adaptive and Self-Organizing Systems (SASO). doi:10.1109/saso.2016.8

Washington, H. (2015). Demystifying Sustainability: Towards Real Solutions. Edition. Routledge.

Weinthal, L. (2008). Bridging the Threshold of Interior and Landscape: An Interview with Petra Blaisse. Architectural Design, 78(3), 64-71. doi:10.1002/ad.676

Weinthal, L. (2011). Toward a new interior. New York: Princeton Architectural Press.

Wilson, E. O. (1984). Biophilia. Harvard University Press.

Wilson, M. (2017). Microsoft Is Teaching Your Plants To Talk Back. Retrieved March 25, 2018, from http://www.fastcodesign.com/3060347/microsoft-is-teaching-your-plants-to-talk-back

Worbin, L. (2010). Designing dynamic textile patterns (PhD dissertation). Chalmers University of Technology. Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:hb:diva-3550

Yao, L., Ou, J., Wang, G., Cheng, C.-Y., Wang, W., Steiner, H. & Ishii, H. (2015). 'BioPrint: A liquid deposition printing system for natural actuators', 3D Printing and Additive Manufacturing, 2(4), pp. 168–179. doi: 10.1089/3dp.2015.0033.

Zimmerman, J., Stolterman, E., & Forlizzi, J. (2010). An analysis and critique of Research through Design: towards a formalization of a research approach. Paper presented at the Designing Interactive Systems, Aarhus, Denmark.

APPENDIX

Publication I

Keune, S. (2017). Co-designing with plants. Degrading as an overlooked potential for interior aesthetics based on textile structures. The Design Journal, 20(sup1), S4742–S4744. http://doi.org/10.1080/14606925.2017.1352977

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Co–designing with plants. Degrading as an overlooked potential for interior aesthetics based on textile structures

Svenja Keune

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Co–designing with plants. Degrading as an overlooked potential for interior aesthetics based on textile structures

Svenja Keune[a*]

[a]ArcInTexETN, Svensson AB, Swedish School of Textiles
[*]Corresponding author email: svenja.keune@ludvigsvensson.com

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).

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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 germs/coleoptiles after two days of water supply. The coleoptiles grew straight upwards. The radicals and the seminal roots, white and red, grew inwards and gathered at the bottom. Within a couple of days, green leafs 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 withdrawal of their color and shape and thus turn into a harmonic hybrid expression of dried textile–plant–object.

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 leafs, 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 leafs 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 weave, using specific materials for managing watering and nutrition.

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References

Doron, G. (2005). 'Urban agriculture: Small, medium, large', *Architectural Design*, 75(3), (pp. 52–59).

Bohn, K. (2005) *Continuous productive urban landscapes: Designing urban agriculture for sustainable cities*. Oxford: Elsevier Architectural Press.

F-ABRIC Compost. (2017). FREITAG. Retrieved 11 May 2017, from https://www.freitag.ch/en/fabric/compost

Lenzing fibers. (n.d.). Retrieved 11 May 2017, from http://www.lenzing-fibers.com/en/home/

Tabellini, G. (2015). *Mycelium Tectonics: Studio di comportamenti morfologico–costruttivi attraverso sistemi biologici e simulazoni al computer*. Ph.D. alma mater studiorum – Università di Bologna.

Lee, S., du Preez, W. and Jones, N.T. (2007) *Fashioning the future: Tomorrow's wardrobe.* London: Thames & Hudson.

Yao, L., Ou, J., Wang, G., Cheng, C.-Y., Wang, W., Steiner, H. and Ishii, H. (2015) '*BioPrint: A liquid deposition printing system for natural actuators*', 3D Printing and Additive Manufacturing, 2(4), (pp. 168–179).

Chieza, N. and Ward, J. (2015). Design in the Age of Living Technology. In: *Proceedings of the 2nd Biennial Research Through Design Conference*, 25-27 March 2015, Cambridge, UK, Article 2.

Downloaded by [216.46.4.250] at 08:53 14 October 2017

Publication II

Keune, S. (2017). Alive. Active. Adaptive. In International Conference 2017 of the DRS Special Interest Group on Experiential Knowledge (Vol. 19, p. 90).

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

Svenja Keune, ArcInTexETN, Swedish School of Textiles, University of Boras, Sweden

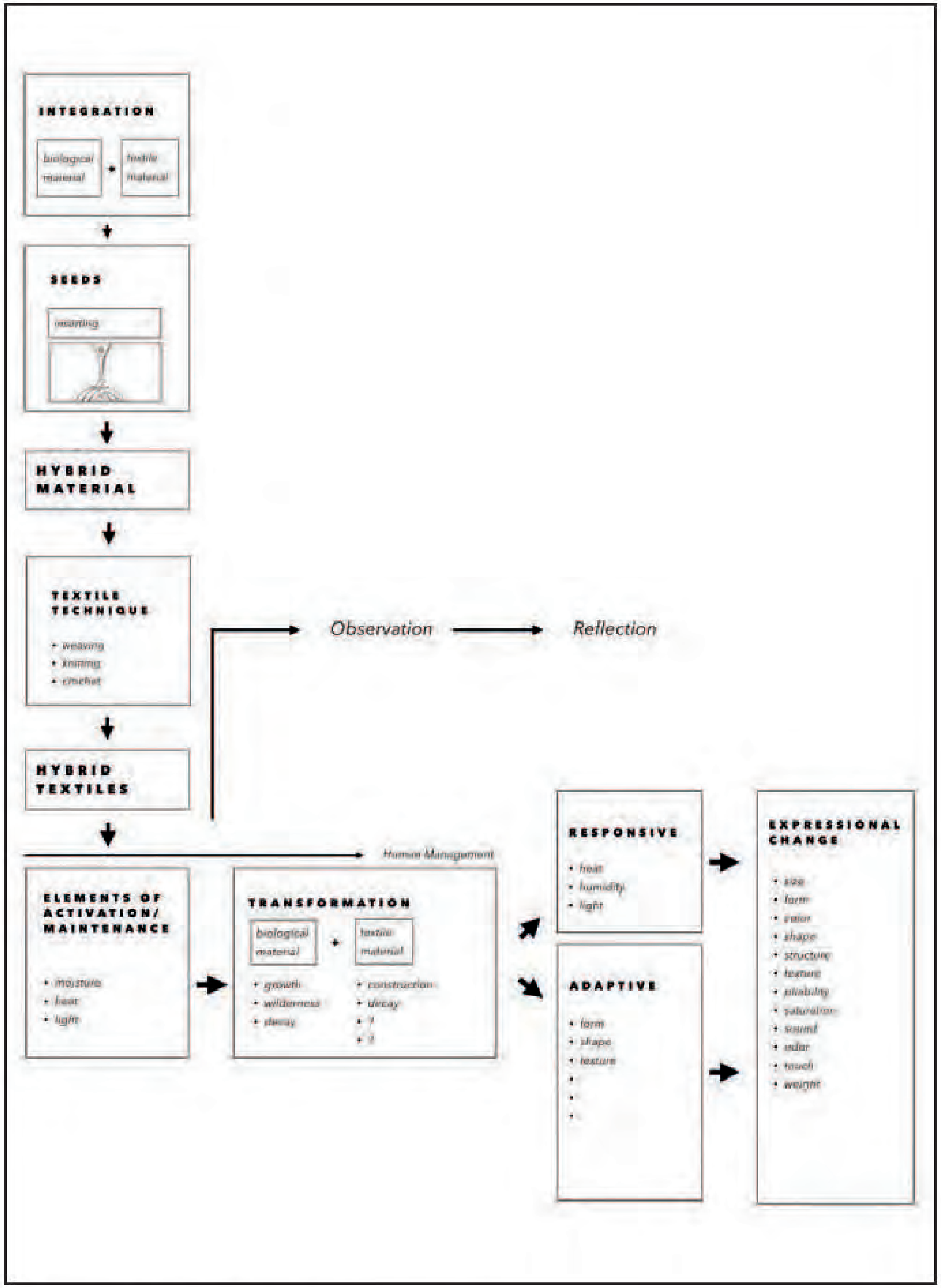
Keywords
biodesign;
dynamic expressions;
textile transformation;
living with plants;
indoor greenery

Abstract

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.

Introduction

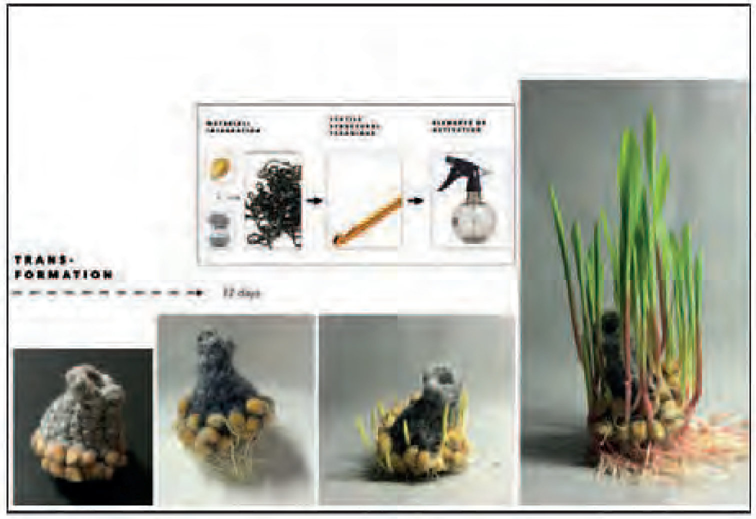
The transformative character of textiles by traditional techniques has been expanded through the development of smart materials (Worbin, 2010; Dumitrescu et al, 2014; Talman, 2015), therefore the functionality of textiles shift from static and passive towards dynamic and active expressions (Schülke,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



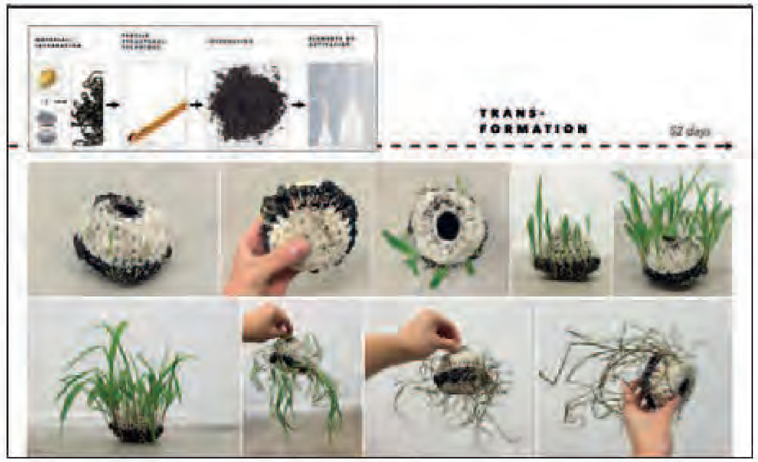
Delft University of Technology, The Netherlands

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 Chieza and Ward. They are developing a closed–loop manufacturing system for textile dyeing and printing by using bio–pigments, produced by living bacteria (Chieza 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

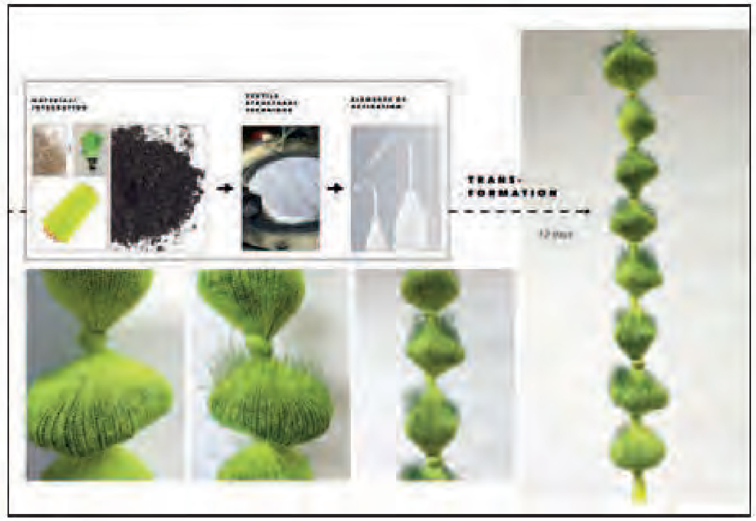
Set 4 shows a wool–corn material crochet into an organic form. The woolen tubular knit was chosen due to its material qualities and the fine construction that highlights the corn. Activated by regular watering, the outgrowth of roots positioned, stabilized and enlarged the object towards the ground and 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.

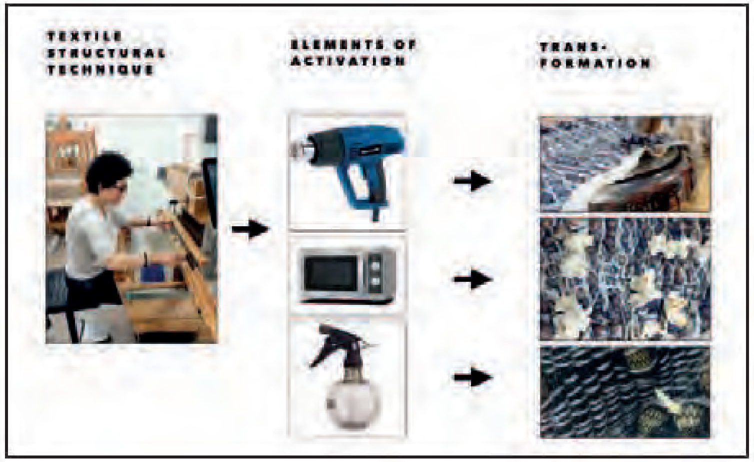


Set 6 shows a tubular knit from Polyester, filled with soil and grass seeds. The textile materials was chosen due to its color, the grass due to its potential to cover an entire surface. The outgrowing grass covers the up–facing parts of the structure like a fur. Its density increased, the expression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

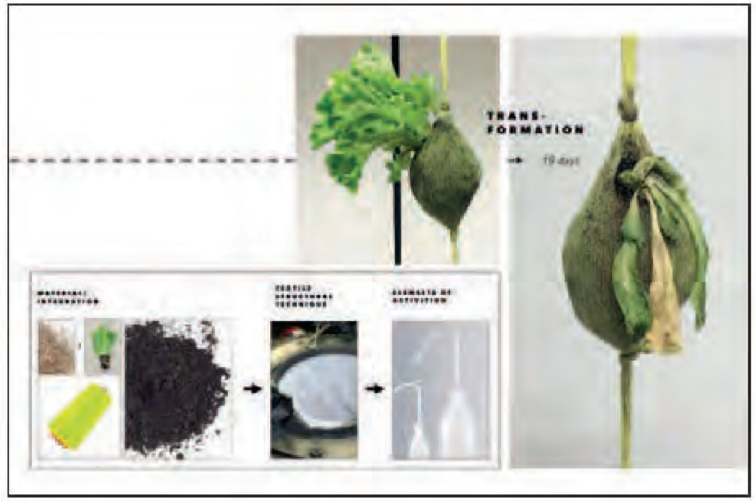


Set 1 shows corn, introduced into a tubular knitted material made from cotton and polyester. The cotton–corn material has been heated in a microwave, popped and expanded the tube. The corn-polyester material has been sprayed with water, roots were developing after two days. The experiment was directed to explore the transformation of a material that unactivated can be used in textile constructions. The corn was chosen due to its potential of reacting to heat and moisture.

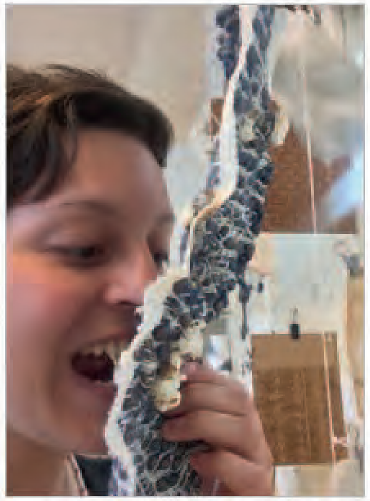
Set 2 shows a prev. described cotton–corn material used in hand weaving. It has been activated by a heatgun (4mins), a microwave (2x2mins) and a water spray bottle (2x/day). The experiment explores 3 forms of activating a cotton–corn–cloth and its transformation/disruption over time. The popcorn–cloth turns brownish, expands broadly, has a sweet smell, the sprouting cloth has an earthy smell, and sharp, green sprouts.



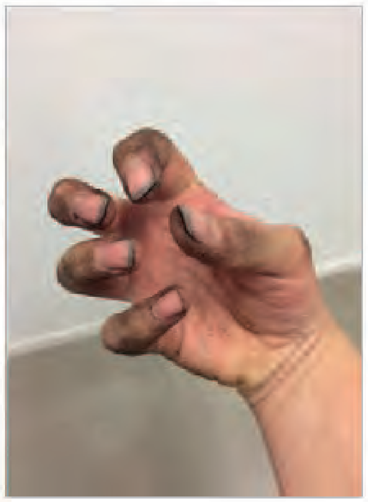
Set 3 shows a cotton–barleygrass material crochet onto a weave. The barley grass was chosen due to its fast growing process and its nutritional value. The textile has been activated by regular watering with a spray–can. Due to the green colored cotton–barleygrass material and its sprouts, the first changes and the contrast between the plant–parts and the textile design are subtle, thus they are aesthetically interwoven and blend into one another.



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, threedimensional 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.



Both, the biological material and the textile material, transform over time, due to their distinct material qualities. The biological material, seeds for example, will express different states of plant–life, in this context described as growth, wilderness and decay. These transformations open up for people–plant–interaction which is summarized as human management and includes activities such as observing, manipulating, harvesting, draping, touching, cutting, braiding. The transformation itself and the human management lead to expressional changes on the different levels/ scales that can be perceived as adaptive and responsive and expressed by changes in size, form, color, texture, pliability, weight and odor, to name a few.



Discussion

The use of knitting, weaving and crochet, as illustrated in this picorial, 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 spacial and threedimensional constructions. The density and the position of the knit influence the outgrowth of the germinating seeds. The material effects 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 plant/s 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 characteristics initiate the silent changes of movement, which is more a 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 reltionship 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 biocycle by focusing on pure cellulosebased 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

Worbin, L. (2010). Designing Dynamic Textile Patterns. PhD-Thesis, The Swedish School of Textiles, University of Borås, Chalmers University of Technology, Gothenburg, Sweden.
Dumitrescu, D., Nilsson, L., Persson, A. and Worbin, L. (2014). Smart textiles as raw materials for design, Textile and Design Lab and Colab at Auckland University of Technology.
Talman, R. (2015). Exploring the relationship between material and textile structure in creating changing textile expressions, Tangible Means Experiential Knowledge Through Materials EKSIG 2015 – Kolding: Design School Kolding, Denmark.
Schülke, B. (2014). New materialism - The transformation of intelligent textiles towards an interactive youser generated interface, ESJ September 2014 /Special/ Edition VOL.3: European Scientific Institute, ESI.
Hibbert, R. (2001). Textile innovation: Traditional, modern and smart textiles. London: Line.
Chieza, N. and Ward, J. (2015). Design in the Age of Living Technology. In: Proceedings of the 2nd Biennial Research Through Design Conference, 25-27 March 2015, Cambridge, UK.
Scherer, D. (2016). Interwoven. Retrieved October 26, 2016, from http://dianascherer.nl/.
Myers, W. (2014). Bio design: Nature, science, creativity. London: Thames & Hudson.
Yao, L., Ou, J., Wang, G., Cheng, C.-Y., Wang, W., Steiner, H. and Ishii, H. (2015). BioPrint: A liquid deposition printing system for natural actuators, 3D Printing and Additive Manufacturing, 2(4), (pp. 168–179).

Publication III

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Al Dente Textiles. Notes on edible textiles as economic and ecological intermediality

Tincuta HEINZEL[ac1*], Svenja KEUNE[b], Sarah WALKER[c] and Juste PECIULYTE[d]

[a] "Ion Mincu" Architecture and Urbanism University Bucharest; [b] Swedish School of Textiles Boras; [c] Nottingham Trent University; [d] Vilnius Academy of Arts.

One of the red lines of aesthetics as modern established discipline was the definition of media categories and disciplines in order to support "efficient" ways of expression. The debate between Gotthold Lessing and Charles Batteux in the XVIII century, and later on the propositions of artists and critics in the beginning of 20th century, have all emphasised the need of a certain "aesthetic efficiency" of artistic production. This aesthetic "efficiency", a term of economical ascendency, was to be achieved by taking into account the limitations of materials used by different forms of expressions and the sensorial channels they were addressing.

Taking as starting point a series of experiments made during a workshop at the Swedish School of Textiles in Boras in April 2016 on edible textiles, the present paper questions the notions of "media efficiency", "economy of attention" and "media ecology" from the perspective of intermediality.

Keywords: *Edible textiles; media specificity; media efficiency; ecology of media; intermediality; multimediality, economy of attention.*

Introduction

In this paper we will present some reflections on edible textiles as a new hybrid form of media. After a brief description of the experiments we did during a two days workshop in April 2016 in the frame of the ArcInTex

1* Corresponding author: **Heinzel Tincuta** | e-mail: **tinca@textiltronics.com**

Conference, as well as a short presentation of some other examples of edible textiles in art and design, we will investigate the way in which edible textiles could be a media. Taking as starting point the concepts of "intermediality" and "medium specificity", our reflection spots to an economical and ecological approach of the media and relates to the present debates on new materialism and ecology of media. The multifaceted aspects we encountered testify of the difficulties to give an overall acceptable definition of media.

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 between April 11-15, 2016, at the Swedish School of Textiles in Boras, there was a general interest in the work-in-progress materials developed by Svenja Keune. Her approach consists in integrating edible and growing materials into different textile structures i.e. knitting, weaving and crochet. These hybrid materials can be activated in order to change shape, pliability, consistence or to initiate processes of plant–growth (*fig. 1*).

A group of participants to the conference agreed to use the initial concept and the materials for further explorations. Composed of seven participants, the group was divided into pairs working towards different aspects of what we called a "chain of production" (*fig. 2)*: "hunters and collectors" (collecting materials to be integrated into textiles), "fillers" (dealing with the integration of collecting materials into textiles), "masterweavers" (in charge to produce a fabric from these hybrid materials) as well as "activators" and "documentarists" (working towards the "activation" of the resulted fabrics).

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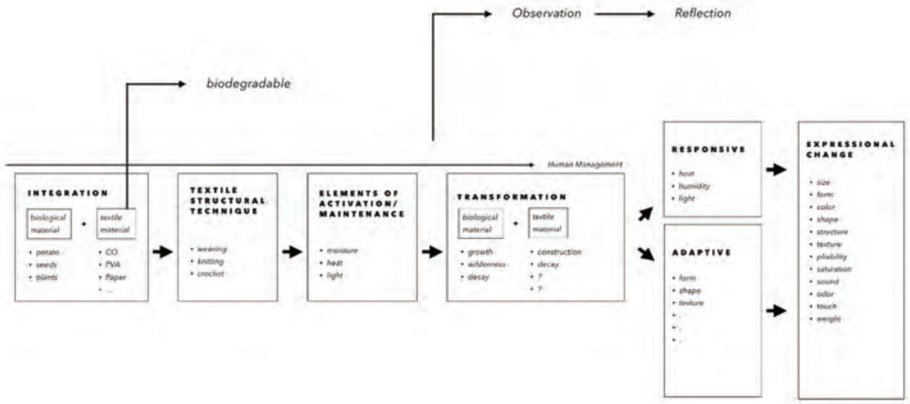

Figure 1. Schema of experiments

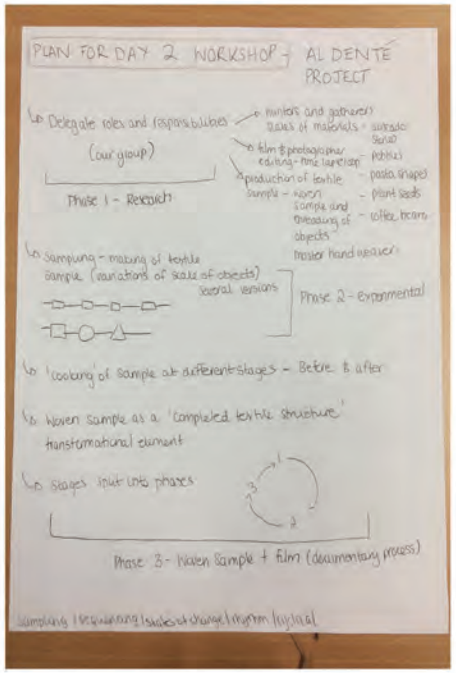

Figure 2. Photo of the planned experiments

3

Materials and techniques

As for the textile materials, we used various commercially available tubular knitted materials in cotton, wool and synthetics. The collected edible and biological materials that were filled into the textiles tubes were cornflakes, corn, coffee beans, hazelnuts, pasta, soil, coconutfiber and boiled eggs. These materials were filled 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 threads displaying different textures qualities.

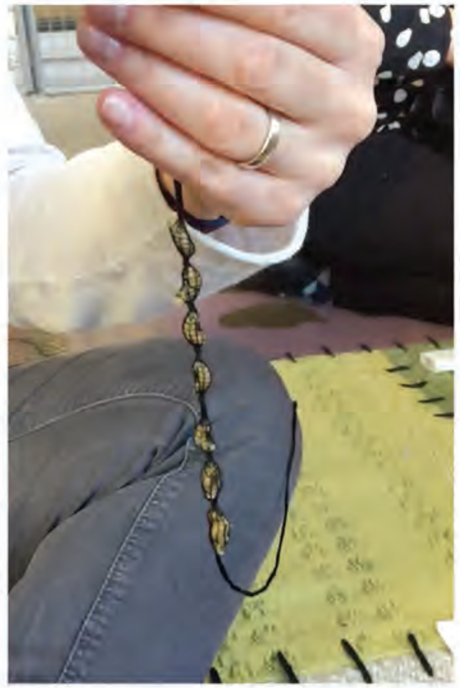

Figure 3. Making of hybrid threads

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These hybrid threads were later hand-weaved on an ARM–loom as a weft–material into pieces of fabrics in combination with common yarns *(fig. 4)*. Later on, the samples were activated to generate ideas for textile interaction and transformation by using the potential of the threads we produced *(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, shape, surface structure, smell and colour, as well as their reaction in time to moisture, heat and light.

Figure 4. Woven Combinations

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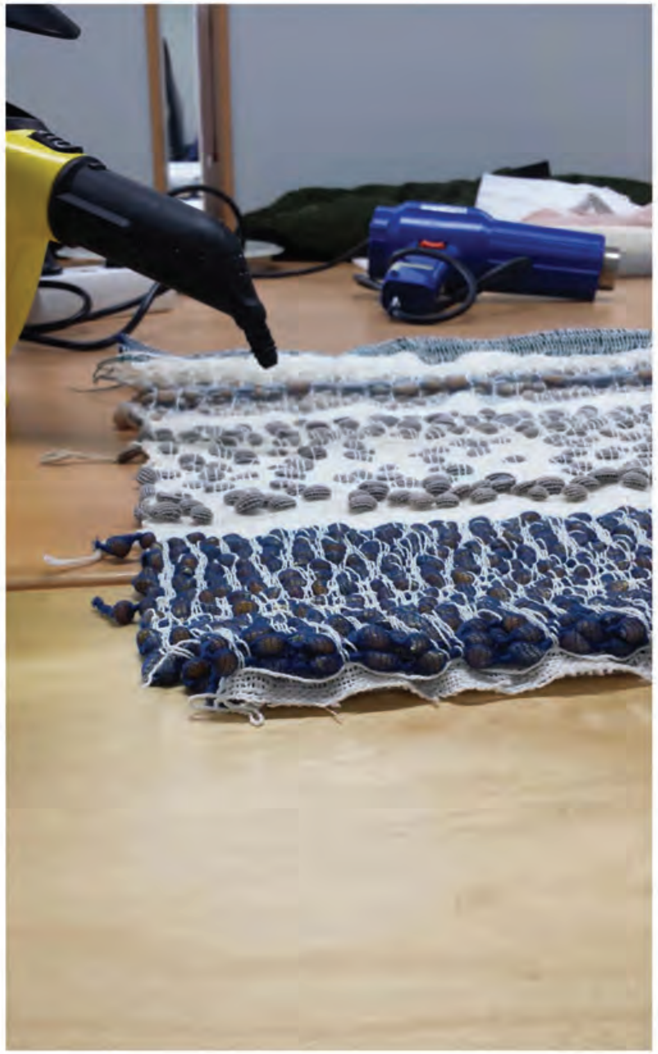

Figure 5. Activating fabric with water

Experiments

In the following section, three materials combination experiments are described more in detail: corn, coffee beans and pasta. The latter gave the name of 'Al dente textiles' and brought into question the possibility of edible textiles as medium.

6

Weaving with corn

As tools for activation we used a spray filled with water, a heat gun and a microwave *(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 observations 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 colour, an opposing consistence through the light, crisp but fluffy popcorns that consequently enhance the texture, adds three–dimensionality, and odour to the structure *(fig. 7)*. The popcorn can be picked from surface or floor and can be eaten. By activating the corn with water, the corns start germinating within one or two days. The small sprout fights 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

7

Figure 7. Weaving with corn

Weaving with coffee beans

The weave with inserted coffee beans was soaked in hot water for a couple of minutes. Observed was a slight change in the colour of the weave, it turned brownish, the strong odour stayed the same (fig. 8). Subsequently 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 promotes alternative ways of living and interacting, especially in terms of afterlife or circular design scenarios.

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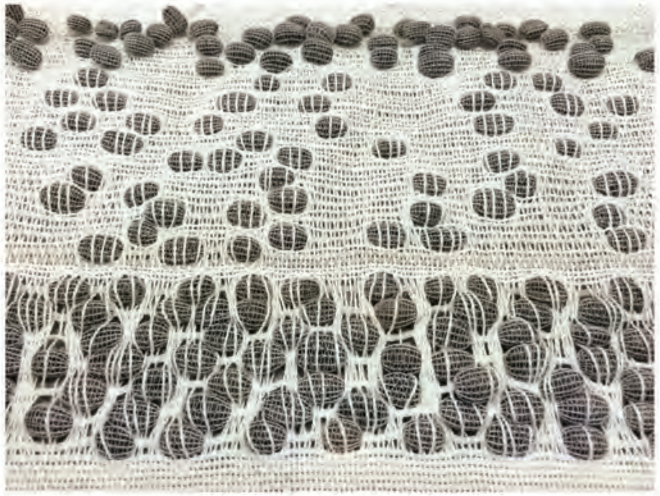

Figure 8. Weaving with coffee beans

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 & fig. 10)*

Our approach of 'collection-integration-activation', which, in a way, brings the cooking production line into textile design processes, opens up for a non-dominant perspective on media and materials for both fields. Why not weaving with pasta as textile material? Why not cooking and eating woven pasta?

Figure 9. Weaving with pasta

Figure 10. Pasta soaked in cold pasta over night

Edible Textiles : Definition and Examples

At the end of these experiments the concept of "edible textiles" imposed itself and the question we are addressing was if we can define them as a new media for arts and design. As a starting point definition, we agreed to define the edible textiles as textile structures made out of materials that can be consumed either by humans, or by animals.

Before any further investigations on what edible textiles as media could be, let us take a look on the already existing practices undertaken by artists and designers. In response to the development of 'food art' the combination of textile materials, growing materials and food has offered an opportunity for textile artists and designers to explore new expressions using a number of different approaches.

Camilla Wordie 'textile based' approaches

Scandinavian artist Camilla Wordie works at the frontiers between textiles and food and defines herself as a food stylist. Her methods consist of either mimicking the food textures into textiles structures, either the conception of textiles and surfaces out of food ingredients. For *Wearing Rice is Nice (fig. 11)* she got inspired by the rice textures which she replicates into textile structures. The white-on-white textured fabrics she designed were also coupled, in a sort of tautologic aesthetic grammar, with real rice seeds in eating situations. In another piece-installation, *Am I chocolate or not? (fig. 12)*, Camilla Wordie replaced the top of a table with chocolate. Her intervention aimed to enhance the common experience of 'crumbly' and 'dusty' chocolate powder. Not only it is possible to eat parts of the table, but by placing warm plates, the table will melt in circles, recording in this way the traces of the dinner plates.

More than anything else, her situations are conceived to re-contextualize the food and the eating experiences by inducing a certain "ambiguity" in order to create a new sensory experiences of food and textiles other than those on a daily basis.

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Figure 11. Camilla Wordie - Wearing Rice is Nice (2013)

Figure 12. Camilla Wordie - Am I Chocolate or Not? (2013)

12

De Culinaire Werplaats 'you are what you eat' – 'politically conscious approaches'

Eric Meursing and Marjolein Wintjes (*fig. 13*) have a design studio/ restaurant that produces edible pastry wrappers made out of dehydrated fruits, vegetables and herbs. In their explorations into edible textiles, they created a collection named 'taste the unwearables'. Their aim was to create a more consciously aware message to the wearer to eat well by using natural, organic and typically healthy use of food ingredients, but also to bring into the debate the ephemeral nature of fashion. In contrast to Wordie's experiments with food, Meursing and Wintjes collection encourages consumption of the textile. A purposefully regenerative process, that uses design to make it visually appealing and edible despite it not being represented in its natural form. An interesting comment made by Meursing and Wintjes in response to their collection stated that "food equals fashion, what you eat and and what you wear reveals who you are". Meursing and Wintjes try to create a parallel with this way of thinking to fashion and its culpability on the environment.

Figure 13. De Culinaire Werplaats (Eric Meursing and Marjolein Wintjes) - 'you are what you eat'

Jana Streak's (and Lady Gaga's) meat dress

To use food as support for political message is to be found in the controversial work of Jana Sterbak who produced a meat dress in 1987 to portray the contrast between vanity and bodily decay. The flanks of meat used were stitched and applied with salt to start the curing process. At that time the dress received widely negative responses, especially from animal rights activists. Since Sterbak's creation, the meat dress has been iterated and worn by Lady Gaga to further make a point about mortality, which equally sparked outrage. These portrayals of edible materials as a textile media were looking to follow the canons of textiles design, especially Sterbak's piece which resembled draped details in the meat muscles stretched across the body. Overall, both pieces created using meat as a media challenged opinions and perceptions on whether it was art, fashion or merely a political stunt.

Orange Fibers

Winner of the Global Change Award by H&M Conscious Foundation, Orange Fiber is a startup aiming at the creation of sustainable textiles from citrus juice byproducts. Initiated by a fashion designer and a media and market expert, the project succeed to develop into an enterprise that transform citrus waste – currently valuing, as the startup mention it on their website, 700.000 tons just in Italy – in a sustainable textile. The project grow from acquiring a patent for the preliminary research, to the development into a startup that take into consideration the whole cycle of fibre production. Besides building on sustainable principles, the project ventures also the properties of the new fibres which can nourish the skin of the wearers. The social aspects are not forgotten either, the project is supposed to create new jobs.

Aniela Hoitink - growing textiles (MycoTex)

To investigate and learn how to create textiles out of living materials and how to process garments, Aniela Hoitink, a Dutch fashion designer and researcher developed a dress from mycelium. The roots of fungi, usually grown in a solid substrate to form objects, were grown on a liquid to achieve thin textile–like layers of mycelium, shaped by the petri dishes they were grown in. The mycelium reacts to environmental conditions and degrades in moist environments. (fig. 14).

Figure 14. Aniela Hoitink - MycoTex (2016)

Notes on Media

What kind of a media edible textiles would be? And what would be their specificity? How the mix of two different media can succeed into a new media? To answer such a question we should address also the question of what media is and in which terms their specificity has to be addressed.

Media Specificity Theory

The debate on media (medium) specificity it is not a new one. It can be traced back to XVIII century when Gotthold Lessing opposed Charles Batteaux on how to approach the arts. In his book *"Les Beaux-arts réduits à un même principe"* (1747), Charles Batteux was suggesting that the rules of art should follow the classic principles of imitation and, therefore, all arts should be treated in the same way. In his eyes, artists should not invent, but follow the rules of nature and beauty. 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*" (1766), some arts are more likely to express better certain ideas than others. The poetry, for examples, was more adapted to depict actions, while painting, as a spatial art, 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 intervention were possible. The workshops were looking to develop new methodologies for every discipline and the trained competences were to form a sort of aesthetic "automatisms" which would allow students to better respond to the industrial forms of ideation and production.

Translated into economic terms, the medium specificity it is to be understand 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. 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 acquire by studying the perceptive abilities of the users (aesthetics and psychology), ergonomics, measurements' standardisation and /or observation of their life style (anthropology).

An economic lecture of the media find nowadays its way through what it is generally called the "economy of attention", and also in the concept of "ecology of media".

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. As some economics acknowledge it (Festré et. all., 2015), aesthetics had always played a role in the theory of economics. Leibniz concept of apperception, as a form of understating relying on previous experiences, or Herbert Simon's interest in the role of visual memory for design's problem- solving processes, find their place in theories of information management as developed by Shapiro and Varian (1999). On the path open by Gestaltung's theory, Gibson's (1977) concept of affordance in the context of ecological theory of perception studies precisely the qualities of perception from a multimodal perspective. Such research into a society dominated by scarcity of attention (Stiegler, 2014), becomes a key factor in various decision-making contexts, including arts and design.

It is also what the "ecology of the media" brings into the debate, by trying to point not only to media aspects, but also to the environment in which this media perform. As some media theorists like Matthew Fuller (2005) or Jussi Parrika (2012) have shown, media can be understood as a complex dynamic system. Jussi Parrika 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 critics of media specificity theory didn't wait long to bring their counter-arguments. 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 art work. 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 performative 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 media specific use has pedagogical usefulness and can support future repositions.

Fluxus movement's interest into intermediality (Higgins, 2001) relates to the anti-mechanistic approach of society and production of objects. Critical against categories and classification, Fluxus's intermedia actions were about to produce a space of dialogue, of aesthetically rewarding possibilities. Creating situations, provoking events, assembling environments, where all forms of intermedia. Even later in the 1980s when intermedia was central to post-modernist debate, someone like Higgins will claim that "*Intermedia has always been a possibility since the most ancient times, and though some well-meaning commissar might try to legislate it away as formalistic and therefore anti popular, it remains a possibility whoever the desire to fuse two or more existing media*." (Higgins, 2001, p.52-53).

Also critical to the idea of media specificity as form of marketisation, another Fluxus artists, Robert Filliou (1984) will try to sketch some principles of 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, Filliou 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.

How to define a medium?

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. The medium is in this way a form that allow the content to exist. In this case we deal, with a comprehension of the medium as form of "in betweenness" - between an idea and its materialisation, between a thing and its reproductions - as an intermediary, an agent of an operation (Rancière, 2008).

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 technologist, the other one is phenomenologist and anthropologist. The first perspective values the role of the matter in configuring the means of production, pointing to the way in which the properties of the matter influence the tools we develop and the way we use them. The other perspective sees in the medium the exteriorisation of our senses, exteriorisation that can define our "environment".

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 uses different states of the matter as tool of characterization of technical tendencies. For him, the materials condition 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 the 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 re-defining our existence. It is how the content of the media it is the media in itself, as the syntagma "*the medium is the message*" proves it. If there it is a message to send, then this message lies in the change of scale, rhythm, or the model the new media produces.

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 assert in fact that, being into an operational position, artists and designers have to know well enough their tools to better support their mediation interventions. Even though, a perspective that encourages the first approach would more likely pay attention to the craft and the exuberance of the skill, while the second approach will focus, as we saw in the case of Noel Caroll's critique of media specificity, on the nature of the message to be invoked.

Textiles and food as medium

One of the key persons in the definition of textiles as a medium is Anni Albers. In her book "On Weaving", Anni Albers defined fabrics in terms of construction (Heinzel, 2012). The specificity of the textiles will reside, from her perspective, on the way the threads are brought together to form a fabric and the main channel of appropriation of a fabric is the texture which is generally given by the threads' properties and aspects, by the way they fold.

Still, if we are about to follow the distinction that exists between the two understandings of the medium, then from a techno-morphological point of view there are threads as "flexible solids" that we should take into consideration as research focus. Otherwise, if we are to follow Marshal

McLuhan and his "phenomenological" perspective, then there are not the threads that will interest us, but rather the cloths as a second skin and therefore as a body extension. And, as he describes in *"Understanding Media"*, the cloth has a double role: 1) to offer a thermo-regulatory mechanism to the body and 2) to socially define the individuals. Fashion in this sense participates to the definition of the social distinction through cloths.

When it comes to food, we can also 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 the food and the cultures of food consumption. As a basic need, food is consumed on daily bases. But then we can also delimit between common food and special occasion food, ritual food. The discrepancies between different geographical regions, between the social classes, are also not to be neglected. Last, but not least, our approach to the food waste rises up as much concern as the way we manage the textiles waste and the ecological implications of textile production.

Final remarks : edible textiles as intermedia

Already in "*Understanding Media*", Marshal McLuhan speaks about the hybrid energy of two media joining forces. Such encounters results into new forms. 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).

In many respects edible textiles are intermedia. But how should we approach them? Both textiles and food are used on daily bases. Probably in order to answer the question of what kind of media edible textiles are, we should ask how their productions and their uses it is to combine.

As our experiments have shown, edible textiles are textiles' new potentialities. The multiple forms of activation they exhibit ask for different forms of appropriation. And as a new form of media, they will certainly develop new kind of economies. 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?

As the examples of citrus fibres show us, there are not many obstacles to transform the waste of the food into fabrics. They can even prove to be economically interesting, ecologically friendly and aesthetically appealing. Nobody is really tempted to question the use of such fibres and they are easily accepted as new source of raw materials for textiles.

Still, when it comes to eat your cloths, the solution might be less appealing. But cloths as food can be a provocative support for a series of questions related to our general practices and habits when it comes to cloths, fashion, food. Or maybe, our way to feed ourselves will change and the skin will be not only a body barrier, but also an absorber of energy and nourishing substances.

References

Albers, A. (1993). *On Weaving*, Mineola: Dover Publications.

Carroll, N. (1985). The Specificity of Media in the Arts. *Journal of Aesthetic Education*, 19 (4), pp. 5-20.

Festre, A. and Garrouste, P. (2015). The 'Economics of Attention' : A History of Economic thought Perspective, *Oeconomia. History, Methodology, Philosophy*, 5(1), pp.3-36.

Fuller, M. (2007). *Media Ecologies: Materialist Energies in Art and Technoculture*, Cambridge, MA: MIT Press.

Gibson, J.J. (1977). "The Theory of Affordances", in R. Shaw & J. Bransford (eds.). *Perceiving, Acting, and Knowing: Toward an Ecological Psychology*. Hillsdale, NJ: Lawrence Erlbaum, pp. 67–82.

Gropius, W. (1919). Bauhaus Manifesto. Available from: https://www.bauhaus100.de/en/past/works/education/manifest-und-programm-des-staatlichen-bauhauses/ [Accessed: 18th of December 2016].

Heinzel, T.(2012). Textiles électroniques et réactifs : fondements et textures. PhD Thesis, Paris 1 University Pantheon-Sorbonne.

Heinzel, T. (2014). "Haptic and Sound Correlations in Textiles", in *Proceedings of Ambience'14 Conference*, Tampere, Finland. CD-rom.

Higgins, D. and Higgins, H. (2001). Intermedia. *Leonardo*, 34 (1), February 2001, pp.49-54.

Lessing, G.E. (1766). *Laocoon. An essay upon the limits of painting and poetry.* Available from: http://www.zeno.org/Literatur/M/Lessing,+Gotthold+Ephraim/%C3%84sthetische+Schriften/Laokoon. [Accessed: 2nd of June 2014].

Leroi-Gourhan, A. (1943). *L'Homme et la matière.* Paris: Albin Michel.

McLuhan, M. (1964). *Understanding Media.* New York: McGraw-Hill Book Company.

Parrika, J. (2012). New Materialism as Media Theory: Medianatures and Dirty Matter. *Communication and Critical/Cultural Studies*, 9 (1), March 2012, 95-101.

Rancière, J. (2008). Ce que medium peut vouloir dire: l'exemple de la photographie, in *Revue Appareil,* Available from: http://revues.mshparisnord.org/appareil/index.php?id=135. [Accessed: 18th of December 2016].

Shapiro, C., Varian, H. (1999). *Information Rules. A Strategic Guide to Network Economy*, Boston, MA: Harvard Business School Press.

Simon, H.A.(1969). *The Science of the Artificial.* Cambridge, MA : MIT Press.

Stiegler, B. (2014). "L'attention, entre économie restreinte et individuation collective", in Citton, Y. (ed.). *Economie de l'attention. Révolution à venir?*. Paris: La Decouverte, pp. 121-135.

Youngblood, G. (1970). *Expanded Cinema*, New York: P. Dutton & Co., Inc.

Websites

Orange Fibers. Website available from: http://www.orangefiber.it/en/. [Accessed: 18th of December 2016].

Aniela Hoitink Website available from: http://neffa.nl. [Accessed: 18th of December 2016].

Camilla Wordie Website available from: http://camillawordie.com. [Accessed: 18th of December 2016].

De Culinaire Werplaats. Website available from: http://www.deculinairewerkplaats.nl. [Accessed: 18th of December 2016].

Publication IV

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Growing textile hybrid structures: Using plants for dynamic textile transformation, an approach towards Biophilic Urbanism on the scale of the interior

Svenja Keune[1]

[1] *ArcInTexETN, University of Borås and Svensson AB, Sweden*

[1] *http://svenja-keune.de/en/, https://arcintexetn.com/tag/svenja-keune/*

[1] *svenja.keune@hb.se*

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; Beatley 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 shelfs, 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.

Figure 2-6 (A series of pattern designs for pocket weave that focus on envelopes in various sizes and shapes, connected by tunnels or closed from each other.)

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.

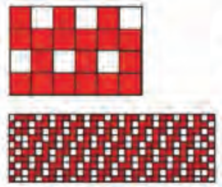


Figure 7 (loose selvedge in the top opens easily for inserting substrate and seeds, the selvedge in the bottom is used for the fabrics at Svensson AB and creates a stable edge and prevents the fabric from becoming frayed.)

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/fits an architectural scale.

Figure 8 (the process of weaving on a Picanol at Svensson AB)

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, rucola 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.

Figure 9-12 (The series of images shows coconut tablets, cotton padding, perlite and a mixture of seeds, used for growing edible sprouts.)

The sixth step dealt with the insertion of the seeds, substrates and if applicable an integrated watering system. Using the openings on the cutting edges, plastic pipes for watering were inserted into the warp oriented channels. The substrate was inserted with the help off a cone and by using the loose bindings to create an opening in parts of the patterns or by opening the construction from the sides which was enabled by using a loose binding for the selvedges. The coconut tablets were introduced through openings within the patterns.

Figure 13-17 (pocket weave with an open and dense construction, manipulated to facilitate the insertion of biological materials, i.e. seeds and coconut tablets or perlite)

The final stage of the experiment focused on the further processing of the material system by using the vegetal–compound structures as curtains, upholstery, tablecloth, carpet and ceiling, exemplifying a common interior scenario.

Results.

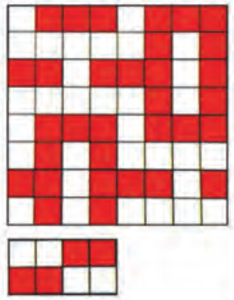
The installation, illustrating the interior scenario was exhibited in the Textile Museum at the University of Boras and comprises five sets of prototypes: seat poufs, a table cloth, a carpet, a curtain and a textile ceiling [FIGURE 1].

The basic prototype is a fabric, woven on a Picanol jacquard loom using a black and white warp 1:1. The warp material is a 32/2 mix of wool 85% and Polyamide 15%. The warp is used for the production of the upholstery collection called ACCESSOIRE at Svensson AB (12 different patterns on the same warp). At a width of 150 cm, the warp consists of 4096 warp threads with a density of 27 threads per cm. Principally an organic combed 24/2 cotton material was used as a weft material. However, for the carpet the warp material has been used in the weft as well. Four bindings, and two bindings for the selvedge were used as basic constructions [FIGURE 14]. Their main differentiation is the density of the bindings, directed to enable openings or prevent substrate with different graining 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.

ceiling

Figure 19-21 (The first image shows a hand–weaving experiment which led to the development of the pattern and the ceiling prototype)



This Prototype originated from small scale hand–weaving experiments. The piece differentiates in its purpose as a ceiling fabric. Its geometrical stripes include channels in which lettuce seed–tapes were inserted. The fabric consists of striped tunnels with an open construction on the face and a dense construction on the back, separated by stripes interweaving both layers. A sprinkler system is an attempt to provide a regular level of light rain under which the seeds would germinate. The emphasis on the interaction between seeds and construction applies here as well. The goal is not to grow plants, but to observe the seeds transformation through the translucent ceiling fabric. However, it is difficult to figure out the right raining periods and to avoid dripping scenarios or long times of dryness.

Figure 22 (Upper layer bindning 2/2 for creating an open construction, more dense construction 1/1 on the backside. Both layers are joined using a 2x4 construction.)
Figure 23-25 (Three views of the striped double–weave with channels with an open face and a dense back. The second image shows the inserted seed–tapes and the translucent expression of the fabric as a ceiling)

carpet

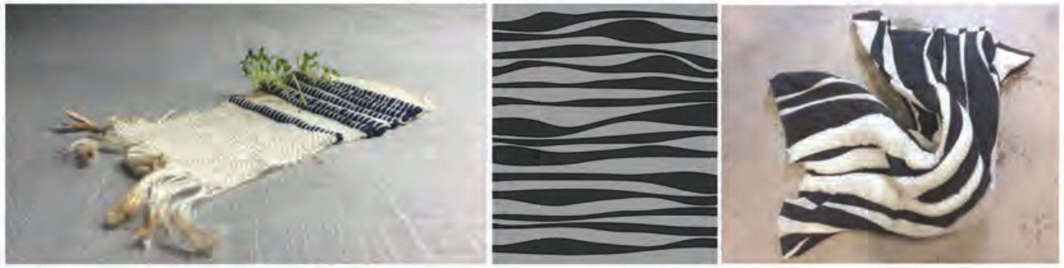


Figure 26-28 (The idea of a carpet derived from a small scale experiment and let to the design of a pattern and the full scale prototpe.

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, rucola 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.

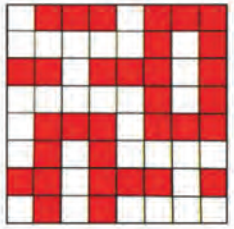


Figure 29 (pocket–weave construction consisting of 2/2 and a 1/1 bindning for creating an contrasting construction)

table cloth

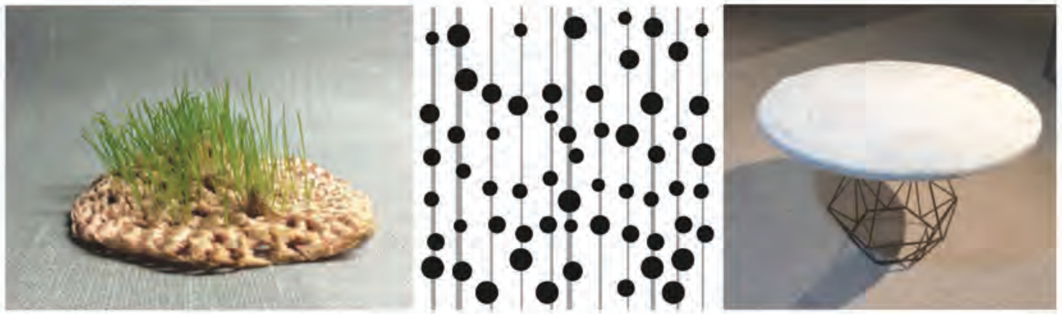
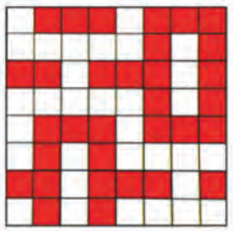


Figure 30-32 (An experiment with crochet and grass seeds turned into a pattern with circular enclosures and the prototype of a table cloth.)



Inspired by a circular matrix for plant growth, the table cloth contains various seeds i.e. red clover, mung beans, in a mix and separatly. 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.

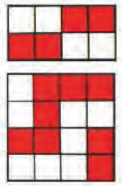
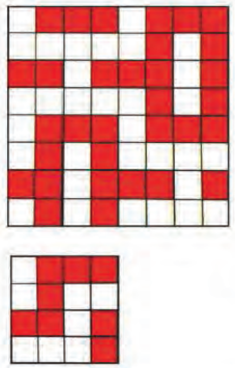


Figure 33 (The image shows all the used double weave constructions)

curtain

Figure 34-36 (The first image shows the initial inspiration in form of an early exploration, followed by the pattern design and the final result in the installation)



This prototype illustrates a vertical structure for containing bigger plants in a pattern that can also be used to integrate a drip irrigation system by using balloons filled with water. The pattern design consists of a range of channels that connect bigger organic shaped pockets in warp orientation. Therefore it can be adapted to different lengths for usage in the scale of the interior or architecture. The balloons in the upper sequence of pockets provide water for a singular flow. The foundational construction of the prototype is a 1/1 pocket weave on both sides which creates dense pockets/ channels that prevent substrate and water from coming through easily. The light grey parts in the pattern design [FIGURE 35] refer to the open construction 2/2 that has been used to create openings on the face and to fill the round shaped pockets with perlite and seeds [FIGURE 35, 38].

Figure 37 (The 2/2 1/1 construction for the open parts of the pockets. The bottom image shows the foundational 1/1 construction for dense pockets and channels.)

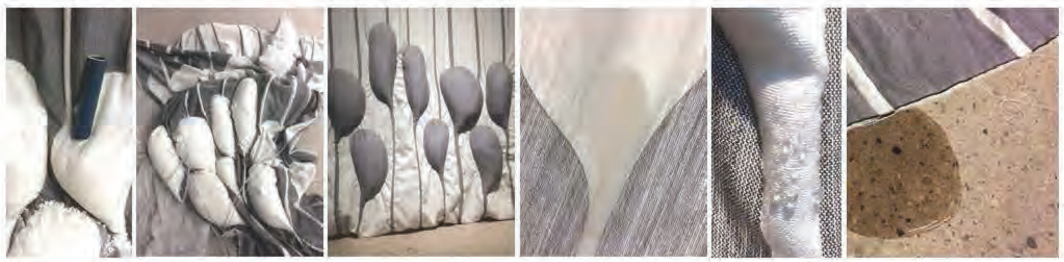


Figure 38-43 (From left to right the series of images shows the process of inserting perlite, inserting the tubes for watering, a back view on the filled structure, balloons in the upper layer of envelopes for watering the ones below. The last two images show an observation of water flowing through the 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.)

seat poufs

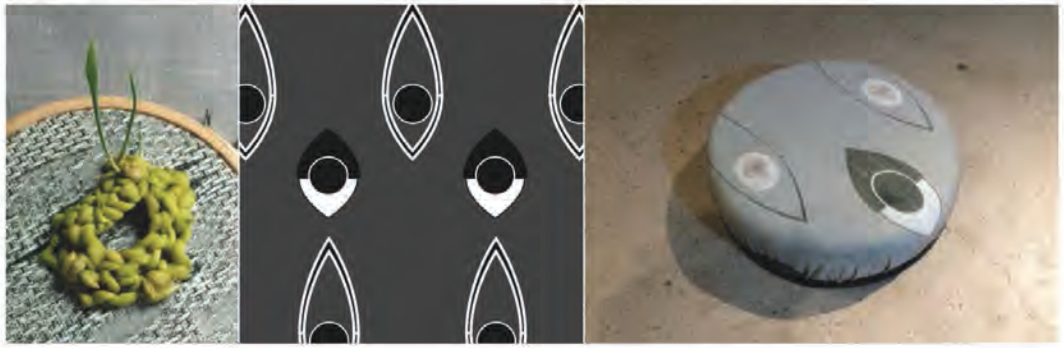
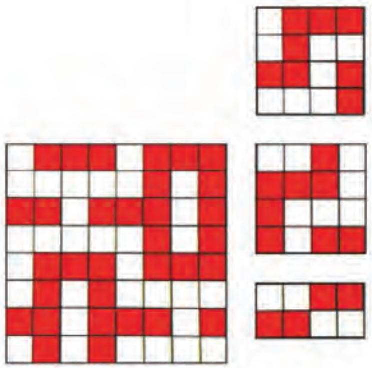


Figure 45-47 (the pattern design based on a material exploration with a vegetal–textile hybrid crochet on a weave with a contrast of open and close constructions led to a seat pouf with envelopes that are filled with soil tablets and seeds)



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).

Figure 49-54 (From left to write the images show an opening, enabled by the open construction, the inserted coconut tablet, the raining system, a seat watered by the raining system and the water–drops on the cotton–wool mixed fabric.)

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 end 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.

Wilson, E.O.O., *Biophilia,* Harvard University Press, Cambridge, MA, USA, 1984.

Beatley, T. and Newman, P., 'Biophilic cities are sustainable, resilient cities', *Sustainability*, vol. 5, num. 8, pp. 3328–3345, 2013.

Stephen Kellert, "Biophilic urbanism: the potential to transform", *Smart and Sustainable Built Environment*, vol. 5, num. 1, pp. 4 - 8, 2016

Doron, G., 'Urban agriculture: Small, medium, large', *Architectural Design*, vol. 75, num. 3, pp. 52–59, 2005.

Viljoen, A., Bohn, K. and Howe, J., *Continous productive urban landscapes*. 1st ed. Amsterdam (etc): Architectural Press, 2005.

Louv, R., *Last child in the woods: Saving our children from nature-deficit disorder,* Atlantic Books, London, 2010.

Ryan, J., Vieira, P. and Gagliano, M. (eds.), *The green thread: Dialogues with the Vegetal world,* Lexington Books, United States, 2015.

Fredriksson, M. and Warne, B., *På akacians villkor,* Warne Förlag, 1993.

Manuel DeLanda, 'Material Complexity', *Digital Tectonics*, John Wiley & Sons, Chichester, p 21, 2004.

Menges, A., Material Computation: Higher Integration in Morphogenetic Design, *Architectural Design*, vol. 82, num. 2, Wiley Academy, London, pp. 14-21, 2012.

[1]http://www.ludvigsvensson.com/interior-textiles/about-us/what-we-do.

[2]http://inhabitat.com/utopian-off-grid-village-grows-ownfood-in-shared-local-eco-system/

[3]https://www.dezeen.com/2016/05/20/effekt-designs-regenvillages-produce-own-food-energy-danish-pavilion-venice-architecturebiennale-2016/

[4]http://www.dezeen.com/2013/09/12/pasona-urban-farm-by-kono-designs/

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