DIGITAL NARRATIVES
FOR LIVING MATERIALS

A study into new digital communication for textiles made from living organisms

GRADUATION REPORT   Julie Arkes

28-09-2021 | Elvin Karana
Hazal Ertürkan
Bruna Petreca
Patrizia D´olivo

PREFACE

'New digital narratives for living textiles' is the end result of a graduation project that is based on a quantitative study into the use of different social dimensions in storytelling to present materials made from living organisms in online environments. The study was set up in order to fulfill the graduation requirements of the master program Integrated Product Design at the Technical University of Delft (TUDelft). I was engaged in researching this subject from march to september 2021.

This project is set up in collaboration between the TUDelft and the Materials Science Research Centre at the Royal College of Art in London. The research question was formulated together with my supervisors, Elvin Karana, Hazal Ertürkan, Bruna Petreca and Patrizia D´olivo. This project was surprisingly interesting and taught me a lot of things about doing proper research. Together with the team I was able to convert an extensive investigation into a concrete subject and result. I can happily say that I enjoyed working on this project mainly because of the big support team that was available for me to answer my queries.

I would like to thank my supervisors for their excellent guidance and support during this process, especially during times where social interaction is so important. You all have definitely kept me motivated in these times. I also wish to thank all of the respondents, without whose cooperation I would not have been able to conduct this analysis.

I hope you enjoy your reading.

Julie Arkes

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EXECUTIVE SUMMARY

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Today, the foundation of the textile industry is built upon the possibility to purchase synthetic fibres as these allow people to have an extensive amount of choices. Unfortunately, they are as far away from nature as it can get. Over the last decade, the industry is increasingly trying to move towards a more bio-based future, often this can be seen in the increased demand for materials sourced from renewable resources such as plants (living organisms) fabrics like cotton. Alongsides the increase in traditional fabrics multiple new initiatives are popping up to connect the textile industry with nature. Due to these endless possibilities, future consumers find it hard to see the wood for the trees. Navigation into the world of biodesign is a necessity to set the next step towards this envisioned sustainable future. What if I told you, to think beyond sourcing materials from living organisms? What if we let living organisms become part of our daily life again? Bioassembly makes it possible to source raw materials from living organisms, produced with living organisms to create a material that is still alive in the use phase. This concept changes the relationship between the consumer and the material. To create comfort around this new relationship innovators should be more interactive with future consumers' so preconceptions can be addressed.

Currently digital platforms are the most efficient way of communication between the consumer and the innovator, especially since the shift towards digital channels particularly increased the past year due to social distancing measures as a consequence of Covid-19. However traditional tools are still inadequate in capturing and communicating the qualities of these living materials (D'Olivo & Karana, 2021). Clear digital communication should be transparent and interactive. Besides, it should give a clear image of the aesthetics that currently go beyond beauty and include morals. Morals encourage change on a societal level, where the individual is part of something bigger. The appreciation, attention and understanding of new innovations is built upon social situations and group associations, which are also digitally visible since the rise of social media. So we can state that digital social influence matters since it affects what we think and do. What if we could thoughtfully use social dimensions for the communications of new innovations like 'living' textiles? Social dimensions can be split into different levels. Firstly the macro-level of society is envisioned as a concept which is called social impact storytelling. It envisions a clear image on what we could create together in order to provoke change worldwide. Secondly social presence can be used to create a space where people feel safe and free to share and cherish information with others. To finally be influenced by each other; you can pioneer, you can follow or you can do the complete opposite.

A qualitative study researches how these particular social dimensions can contribute to the level of understanding and appreciation regarding living textiles. Taking into account the data of 160 participants it should be noted that social dimensions should be used carefully. Innovators should be very specific in what they exactly want to communicate. Social presence can lead to a less professional story since the innovator is not the only source of information anymore. Furthermore innovators should clearly decide to whom they communicate since different groups could be addressed differently. For social impact storytelling this mainly applies when distinguishing between different age groups as there is a lot of difference in what kind of relationship they have with the digital world.

The digital world can be a notably broad playground for communication. Let's design a place that stimulates creativity by giving shape to a material and its 'livingness'. A world where preconceptions around health, smell and hygienics can be addressed. A world where we can try something new, together.

INTRODUCTION

Consumers are increasingly using digital channels to be better informed and more selective while caring more about the sustainability and safety of the goods they buy (Lay et al, 2019). This particularly increased in the past year as a consequence of Covid-19 (Shetch, 2020). Raw materials play an important role in facilitating sustainable consumer choices. Therefore the rise of biodesigned materials, which are not harmful to people and the planet, is of tremendous value. In the fashion industry biodesign should become integrated into textiles. Biodesigned textiles further differentiate according to their 'livingness' aspect (Karana et al., 2020), namely the characteristic for which the living organisms used in the biofabrication process become inert or are kept alive in the material outcome. However traditional tools are still inadequate in capturing and communicating the qualities of this living aspect (D'Olivo & Karana, 2021). Meaning that digital means do not yet have the qualities of displaying 'livingness' in an understandable way, with the result that customer appreciation cannot increase due to digital communication.

Appreciation of textiles, meant for the fashion industry, is not only dependent on the individual level, the evaluation is built upon social situations and group associations (Niinimäki, 2014). This project envisioned ways to create social situations and associations by defining 3 social dimensions that could contribute to the communication namely; social value, social presence, and social impact.

The first dimension is social value, this concept describes the value perceived from a social environment by an individual due to emotional and informative support. Hereby the value delivery is a one-way concept, which the individual benefits of. Secondly, social presence is considered as the second dimension. Hereby the individual benefits from a personal and warm social atmosphere but is also able to interact with other consumers or the brand itself. In social presence, it is about the individual being present in the relationship, to improve the relationship quality and thereby contributing to a social environment where more than one can benefit from. Lastly, social impact is a concept based on social impact and social benefits. This concept goes beyond creating participating as an individual, and instead, is based on a feeling of community and what that can achieve.

This paper aims to explain how social dimensions influence the level of appreciation and understanding of the future consumer. In addition, the aim can be seen to create new thoughts about potential tools for the communication of 'livingness', for future research. In order to meet the research objectives, a multi-group quantitative online study is performed in order to compare 3 prototypes that envision all social dimensions and allow for a discussion considering strategic alternatives that can be suggested for digital narratives for 'living' materials.

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1.1 INTRODUCTION

Following a report of McKinsey 2021 (Sneader & Singhal) the covid-19 situation is contributing in reshaping the global economy and creating imperative for companies to reconfigure their operations. Within this scenario, the necessity to innovate is becoming more evident, also for the fashion industry.

On one side the crisis has had a devastating impact on businesses and jobs but on the other side, it also may accelerate responses that can lead to positive outcomes. Many fashion companies took time during the crisis to reshape their business models, streamline their operations and sharpen their consumer propositions (Sneader & Singhal) often mainly focussing on the following elements; one, creating sustainable change and two adapting to the digital shift within the industry. The textile industry is nowadays responsible for producing 1.2 billion tonnes of greenhouse gas emissions annually (MacArthur, 2013). Moving towards a more circular fashion system can be done in the following ways; one; produce what we sell, two; make the system circular by keeping used textiles in the loop again and again and thirdly look at new textiles that are circular themselves. For example, a growing community believes the answer for circular textiles is to follow nature's blueprint, by integrating living processes and organic matter (biodesign) into the creation of clothes (Goodman, 2021) .

The second focus point is the fact that; consumers are increasingly making use of digital channels to be better informed and more selective while taking more care about the sustainability and safety of the goods they buy (Lay et al, 2019). Such a shift towards the use of digital channels particularly increased in the past year due to social distancing measures as a consequence of Covid-19 (Shetch, 2020).

In order to move towards a more circular and digital future for the fashion industry, the complex interaction between production, digital communication, and consumption of textiles should be recreated. This creates an opportunity to combine biodesign, digital communication and consumer engagement to revolutionize the fashion industry.
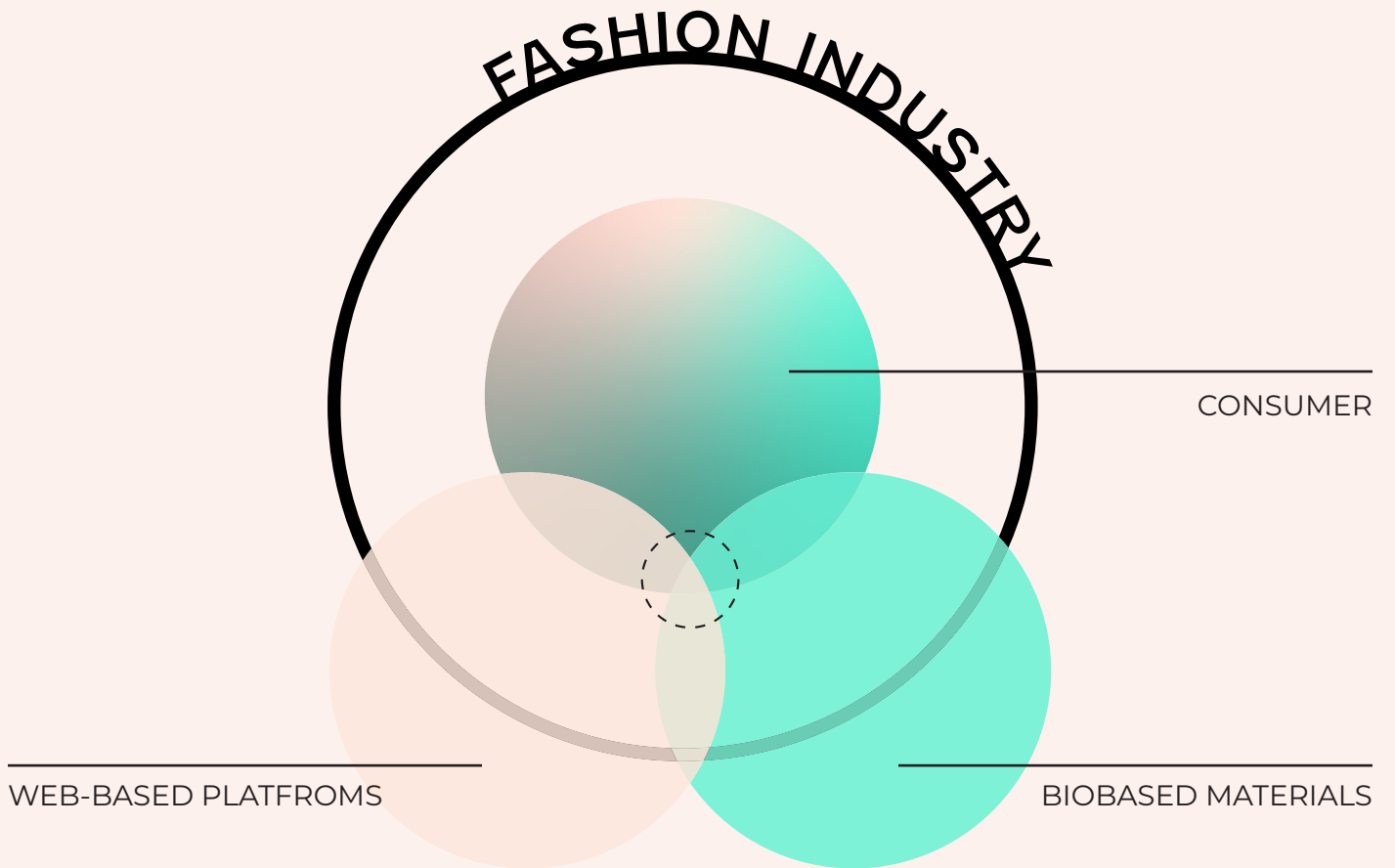
8.

FASHION INDUSTRY

CONSUMER

WEB-BASED PLATFROMS

BIOBASED MATERIALS

Figure 01

PROJECT SCOPE

1.2 FUTURE OF FASHION & TEXTILES

Let's start on a positive note! We live in a world where we are able to create our wildest dreams. A world where we are able to learn from the past and the present in order to find infinite possibilities to build a better future. Within a world where so much is possible, people are constantly seeking for more. Therefore overproduction and overconsumption are problems society is facing. Selling and producing large quantities of inexpensive clothing is called 'fast fashion' notwithstanding the serious consequences on our health, planet, and working conditions. 'Fast fashion' is still a dominant approach within the fashion industry.

The fashion segment generated 74% of the income of the textile industry in 2020, due to the increase in consumer spendings on clothing and apparel (G.V.R, 2020). The textile industry creates both natural fibers (such as wool, cotton, and silk) and synthetic fibers (nylon, etc.)(Major et, al, 2020). Thereby, manufacturing and finishing processes like dying, weaving, and printing fabrics are used to envision a wide and diverse range of material outcomes.

Washing, solvents, and dyes used in manufacturing are responsible for one-fifth of industrial water pollution, and fashion accounts for 20 to 35 percent of microplastic flows into the ocean (McKinsey, 2020).

In addition to all the unsustainable consequences, the enormous and rapidly varying range of clothes ensures that people can express themselves. A person's fashion style is never out of trend and is able to communicate many stories, personally, emotionally, and socially.

"Style is a simple way of saying complicated things."

Jean Cocteau

Fashion brands are considering their environmental and social impacts, along with the change in the mindset of consumers that are more concerned about ethical and sustainable alternatives driving innovation (Biofabricate and Fashion for Good, 2020). All fashion value chain stakeholders like consumers, individual brands, manufacturers, aggregators, and marketplaces have a role in driving this circular innovation (McKinsey, 2020). Together they share the understanding that circular design becomes more integrated with more ecologically friendly materials.

Yet the textile sector still represents 6 percent of global greenhouse-gas emissions and 10 to 20 percent of pesticide use (McKinsey, 2020).

Raw materials play an important role in facilitation of a sustainable fashion system. Therefore the rise of biodesigned materials, that are not harmful to people and the planet, is of tremendous value. In the fashion industry biodesign should become integrated into textiles. Living organisms (i.e., algae, bacteria and fungi) are used in biofabrication processes as building blocks to develop textiles and fabrics that are non-toxic and compostable (D'Olivo & Karana, 2021). An example of an organization doing this is London-based Dai Wear, which employs recycled and recyclable fabrics to produce performance wear. The company uses biodegradable yarns for seams and air-dried fabrics to reduce washing needs. Next to that, the company Freitag makes a textile called F-abric made from Hemp, which looks and feels like linen. F-abric is made and processed with prioritization to limited water use. Biodesigned textiles further differentiate according to their 'livingness' aspect (Karana et al., 2020), namely the characteristic for which the living organisms used in the biofabrication process become inert or are kept alive in the material outcome. Examples of materials where the living organisms used in the process become inert are BrewedProteinTM by Spiber where fermentation of bacteria with other natural ingredients is used to produce silk proteins that are later turned into fibers. Furthermore, Stella McCartney is a conscious brand partly because of the banned use of leather, feathers, and other animal-based products. They were able to re-create leather in a vegan manner by using lab-grown MyloTM, a type of mycelium leather that is based on mycelium cells grown on beds of renewable organic matter. Hereby, material outcomes are depending on the usage of old materials or the creation of materials with an origin that fits better into our circular economy. Next to raw material supply, business models are reinvented to be more demand-based. Looking forward, research into

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materials, technologies, and business models will keep extending in the coming years. This will lead to moving beyond raising sustainable awareness towards real-time commitment. This means that the movement towards a more sustainable fashion system is not new, the consumer mindset was already showing signs of shifting towards a more transparent and sustainable direction before the pandemic. While passing the pandemic, consumers need to act in line with their mindsets by changing their behavior. This behavior should be supported by the philosophies of fashion brands. With easy access to information, consumers are able to be critical and more selective towards the brands. Therefore, brands need to consistently involve consumers to align their mindsets since consumers are becoming less brand loyal. Among millennials, two-thirds say they are willing to switch brands for a discount of 30% or more (McKinsey, 2021).

" This industry is about emotional attachment, loyalty, and excitement for brands. We are very convinced that, in the future, brand love and brand loyalty will very much be dependent on the sustainability attributes that a brand enables or builds with its consumers. "

Karl-Hendrik Magnus

Consumer loyalty became more dependent on prices due to the pandemic (McKinsey, 2021). This resulted in an increased gap between the best-performing brands and the rest because stronger players were able to bargain their price and therefore seize market share.

45% of fashion executives expect market share redistribution to be a top theme in 2021 (McKinsey, 2021).

This means that brands should keep working hard to generate revenue. Nevertheless, the pandemic is responsible for a negative effect on the entire fashion industry revenue

Which will shrink by 15 to 20 percent in an Earlier Recovery scenario, or by 25 to 30 percent in

a Later Recovery scenario (McKinsey, 2020).

Since the demand for fashion is also unlikely to bounce back to normal due to a decrease in consumer confidence, brands should enable flexibility and faster decision-making, and balance speed against discipline in the pursuit of innovation in order to manage unprecedented levels of uncertainty (Mckinsey, 2021). People aren't shopping in stores. They are sitting at home, questioning why they have so many clothes in their closet. Therefore companies need to find new ways to outperform old categories, channels, and territories. Hereby the main driver for growth will be the use of digital channels allowing companies to engage with consumers in very creative levels like live streaming, social shopping, and customer service chats (MCKinsey, 2020). Providing a broad range of information regarding new material innovations, product outcomes, and styles that is quickly available to a wide public. As this digital trend keeps increasing, consumers demand even more refined digital interactions, therefore brands need to find ways to optimize their digital strategies while integrating a human touch(McKinsey, 2020). This digital revolution is reinforced by the fact that many people stay reluctant to gather in crowded spaces.

71% of fashion executives expect their online business to grow by 20% or more in 2021 (McKinsey, 2021).

Communicating through online platforms such as websites can have an important role in enhancing the adoption of new novel materials by triggering consumer awareness (D'Souza et al., 2015) and acceptance (D'Olivo & Karana, 2021). Platforms capable of properly introducing such materials and engaging the consumers in taking part in the circular process can form an example. Next to creating awareness and acceptance, digital communication can contribute to a change in consumer behavior. Morgan and Birtwistle (2009) found out that there is a lack of knowledge on how and where clothing is disposed of and thus, consumers could be encouraged to donate more by providing more information and collection points.

1.3 KEY INSIGHTS

Communication is key

Communication can play a vital role in the adoption of new, novel materials and thereafter in changing consumer behavior. With the high consumer reach of digital platforms, this importance increases even more.

Be flexible and change fast

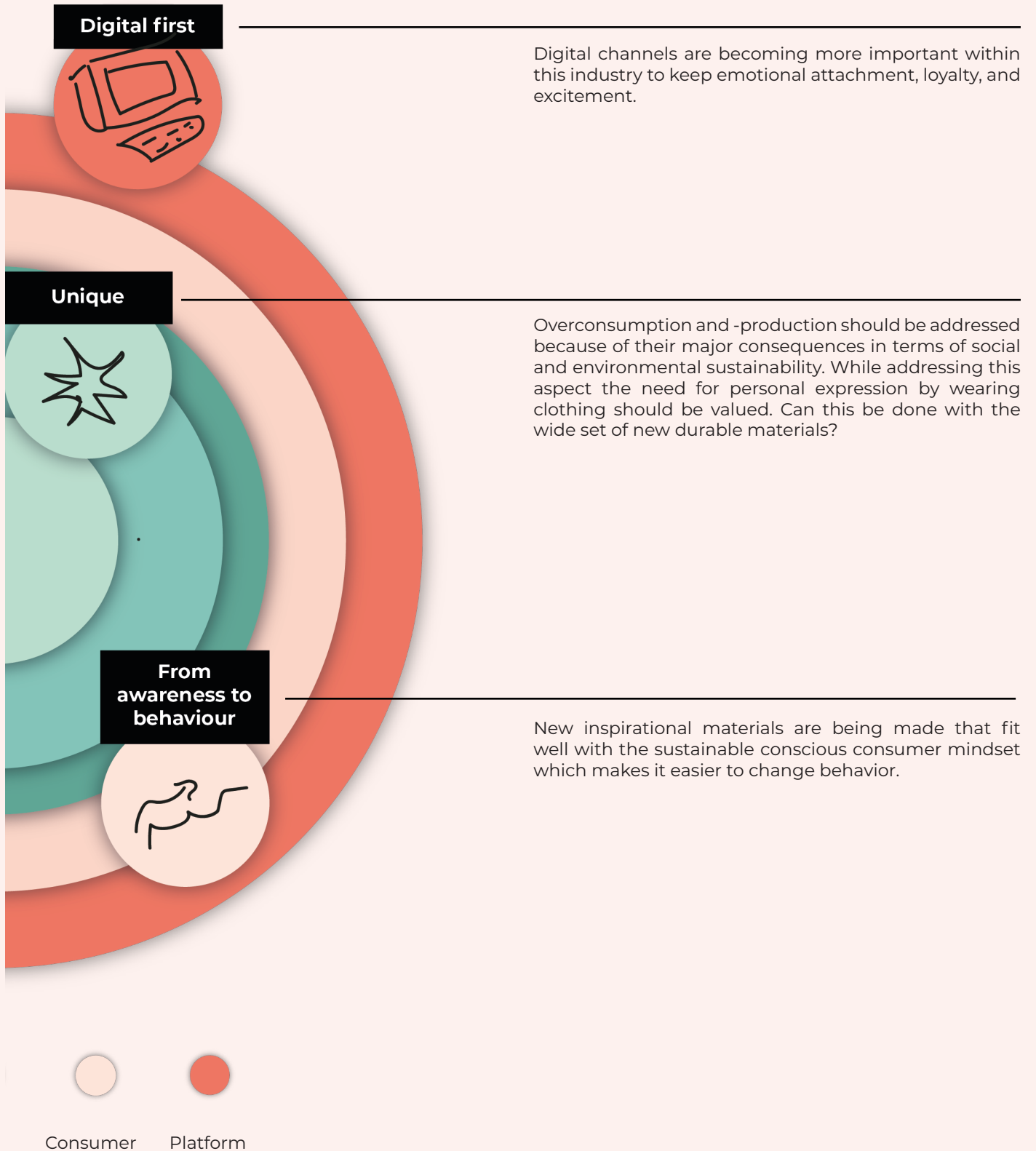It becomes harder for small businesses to enter the market. Companies should enable flexibility and faster decision-making, and balance speed against discipline in the pursuit of innovation

Constant alignment

Brands need to consistently align their mission to their consumer values since keeping loyalty becomes harder.
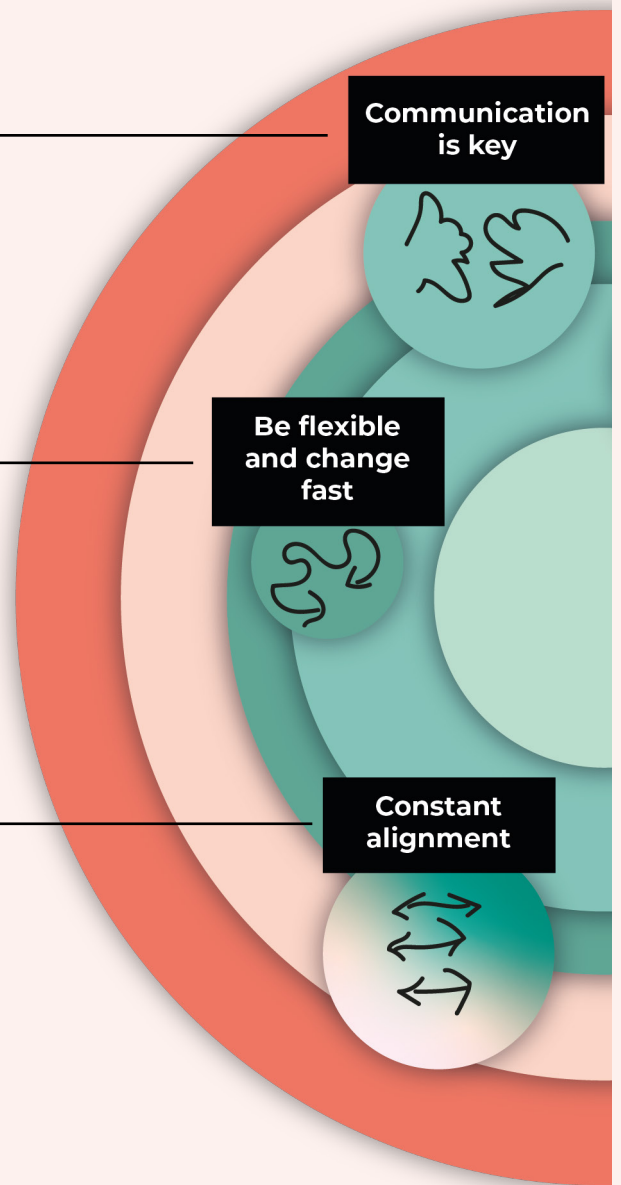
Material   Innovator   Brands

Figure 02

KEY INSIGHTS PROJECT BRIEF

Digital first

Digital channels are becoming more important within this industry to keep emotional attachment, loyalty, and excitement.

Unique

Overconsumption and -production should be addressed because of their major consequences in terms of social and environmental sustainability. While addressing this aspect the need for personal expression by wearing clothing should be valued. Can this be done with the wide set of new durable materials?

From awareness to behaviour

New inspirational materials are being made that fit well with the sustainable conscious consumer mindset which makes it easier to change behavior.

Consumer   Platform

1.4 ASSIGNMENT

Finding new ways of creating digital narratives for biodesigned textiles can specifically influence: 1); consumers' willingness to purchase biodesigned textiles, 2); the length of the life cycle of the biodesigned textiles (e.g., through repairing or reusing garments), and 3); the possibility of recycling those materials when they are no longer reusable (Dahlbo et al., 2017).

Despite the great interest in the use of bio-designed materials, they nevertheless occupy a smaller market share than wished for (D'Olivo & Karana, 2021). This can be due to the fact that the adoption of a new material within society takes about 20 years (Maine et al, 2000). An opportunity to accelerate the adoption of new materials within society could be found in the use of Digital platforms. However, an analysis done by D'Olivo & Karana (2021) confirms that the traditional online tools remain inadequate to capture and communicate the qualities of bio-designed material which are still unfamiliar to society. Biodesign companies currently give attention to the communication of the material origin, which often is a living organism. This understanding creates a central role for 'the organism' and its 'livingness' instead of solely focusing on the material outcome. Taking an organism or living perspective to the framing of bio-fabricated materials might enhance the appreciation of these materials and help for their seamless integration in our daily life (D'Olivo & Karana, 2021).

Therefore, to design a Digital platform with the aim to properly introduce 'livingness' of bio-designed textiles, trigger the long-term engagement of consumers and consequently improve circularity; the project will be structured according to the following research questions and sub-questions:

R.Q.: How should 'livingness' of biodesigned textiles be introduced and communicated to society through digital platforms?
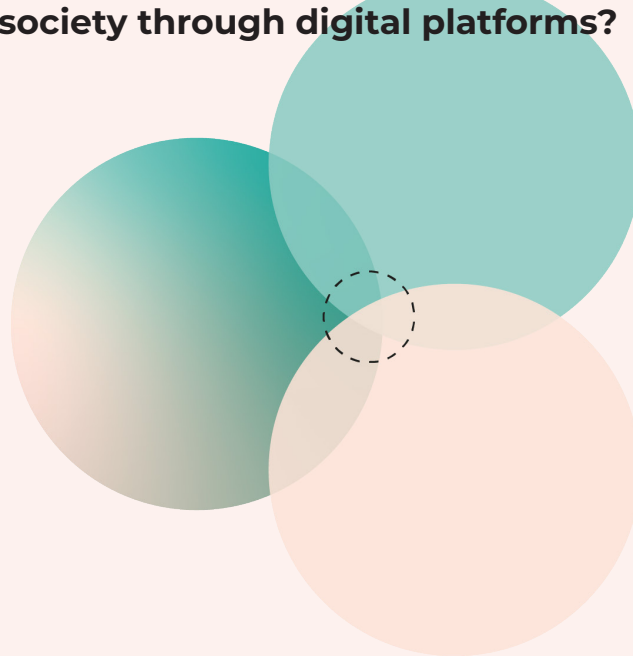

Figure 03

PROJECT SCOPE

'Livingness' in textiles

Which bio-designed materials from living organisms (bio-designed textiles) are available for the fashion industry?

1.1 What are the properties and qualities of bio-designed textiles from living organisms?

1.2 How is their 'livingness' expressed and how does their 'livingness' contribute to a circular economy?

1.3 How can the materials' 'livingness' and its contribution to the circular economy be communicated?

Consumer

How can a digital platform inform, engage and support consumers in maintaining a long-term relationship with bio-designed textiles to contribute to the circular economy?

2.1 Do consumers prefer an active or passive engagement?

2.2 Do consumers prefer a personal vs. social experience? How can social experience contribute to the communication of 'livingness'?

Digital communication

What tools are able to support digital communication of bio-designed textiles and/or to actively engage the future consumer of living textiles.

1.5 APPROACH

With this planning, this project aims to make it possible to create a digital platform built upon understanding biodesigned textiles made from living organisms. The structure of the planning is based on some elements of the Material Driven Design method (MDD) which facilitates designing for material experiences. Nevertheless, this project aims to create a digital product that aims to further develop consumer relationships with the material instead of a physical object that is often used in cases that use the MDD methodology to develop the material/product itself.

This project is viewed from a material perspective. Therefore the first step is to understand the material, in this case bio-based textiles and especially focussing on textiles that contain living organisms in their material origin, material process or material outcome. Because this is a digital project the material is also researched in its digital form, looking at digital communication. Next to that this project targets the end consumer and therefore addresses this target group in the first phase. Secondly the material characteristics are encapsulated especially focussing on Biogarmentry. Hereby the future of bio-designed textiles is considered. Furthermore phase two reflects on the materials purpose by looking at the consumer, -material relationship and finding aims through improving this via a digital platform in order to turn this into a material experience vision. In phase 3 this material experience vision is going to be tested with the end consumer in a quantitative case study. This case study makes use of digital prototyping. Finally phase 4 will discuss the results of the conclusion and will turn this into a guideline for digital platforms about 'living textiles'. Lastly these guidelines will raise new questions for the digital communication of 'living' textiles.
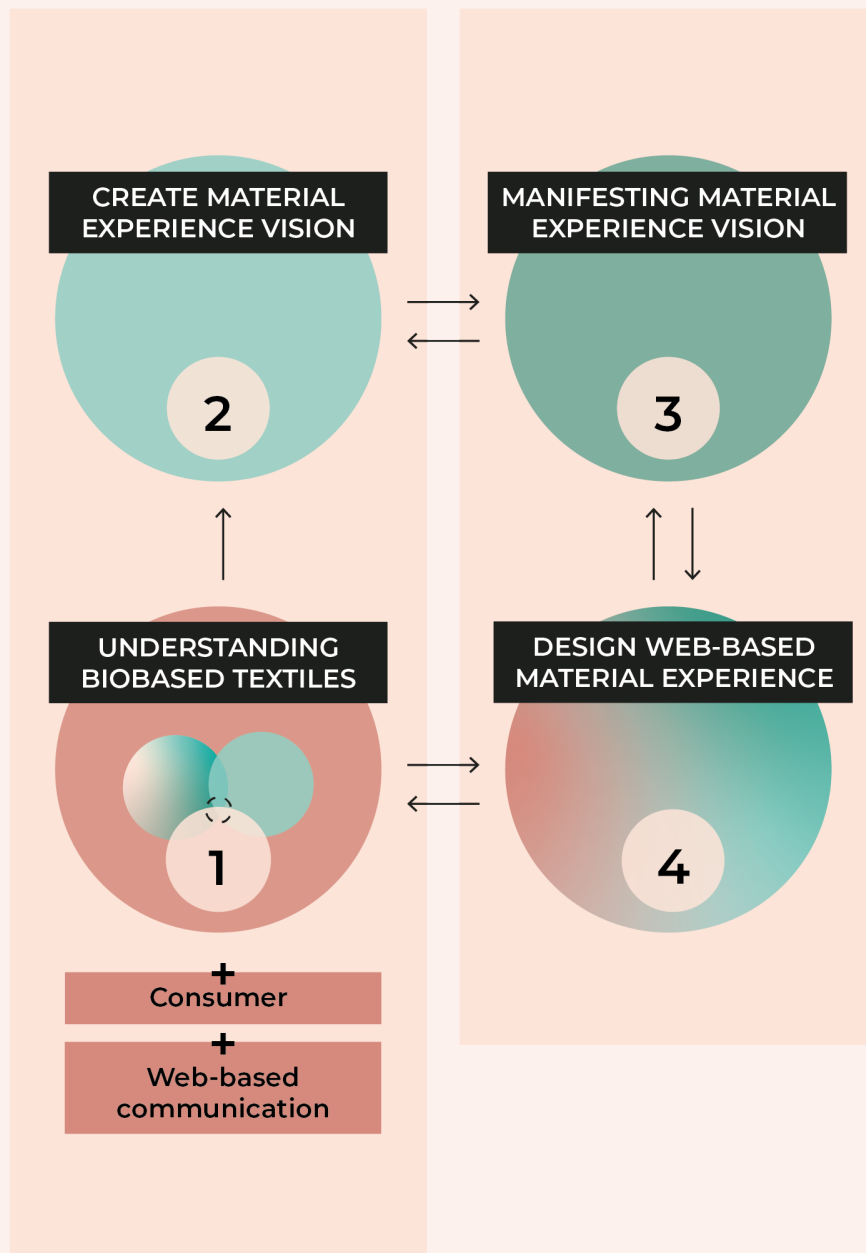
CREATE MATERIAL EXPERIENCE VISION

MANIFESTING MATERIAL EXPERIENCE VISION

2

3

UNDERSTANDING BIOBASED TEXTILES

DESIGN WEB-BASED MATERIAL EXPERIENCE

1

4

+
Consumer

+
Web-based communication

Figure 04

APPROACH

'LIVING TEXTILES

02

2.1 INTRODUCTION

In the world of fashion, new and innovative resources are going to play a bigger role. They are part of the solution to move towards a fully sustainable future. Since we interact with materials through products, an important part of the design is to choose the right material for those products. Designing products made with innovative and novel materials that fit with the values and needs of consumers today is important. Alongside the rising ethical concerns from consumers, brands are reconsidering their environmental and social impact, hereby the search for more 'sustainable' alternatives is driving innovation. These 'sustainable' alternatives can be found in bio-based materials. Bio-based materials aim to have a lower carbon footprint, their organic bases are more renewable than fossil-based synthetic materials and they resonate better with the rapid growth of veganism by replacing animal-derived materials (Biofabricate, 2020). The field of biodesign keeps developing, introducing new designs over time. Currently, growing design is an emerging new material approach that combines the fields of biology, science, art, and design. This rising approach changes the role of the designer from passive recipients to active makers of materials (Karana, et al., 2015) (Myers, 2012). It creates the opportunity to produce local resources and connects designers immediately with the biosphere. Nowadays, bio-based textiles are seen as 'emerging and novel' fibers, yet they have been around for a long time. Studies show development of biobased textiles from the late 1800s to development to 1940s when there was a short supply of oil (Orlandi, 2018). As a result of its long existence and the increasing attention for further research, a huge diversity of biomaterials has emerged. Therefore the category Biomaterials remains ill-defined. This raises questions like; what exactly are biomaterials? How sustainable are they and what makes them different from traditional fibers (Biofarbricate, 2020)? Will synthetic fibers completely be replaced by bio-based fibers? How will this biobased future look and what are the

benefits? While addressing these questions this chapter will discuss the characteristics of bio-designed materials. At the same time, it reveals gaps in the communication of these materials, with a particular focus on comprehensibility for future customers.

2.2 BIOBASED MATERIALS

INTRODUCTION TO BIOBASED//

Already in the 1930s, Henry Ford used materials like soybeans, hemp, cotton, flax, and wood pulp for the production of parts in the automotive industry. These materials were considered biobased materials. Ford took this to the next level in 1941 by creating a prototype car made from 70 % hemp fibers and 30% phenolic resins. However, this prototype was not yet satisfactory as a commercial product at that time. Nevertheless, society has kept on developing products made of natural materials since then. Over this period of time, bio-based plastics have come closer to meet exceeding performance and cost parameters versus conventional plastics than ever before (Orlandi, 2018).

Taking this Ford example into account it is still hard to imagine a world without fossil-based plastics, although the large-scale production and use of plastics only started in the 1950s. Despite the fact that they are fairly new raw materials, their versatile and unique properties and multitude of applications have led to the production of more than 8 billion tonnes of plastics worldwide over the past 70 years (Geyer et al., 2017). This large-scale production and its unique properties are also the cause of materials ending up as waste streams. This was an unpredicted outcome, which gives us insights today on how to approach material design in the future. Part of this plastic production is used to create synthetic fibers which are used as a basis for textiles. In figure 5 can be seen that the world is still highly dependent on fossil-based resources for the production of synthetic textiles. Dependency on fossil-based resources is becoming riskier and increasingly undesirable to modern, progressive businesses. Bio-based resources give us alternatives to manufacturing textiles and apparel while opening up opportunities for new performance capabilities with less impact on resource use (Orlandi, 2018). Where the most important aspect is to evoke a shift from a linear to a circular economy. To achieve this, materials should be considered in their entirety. This is a big task because designing for everyone and everything concerned now and in the future, you must consider the macro, meta, and micro-level factors that affect their outcome. The finest example of designing for entirety, is planet earth. Although it is not possible to entirely master the earth as a whole, it is possible to grasp inspiration from smaller parts of nature. Stimulated

by this methodology, today's power and precision to manipulate living things are stronger than ever. Committed to this methodology, several technologies are evolving. For example, genetic engineering is only a few decades old. New fields in biotech, such as synthetic biology, are much younger. Many industries have adopted these biotechnologies, but biotech shouldn't be left solely to market forces. We need to inject design thinking into the engineering of biology (The BDC Editors, 2021). In 2007, physicist Freeman Dyson predicted in an essay called "Our Biotech Future" that "the domestication of biotechnology will dominate our lives during the next fifty years at least as much as the domestication of computers has dominated our lives during the previous fifty years."

DISCOVER THE FIELD OF BIODESIGN //

Society is starting to work on a 'biotech future', a sustainable world built with biology, to tackle issues like; waste streams, unrenewable energy, and social issues. The fashion business has been proactive in developing and using bio-based materials for apparel, shoes, etc. Bio-based materials, however, remain an ill-defined category (Lee et al, 2020) (D'Olivo & Karana, 2021). This is due to the fact that there is a large amount of different bio-based materials that can be separated into several categories. For example: biofabricated or biosynthetic. All these categories are built on the same thing but also consist of differences. The introduction of this new 'bio' language to the field of fashion and textiles is caused by new technology material innovators, the urge from brands to communicate and understand innovation internally and to their consumers, and the immersive attention for 'bio' design in the media (Lee, 2020). This chapter will explain what bio-based materials are and why we consider them sustainable. Furthermore, it will discuss the similarities and differences between the different categories, and lastly, it will explain the most versatile and unique properties of these materials of the future

Synthetic fibres are made from polymers of small molecules. derived from raw materials such as petroleum-based chemicals or petrochemicals.

Biobased or natural fibres are directly direved from living organisms

Cotton fibres are made from polymers of small molecules. derived from raw materials such as petroleum-based chemicals or petrochemicals.

Biofabricated

Biosynthetic

Bioassembled

Biofabricated ingredients

20.

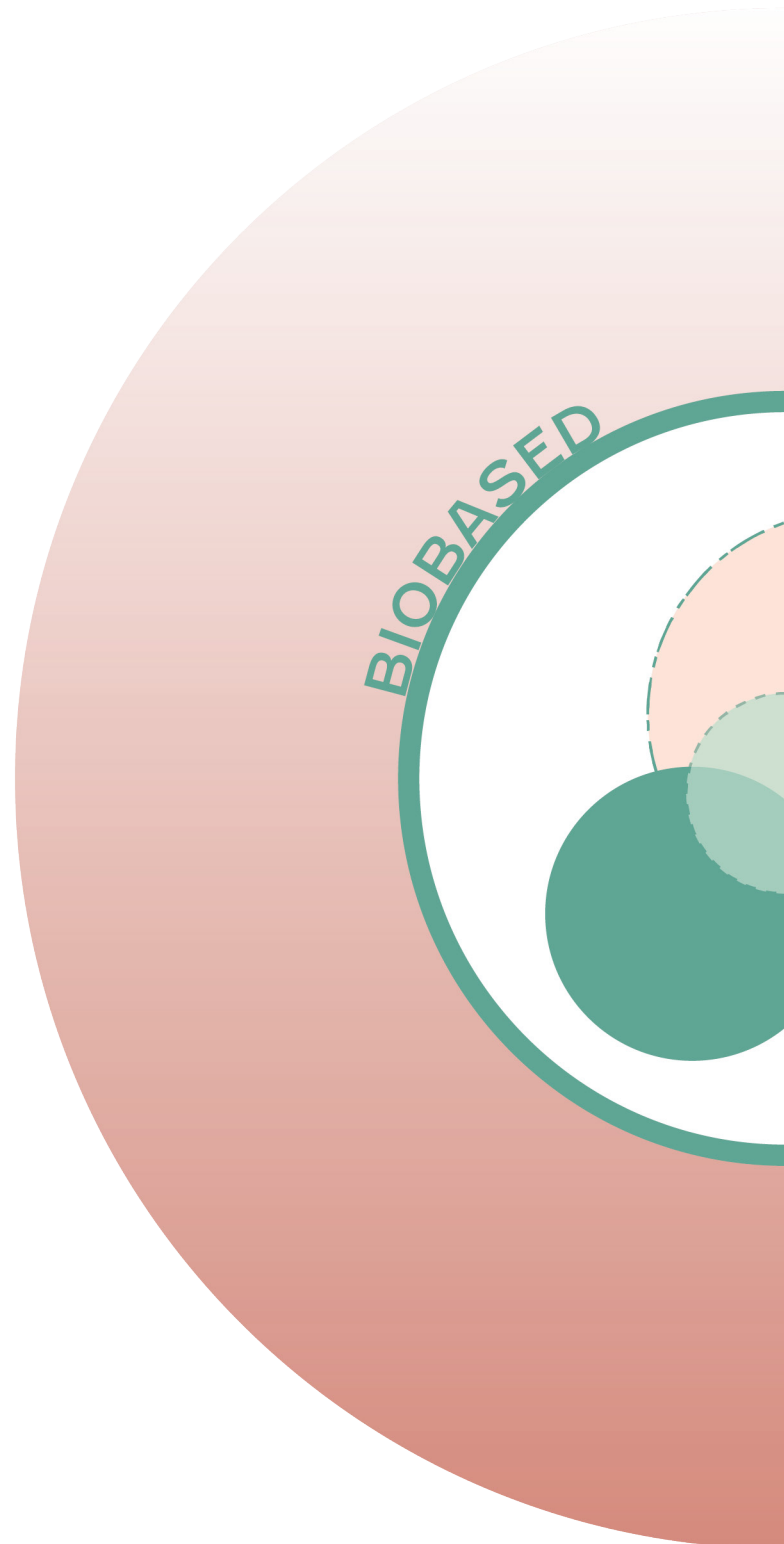BIOBASED

Figure 5

BIOBASED FIELD Image based on: (textile exchange,2018) (Biofabricated, 2020)

62 % of globol textile production is made up by synthetic fibers have

Polyester had a market share of around **51.5 %** percent of total global fiber production

38 % of globol textile production is made up by biobased fibers

Cotton is the second most important fibre and has a market share of **24,4%.**

21.
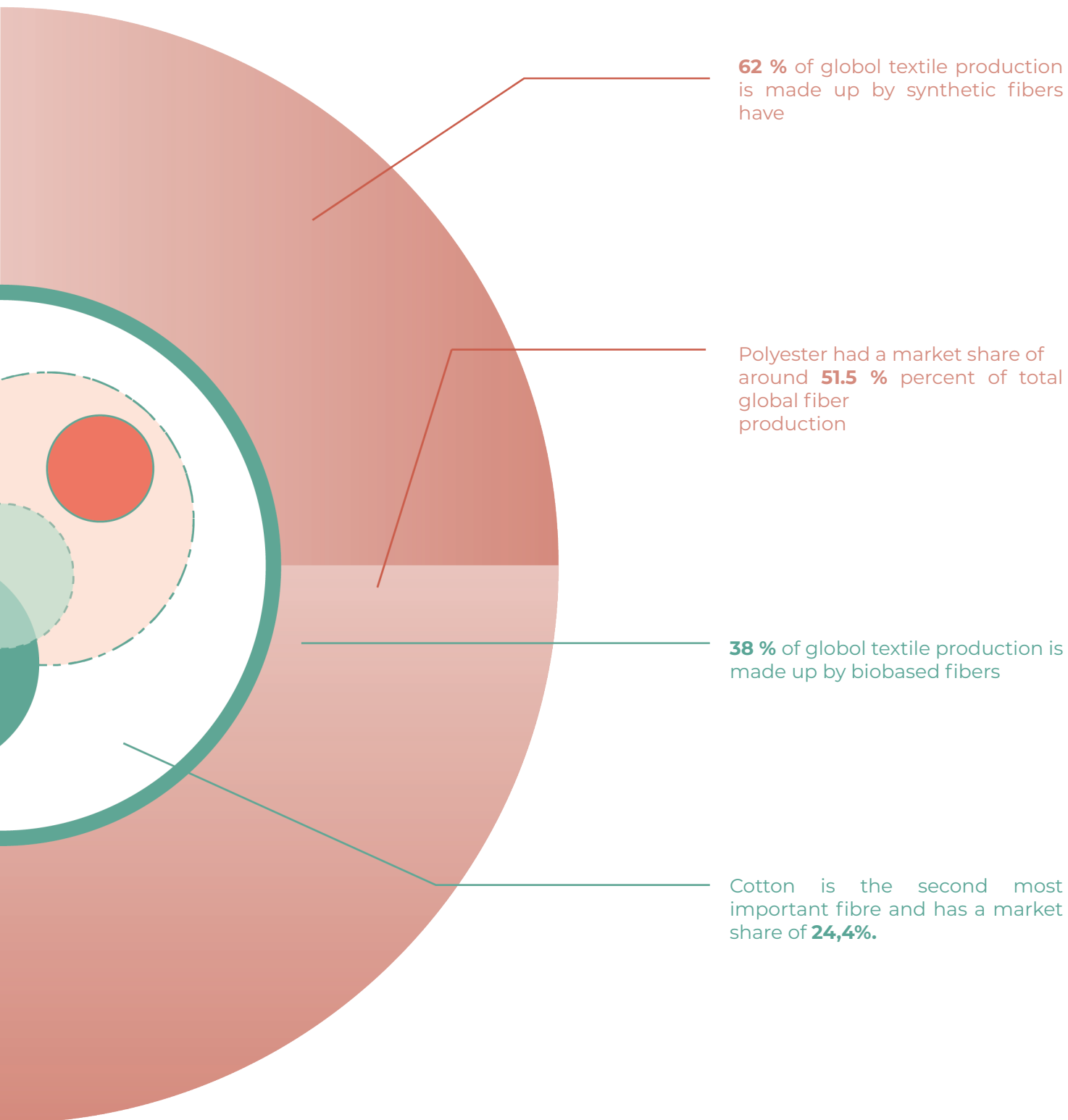
WHAT'S IN THE NAME?

It should be noted that 'bio' can be seen as a synonym for 'organic' (Lee, 2020), as a prefix 'bio' will be used throughout the report. Biobased materials is the umbrella term to indicate materials that are based on a non-specific biological association. Often assumptions about its properties are made too early. For example, people relate the term 'bio' to something that is better and more sustainable or if 'bio' is in the name people are likely to think it must be biodegradable (Lee et al, 2020). Due to the huge variety and the vagueness of the term, it becomes hard to understand what bio-based materials are. They include everything in between conventional as well as non-animal 'leathers' that contain fruit or vegetable waste furthermore it ranges between synthetic polymers to a pure cotton fabric or indeed a polyester-cotton mix (Lee, 2020). All biomaterials are bio-based meaning they are either wholly or partly derived from organic bases. Bio-based materials commercially available today most often come from the 1st generation of feedstocks such as corn, sugar cane, beets, and plant oils. They include polymers that are 100% or partially bio-based. Other technologies are still under development to produce for instance biosynthetics (Orlandi, 2018). Biosynthetics use chemical compounds in their production processes such as precursors for polyester and nylon. These compounds can either be made with an input of biological origin (biomass, 2d generation) and/or where the process is performed by a living micro-organism (Lee et al, 2020). The 3d generation of feedstocks that can be used are microorganisms such as fungi, algae, and bacteria (Orlandi, 2018). These living cells can produce biofabricated materials further processing is needed in order to make a macroscale material structure (Lee et al, 2020). In figure 5 can be seen that biofabricated materials consist of bio fabricated ingredients and bio assembled materials. All bio-assembled materials use the living organism to grow the actual macro material structure. In figure 05 an overview of the textile classification can be found which is based on the industry-accepted groupings as defined in legislation such as the textile fiber Products Identification in the USA. Next to that research shows that more work needs to be done to improve consumer knowledge on this bio-based terminology. This research into understanding the consumer's perspective of bio-based products indicates that environmental sustainability is a significant factor when choosing between products. However, terms like compostable and biodegradable are the words that positively influence the consumers the most (Gaffey et al., 2021).

VERSATILE AND UNIQUE

Bio-based materials are derived from renewable resources like; crops, waste, or non-foods (bacteria, etc.). Unlike synthetic materials which are derived from petroleum-based resources and therefore considered nonrenewable. Bio-based materials are often produced only from a%age of bio content (Lee et al, 2020). By increasing the bio content bio-based material innovators within the fashion industry aim to improve material potential on the following properties; biodegradability, recyclability, and sustainability. In this chapter the unique properties of biomaterial subcategories (biosynthetics, biofabricated, and assembled) will be discussed. This discussion will be led by the following material elements; material origin, production, and material outcome. Hereby material origin explains the input of the biological origin and thereby which building blocks are used. Production explains the process and necessities that are needed to come to a material outcome that is considered biobased.

BIOSYNTHETICS

Biosynthetics are polymers that are chemically identical to the synthetics polymers like nylon. Yet they are based on biological origins like sugar instead of fossil-based building blocks. There are two options to process this biological origin into a biosynthetic. The first scenario is by using chemical synthesis, in the laboratory. In another scenario, living organisms are able to process the building blocks due to their ability to fermentate (Lee et al, 2020). Both scenarios are able to convert sugar or other natural compounds into a new material that consists of similar properties as fibers and fabrics made of fossil fuel origins. For this category, it should be noted that even if the chemical compound is totally biodesigned at the end, the material outcome can be blended further down the chain with non-biological elements. This means the final material outcome could consist of for example 35% biobased material and 65% fossil fuel derived (Lee et al, 2020). An example of a biosynthetic is Microsilk™, a silk-like fiber made by the company Bolt Threads. The fiber is made through the fermentation of water, yeast, and sugar with spider DNA.

22.

Figure 6

Adidas X stella Mccartney tennis dress

BIOFABRICATION

This category can be seen as one of the newest techniques in the fashion industry. Biofabrication was in 2009 described in a journal 'Biofabrication' by Mironov et al as:

"The production of complex living and nonliving biological products from raw materials such as living cells, molecules, extracellular matrices, and biomaterials"

Living organisms are used as building blocks to create an ingredient or a material. The living organisms used in fashion are yeast, mycelium, algae, bacteria, and sometimes mammalian cells. These ingredients or materials are produced through processes such as fermentation (Lee et al, 2020). Bio-fabricated textiles are mostly biodegradable and break down into nontoxic substances when they are buried (Ki et al, 2020). An example of an biofabricated fabric is brewed protein™ by Spiber.

24.

BIOASSEMBLY

Bioassembly can be seen as a subcategory of biofabrication Just as biofabricated materials, bioassembled materials consist of building blocks that are living organisms. The material differentiates itself by scale and self-organization (Lee et al, 2020). This means that the macro-structure material is grown (processed) by the organism (resource) itself. This means the material outcome is far from manipulated because it is produced by nature. Therefore people nowadays believe that additional processing steps are needed in order to meet performance, durability, and aesthetic material benefits (Lee, et al, 2020). Mylo leather is a non-animal leather produced by the organism mycelium and therefore it is considered as a bioassembly.

Figure 7

Brewed protein (Spiber, 2021.)

2.3 LIVINGNESS AS PART OF BIODESIGN

This research focuses itself on the newest entries of innovation regarding biodesigned materials for the fashion industry, which are fabrics designed by the use of living organisms. Biofabrication processes use living matter as raw materials for their production (Lee et al., 2020) where bio-assembled materials use living organisms to produce an innovative material outcome. Taking this in mind this report uses the term 'livingness' to indicate a unique property of biobased materials. This chapter examines what 'livingness' can mean for the material origin, production process, and the material outcome. Questions that can arise are; What possibilities are there to produce materials from or with living organisms? Is there a possibility that the material is living itself? This chapter discusses some commercial projects where living organisms play a big role. Next to that, it discusses 'livingness' as a material property in order to find its strengths and weaknesses.

COMMERCIAL PROJECTS //

In the 21st century biodesign is in the spotlight for the production of artefacts. Hereby, biological organisms and biofabrication principles are exploited to develop new materials and products for every day (D'Olivo & Karana, n.d.). At this time more materials come to market or are being researched. Within the figure 8 an overview of interesting market-ready projects and research projects are shown. Within the following chapter some interesting projects about biofabricated materials are discussed looking at the following aspects. First material origin, which addresses the aspect where the material comes from. Secondly biofabrication processes for their production. Thirdly material outcome, concerning the final result with its tangible, physical, and real forms.

SPIBER (Spiber, 2021.)

Spiber is a Japanese biotech company that represents a new generation of novel consumer materials. The company was founded in 2007, therefore its philosophy is already standing for more than 10 years. They have expertise in both living organism design, engineering, fermentation, and textiles. Their main project is a new sustainable material that is called Brewed Protein™. The name refers to protein materials produced from
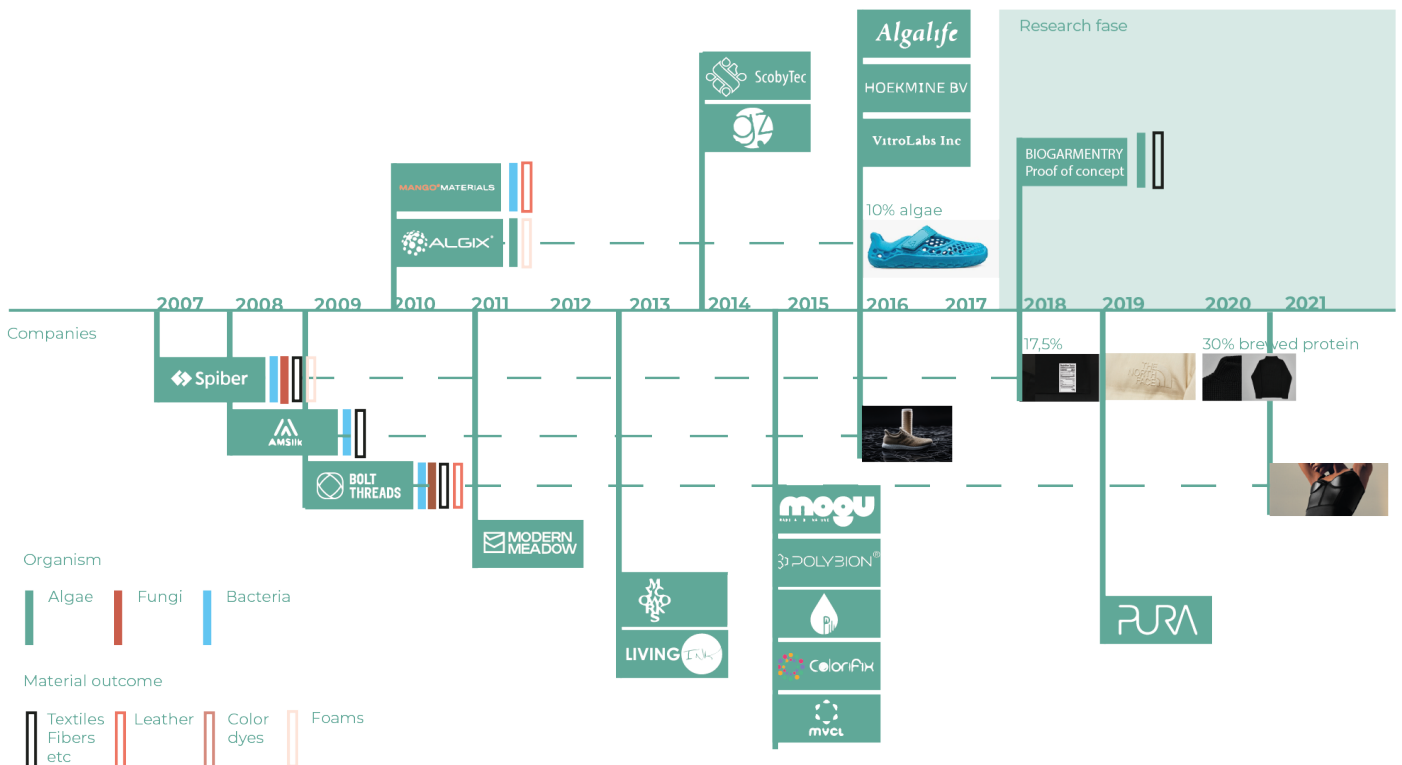

Figure 8

INNOVATION COMMERCIAL PROJECTS Image based on: (D'Olivo & Karana, n.d.)

plant-derived biomass using Spiber's proprietary fermentation process. This unique microbial fermentation technology shows potential in decreasing ethical and environmental concerns like; greenhouse gas emission. The outcome of this process can differ from filament yarns to spun yarns that boast features such as cashmere-like softness or the renowned thermal and moisture-wicking properties of wool. Next to that Brewed Protein™ can produce fabrics like animal-free fur and leather alternatives. Due to this big amount of potential materials that are available to the consumer Spiber can be seen as a mature company with a lot of inspiring projects. The Japanese company released a couture collection with designer Yuima Nakazato in 2019. As well as a limited edition jacket in collaboration with North Face namely the Moon parka™ (Lee et al., 2020). 'Livingness' within Brewed Protein™ can mainly be seen in the production process. Living organisms like bacteria and yeast are used to create material outcomes from fermentation.

Environmental note

The fabrics are designed to be not dependent on fossil-based feedstock. Next to this, they expect Brewed protein™ not to release microplastics while washing. An average of 700,000 fibers is released in a standard laundry load; 7.5 million tons of microfibers (which are a type of microplastic) end up in oceans every year often caused by synthetic fibers (Granskog et al., 2020). Therefore Brewed Protein™ materials are expected to have considerably less impact on marine ecosystems when compared to traditional plastic materials, but this is still under research by the company.

Motivation and adoption note

The Moon Parka™ is a project which can be seen as an example for a long term design process with a new innovative material. In 2015 Northface X Spiber showed a prototype jacket that digitally looked ready to be used in the mountains. According to Director, Kenji Higashi, of Spiber, what actually followed was an additional 4 years of further development between the two teams: "trying to figure out how to use our materials in a garment, and it took a lot of technical resources, not only from Spiber but also from The North Face" (Lee et al., 2020). This example shows that the development of material for an artefact takes time, but purposes and uses can be estimated

faster. Additionally, Spiber has recently announced an agreement with Archer Daniels Midland (ADM) to expand the production of their Brewed Protein™ polymers (Lee et al., 2020), this will eventually create the opportunity to produce on a bigger scale. Furthermore, SpiberTM website made research reports available that were part of the developing process, therefore the company shows a lot of transparency, which makes it easier adaptable for partners to join forces.

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MYLO (Bolt Threads™, 2021)

Mylo is biofabricated product from the American company Bolt Threads™ was founded in 2009, they launched their innovative material Mylo in 2018, this material can be seen in figure 9. Mylo is a leather-like material that is a high-quality alternative for animal and synthetic-based leather. The material is derived from mycelium which is a network of threads of fungus also called hyphae. The mycelium cells are produced by growing them on beds of sawdust and other organic material. Billions of cells grow to form an interconnected 3D network that is processed, tanned, and dyed to make Mylo. People perceive Mylo as soft, supple, and less harmful to the environment. The company Bolt Threads™ collaborates with brands like; Adidas, lululemon, Stella McCartney to produce fashion items. Livingness within Mylo can be seen mainly in the production process of MyloTM, where mycelium makes it possible to grow material outcomes while it is still alive. Yet this livingness is not present in the material outcome since the leather is being post-processed in order to create a leather-like look.

28.

Environmental note;

Mycelium is an infinitely renewable resource that is biodegradable and it breaks down organic matter and provides nutrients to living organisms around it. Furthermore, the production process uses a lot of energy generated by the living organism itself, which is a beneficial source of energy.

Motivation and adoption note:

Forming collaboration with well-known and innovative brands is of big value when new materials are created for commercial use. Bolt Threads plan to launch products made of Mylo™ with their consortium of brand partners in 2021.

Algaeing (Algaeing™, 2021)

Next to mycelium and proteins also algae can be used to create fabrics for the fashion industry. Algaeing is a company located in Berlin, they started introducing their material in 2016. Their aim is to create a fiber that is made from algae and cellulose and is 100% biodegradable. Next to this, they create a dye for their fabrics made by algae with the aim to be 100% biodegradable as well. This dye is called Algadye 3.0 and can be applied on all types of fabrics; synthetic, natural,

and protein-based. On their website, you can not find any existing fashion projects yet. This is mainly due to the fact that they are still in a research and developing face. This is logical since they only started in 2016. On their website, they are asking for partnerships, in order to join forces for further development. Livingness as a material element can be seen in the use of a living organism as a raw material. Whether 'livingness' is used in further steps of material developing remains unclear.

Environmental note:

There are a lot of environmental claims made on their website. For example: it prevents water pollution, it is 100% biodegradable, 100% energy sufficient, cruelty-Free & Vegan, and free of harmful chemicals and fertilizers. Some of these aspects can definitely be achieved by the use of algae and plant-based materials 100% as the origin for the fiber. Nevertheless, some aspects like; energy sufficiency, biodegradability, and the cruelty-free note lack some argumentation.

Motivation and adoption:

Their website does not show a lot of transparency about the material and is definitely used to be promotional towards brands and consumers. It is assumed that this is mainly due to the fact that they are still in a research & development stage. In this phase, they state they are looking for the right partnerships for further development. Yet they also state on their website that their materials are ready to use with all factory systems. Due to these mixed signals, it is hard to state on which level of adoption AlgaeingTM is. Projects that can be found, are mainly based on the participation in biodesign challenges, which they have won often. As a consumer, storytelling should provide more information on actual material properties and production processes in order to fully understand what the fabric is, and what potential it could have for the future of fashion.
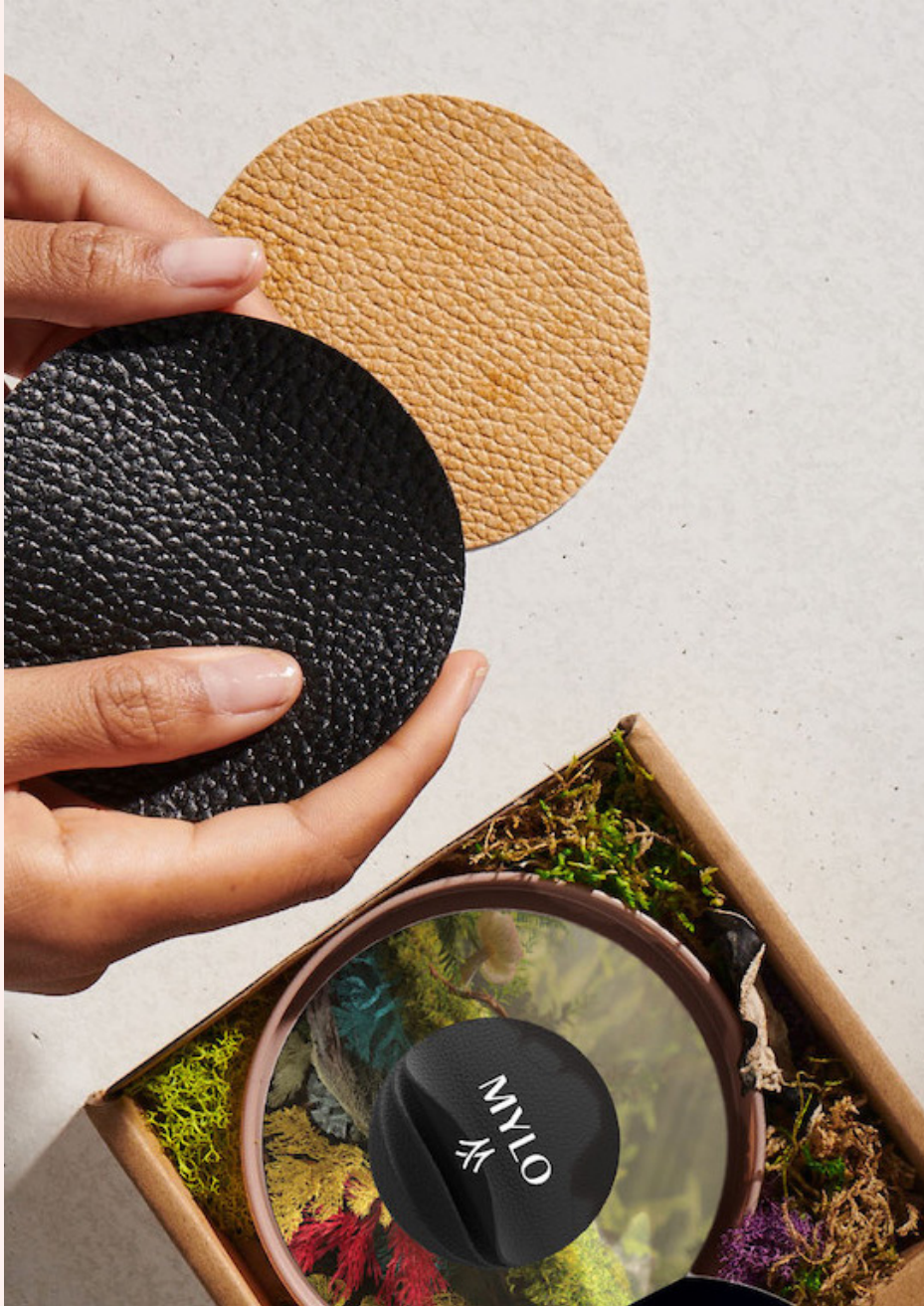
Figure 9

MYLO (Bolt Threads™, 2021)

2.4 'LIVINGNESS'

As discussed, the 3d generation feedstock that is used for biofabricated materials integrates living organisms, such as fungi, bacteria, and algae into the design. By this means designers often mobilize the livingness of organisms at the design time by using their growth to create predefined forms or to use their ability to release color while growing (Karana et al, 2020). In other projects 'livingness' as a material property is still present in the material outcome. An example of this kind of 'livingness' can be found in Biogarmentry and Biologic. The Biogarmentry project envisions a fabric that is made from a mix of cotton and living microalgae. The designer aims to create a textile with present 'livingness' in the material outcome that is able to photosynthesis. In the second example, MIT Media Lab incorporated living bacteria, that respond to body moisture, into a synthetic fabric. In these examples 'livingness' is extended to the use time of artefacts so that unconventional design outcomes can be created that offer the opportunity to create new ways of living and interaction, responsive behaviour while triggering to raise critical questions about care, symbiosis, cohabitation, and adaptation (Karana et al, 2020). This chapter addresses the important principles of livingness that can be divided into —Living Aesthetics, Mutualistic Care, and Habitabilities— (Karana et al, 2020). This chapter is used as a basis to examine the communication of 'livingness' in further stages of the project.

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LIVING AESTHETICS //

This principle concerns how humans experience the nature, degree, and duration of change in a living artefact over time (e.g., immediate or gradual changes in color, form, or function). The term aesthetics is used here to indicate how aspects of 'livingness' come to expression in the artefact, and can, therefore, be experienced. This happens for example when the growth and reproduction of the living organism change sensorial qualities of living artefacts like color, smell, or texture (Karana et al, 2020). Yet internal changes like photosynthesis can not be perceived visually by the user. During a discussion within the research team of this project, an opportunity was seen in showing positive or negative internal changes to the user by digital triggers. Change in living materials may evoke quite different semantic meanings and associations, this principle entails a purposeful design of change from the initial state of a living material to the end of its life (Karana et al, 2020).

MUTUALISTIC CARE //

With this principle, we refer to a complementary and evolving relationship between humans and living artefacts, where humans act upon a living artefact in order for it to thrive. In return for this care, the artefact continues to provide humans with (functional) benefits, for example, by being an ambient light, an air-purifier, or an oil-free colour changing paint Similarly, the bacterial culture in Spark of Light needs to be fed every now and then in order to keep its living function. These performances are seemingly different from what we might typically associate with maintaining a light source to function. The artefacts, on the other hand, can be intended to minimize human intervention by integrating a self-sustaining habitat to keep the organism alive in the absence of deliberate care. Whether cared for by humans or thriving without human intervention, in most examples the living artefacts require sunlight, water, air, etc. Thus, next to particular care actions, how the artefact is situated and configured in the everyday life, what other relationships with other living and nonliving (e.g., the sun) entities are envisaged within its habitat might ultimately affect the material qualities of a living artefact.

HABILITIES //

This principle concerns the way the human body and other living and non-living entities condition the livingness of an artefact. It requires the purposeful exploration of the abilities of things to provide a habitat both at design time and use time. To distinguish between the two habitats at design and use times, we refer to the niche habitat in which the living organisms are embodied in an artefact as first habitat, and the environment containing it in the use time as the second habitat (Karana et al, 2020). This distinction can be used to stimulate certain abilities of the living artefact at the right time. Looking at material production, different habilities are needed to produce the product in synergy with the organism versus containing the material result alive at the end.

tm

2.5 MOTIVATION AND ADOPTION

Rapid industrial uptake by private sector players is a major gap that needs to be filled to bridge the gap between research and adoption. From an 'innovation management' standpoint, this is explained by the fact that the widespread uptake of a new material in society typically takes about 20 years (D'Olivo & Karana, n.d.) . For example, Spiber™ company started with the idea of protein-based fiber in 2007 and developed its first limited edition products 10 years later as can be seen in figure 8. At this time the company is still proceeding with the development of this fiber for a larger scale. Taking this into account, materials science and product design studies increasingly emphasize the critical role of consumer appreciation and understanding in determining the ultimate success of a new material (D'Olivo & Karana, n.d.). This chapter will discuss the two elements; material technicalities and consumer understanding & appreciation as causes for the gap between research and adoption.

MATERIAL TECHNICALITIES // CHALLENGE ONE

Biomaterials are yet on the one hand existing for several decades but on the other hand still in research to be used and produced in new innovative ways. Most of these innovations in the form of new fibers, such as regenerative protein fibers, as well as innovative technologies are currently at the lab level or early stage with limited access to the industry. In contrast, the man-made cellulosic fibers space has witnessed innovations that have secured wide industry adoption and scale (Fashion For Good & Circular apparel innovation factory, 2020). Scaling can lead to a decrease in cost, thereby the price of circular clothing can be decreased when there are more materials and products available and the novel processes are stable and common. Furthermore, time is needed to synergize material production to final product outcomes in order to scale properly. This will also affect the availability of circular clothes, like Dahlbo et al. (2017) pointed out. Scaling up the commercial availability of these innovative fibers will require investment. Economies of scale should help reduce price points, but these newer materials are likely to remain expensive, used only by sustainability-minded designers (Granskog et al., 2020). The main burdens that could stand in the way are maturity level & implementation, availability & scale, cost, and quality of materials (Berg et al., 2020).

UNDERSTANDING AND APPRECIATION // CHALLENGE TWO

As explained in chapter '2.2 Biobased materials' the ability of different terms to indicate variation in environmental impact through inputs and outputs of a particular technology and a product's end of use remains unclear (Lee et al., 2020). Hereby, thermology is often not based on scientific accuracy but they are driven by the consumer's understanding, market strategies, and brand positioning opportunities (Lee et al., 2020). There will be an increased need for communication in order to help consumers understand new innovations (Lee et al., 2020).
Clearly, the need exists to consider how storytelling and visualization can make scientific findings more comprehensible and accessible to the general public. Scientific visualization has much to learn from information visualization in this regard, considering that information visualizations are aimed at the general public and that they draw attention to differences and changes in visual elements. Perhaps scientific visualizations can take a similar approach to reach broader audiences. If we focus on important features by emphasizing how they change across time or experimental conditions, we might be able to tell a compelling story without having to explain extraneous details. This will also help innovators to become more transparent, honest, and co-creative regarding their development goals (Lee et al., 2020). As for brands, it will also become important to take their storytelling and visualization one step further. This can be done by showing possibilities of biodesign by creating awareness about the impact of the materials. Next to that be open about price and material performance, short, medium, and long term. Since all these stakeholders are dependent on each other (innovators, brands & consumers). A principal learning for the success of new innovations is to keep strong partnerships between all (Lee et al., 2020).

31.

2.6 KEY INSIGHTS

This chapter addressed the characteristics of biodesign. It mainly focuses on biofabrication and bioassembly because in these areas 'livingness' is most present. In order to reach a high level of communication, several focus areas should be addressed correctly. The following statements will be used during the report to point out 'livingness' in digital communication;

Figure 10

KEY INSIGHTS LIVING MATERIALS

Spot in biodesign = Understanding how the material is placed in the biodesign industry. 'Livingness' is incorporated in several stages of the design material outcome, process, material origin. Biofabrication and bioassembly contain the most 'living' elements.

Show living Aesthetics = Explaining how aspects of 'livingness' come into expression. This can be in the form of change which can be caused by; growth & reproduction, movement, or internal changes. As a result, changes can be seen like color change, or changes can be felt like cleaner air due to photosynthesis.

Show mutualistic care = The product consumer relationship shifts from a passive relationship to a more active relationship because products are on some level considered to be alive.

Show habilities = Environmental requirements. Some external sources are needed to create a pleasant environment for 'living' textiles like; temperature, light etc.

Overcome preconceptions; Preconceptions can exist about 'livingness' in material design. Are the materials filthy or unhealthy? It is important to overcome preconceptions such as considering fungi and bacteria as filthy or unhealthy organisms for humans.

Stimulate partnerships; Material innovators: look for the right partnerships, in order to improve technicalities and storytelling. Showing impact and being transparent could accelerate further material development.

Develop maturity; 'Livingness' in terms of biofabrication/assembly is the newest field of innovation within the fashion industry and therefore still in the first phase of development. The gap between research and consumption is created by material technicalities and stakeholder communication. Materials can be more mature online to spark inspiration.

SPOT IN BIODESIGN

LIVING AESTHETICS

MUTUALISTIC CARE

HABILITIES

OVERCOME PRECONCEPTIONS

STIMULATE PARTNERSHIPS
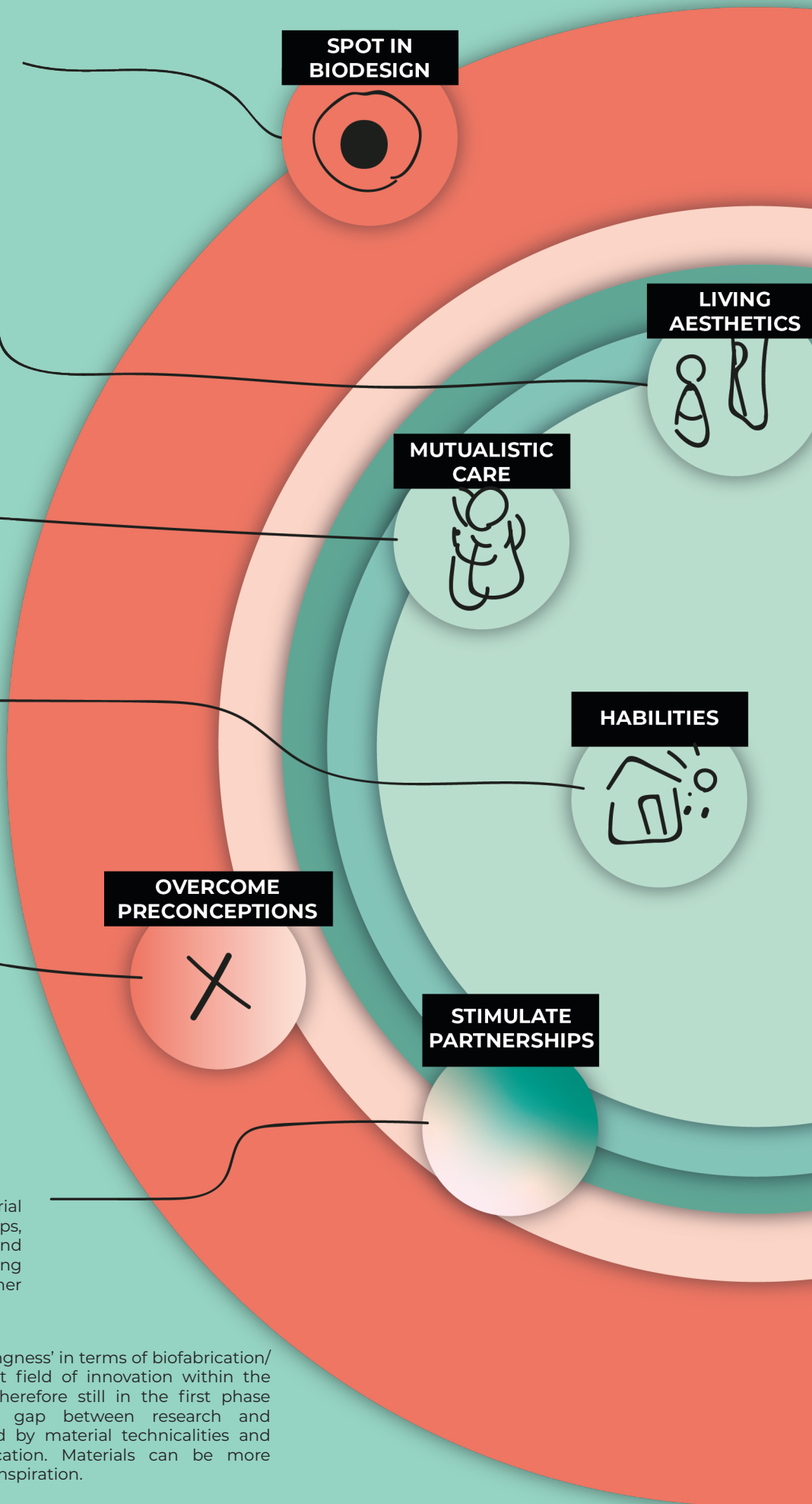
THE CONSUMER 03

3.1 INTRODUCTION

Consumers are one of the most important stakeholders within the fashion industry. Especially in this digital age, they are in constant contact with fashion brands by purchasing products and perceiving and sharing information about those products. Fashion brands are fostering a sense of community through engaging content, virtual social gatherings, and other creative initiatives that involve consumers (Chitrakorn, 2020). In the case of sustainable and circular fashion, the challenge is to share the message related to the reduction of consumption impacts and change consumer behavior, but at the same time sell the products (Black, 2011). Consumers are increasingly waking up to this reality and demanding change. In August 2019, Kering CEO François-Henri Pinault envisioned achieving net-zero emissions by 2050 for the fashion industry. According to McKinsey's 2019 Apparel Chief Purchasing Officer Survey, while the absolute number of sustainable fashion products remains low, there has been a fivefold increase over the past two years. Brands can help further educate consumers about what they can do to minimize the impact of their actions on biodiversity loss. Simple behavioral adjustments and consumption choices can have substantive results (Granskog et al., 2020).

While consumers and fashion brands get more aware of the path they want to take regarding a sustainable future for the fashion industry, there is still little offer to the consumer at this time. Chapter 2.3 (motivation and adoption) explains that the small offer for consumers, is caused by on the one hand the inability to scale materials that meet sustainable and functional demands and on the other hand the lack of understanding and appreciation of new innovations like 'living' materials. Additionally, when products come available in bigger volumes and materials have a certain level of appreciation, other dilemmas arise. In this interaction, consumer choices are still brand-driven. The power of social media means trends are now more often established by

consumers, as opposed to retailers and editors. In an era of fast-changing preferences, being able to respond to shifting demand and tailor production accordingly makes a lot of sense. Fashion is seeing the start of a shift where products are "pulled" into the market based on actual demand rather than "pushed" based on best guesses and forecasts. The change is significant. Previously, procurement, production, and distribution were predicated on designer and buyer predictions of future consumer demand. Products were produced and marketed in traditional "seasons." Under the "pull" dynamic, procurement, production, and distribution are based on consumer demand. (Amed et al., 2019).

This chapter will go into depth about the current digital consumer needs and expectations of future fashion design, their understanding and appreciation of 'livingness' in material design for the fashion industry and finally see how the digital relationship between innovator and consumer can be improved in order to stimulate demand.

3.2 DIGITAL CONSUMER

As stated in the chapter 1.0 Project description, the biggest shift in consumer behavior within the fashion industry is the shift towards using even more digital channels. Consumers account for more than 80% of all internet traffic on average, according to research by the McKinsey Global Institute (MGI) and the McKinsey Center for Advanced Connectivity (MCAC). To better address consumer themes next year, fashion players should focus on clearly understanding how to best use digital platforms like social media websites and omni-channel experiences in order to best deliver industry change toward greater sustainability (Lee et al., 2020).

The trend of digitalization of experience is reflecting the trend established before the Covid-19 crisis and the reluctance of people in many countries to gather in crowded environments. Indeed, recent data show that we have vaulted five years forward in consumer and business adoption of digital in a matter of months. Around the globe, we expect more than 20% annual digital growth in 2021 (with 30% in Europe and the United States) compared with 2020 (Ahmed, 2021). The web has become a predominant communication channel for sustainability initiatives. Social media channels are the most commonly used ways to reach a wider audience and enable companies to contact consumers who have expressed a prior interest, for example, in sustainability issues. Companies are able to share their information easily with the end consumer but that possibility has highlighted the importance of provenance and transparency in communication (Vehmas et al., 2018).

35.

"It's never just a communication between the parties of buying a collection and selling a collection, it's about delivering experience for the end consumer, so there definitely needs to be an attractive consumer experience."

Stefano Martinetto, chief executive of Tomorrow London.

3.3 NEEDS & EXPECTATIONS

For all the potential enhanced connectivity has to greatly impact business around the world, consumers are still the primary driver of demand—and their role isn't likely to decrease as cheaper, faster devices enable access to more and more data (Schiavotto, 2020). One of the greatest changes in communications over the last decade was the shift away from talking to company's stakeholders to talking with company's stakeholders. This change in dialogue, driven by the rise of social and digital platforms, has given individuals more power and greater agency to voice their candid perspectives on a company (Scotti, 2021). This means that the value of a product/material becomes more consumer denied and co-created. One of the biggest causes of this is social media which facilitates engagement consequently through shared content and online communities. This content makes it possible for brands and innovators to gain data that helps to improve their products/materials (Mpinganjira, 2016). This is supported by a report of McKinsey about the fashion system of 2021 explaining that; 'brands will increasingly leverage technology and analytics to gauge consumer sentiment prior to production'. Hereby it is important to examine the relationship between digital platforms and their consumers, in order to create positive designs since we become dependent on them and use them to influence. Positive outlooks here could be the growing influence of platform propositions for 'the good', possibilities to create a personal touch that reflects the priorities of many (Ahmed, 2021), and positive brand-relationship outcomes like trust and loyalty (Dessart, 2017). In this way, platforms can provide the opportunity to positively influence the relationship between consumers and brands or other initiatives.

The trend of the increased use of digital platforms can clearly be seen in the rise of the number of platforms and the attention paid to this by creators. Due to easy accessibility to an extensive amount of platforms consumers are demanding more information on "getting woke," radical transparency, and sustainability first (McKinsey, 2020), because they are able to compare better. This causes companies to increasingly compete for consumer attention. Social media offers unique opportunities to engage consumers on deep and meaningful levels. Consumers partake in interactive experiences with brands or community members beyond a simple purchase, creating more enduring and intimate relationships with brands (Dessart, 2017). Nowadays, we all experience a lot of impulses and as consumers, we get more critical of the digital content we consume and how we consume this. Therefore, the level of engagement plays an important role in investigating the competitive level of consumer engagement when consumers are presented with novel material innovation made from living organisms. A few studies examine arguments that engagement occurs as a result of interactive consumer experiences (Mpinganjira, 2016). A point of interest in this research will be how interactions can be used to shape digital experiences.

In order to create stronger relationships between brands/innovators and their consumers, consumer needs and expectations should be met. This is done by building consumer- understanding and thereby appreciation for innovative materials & products. Firstly, consumers expect extensive, transparent, social, and sustainable information. Besides being informative as a platform, platforms should take it a step further and interact with their consumers. Both will contribute to consumer engagement which plays an important role when it comes to absorbing information and acting on this.

ENGAGEMENT //

'What is engaging?' Examples of objects of engagement would include products, services, brands, advertisements, or Internet applications (Mpinganjira, 2016). There are a lot of different descriptions used to explain the meaning of consumer engagement. Within this report, the definition of engagement will be described as follows: a psychologically-based willingness to invest in digital interactions (Dessart, 2017). Engagement can be defined in three dimensions; cognitive, affective and behavioral engagement. Hereby cognitive engagement focuses on the overall mental activity such as involvement, attention and absorption. Affective or emotional engagement can be measured by parameters like enthusiasm and enjoyment. Lastly, behavioral engagement represents the actions that the user undertakes caused by the digital interaction for example: sharing and learning (Dessart, 2017). Although a substantial amount of research has been conducted on customer behavior, the understanding of the factors that influence

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customer engagement behavior is limited, particularly in the social commerce context (Busalim, 2019). Following literature, engagement can be seen as the new measurement tool for companies and innovators in various industries since it has shown that it provides companies with financial, reputational, and competitive benefits (Eigenraam et al., 2021). Yet, not all online engagement initiatives have a positive effect on brands/innovators. Therefore this report focuses on how to positively engage consumers with new innovations. Since engagement is a wide concept, this report will mainly focus on affective engagement, meaning stimulating feelings of appreciation. Interactivity is an element that consumers currently have in online environments, and literature states that it can create positive consumer reactions if it is consciously designed in web environments (Manganari et al.2009). With this finding, this report will further explore the improvement of appreciation of the consumer on digital platforms by using interactivity to stimulate affective engagement.

INTERACTION //

Online environments are becoming more interactive as technology advances (Dessart, 2017). Interactivity is employed to provide digital inputs to the user after his or her participation, but also to provide cognitive and emotional responses and to offer layers of depth in the stories (Sanchez-Lopez et al., 2020). Hereby interactivity influences users' engagement with the website by expanding their perceptual bandwidth such as psychological arousal on cognitive functioning, (Manganari et al.2009). Interactivity can be divided into four components following an "Online Store Environment Presentation Framework" explained in a paper of 2009 by Manganari. The 4 components are virtual layout and design, virtual atmospherics, virtual theatrics, and virtual social presence (Desert, 2017). Hereby virtual layout and design envision aspects like passive and active web elements concerning the aesthetics and layout. Virtual social presence stimulates consumers to communicate with friends, family, or the general public when online. Furthermore, virtual theatrics is a way for retailers to shape their brand by the use of images, animations, or videos. The term atmospherics is used in academic fields to represent the design of shopping environments to provoke emotional

effects in the buyer that enhance his purchase intention" (Dessart, 2017). Studies by Liu et al. (2015) as well as Mpinganjira (2014), show that high levels of digital interactivity, which are defined by the online responsiveness, have a positive impact on perceived value of users. Human responsiveness on websites has also been found to have a positive impact on perceived experiential value on online platforms (Mpinganjira, 2016) . Referring back to the "Online Store Environment Presentation Framework", interactivity could be integrated into the visual aesthetics and virtual theatrics by adding active elements to stimulate interaction with the consumer. Besides, social dimensions can contribute to interaction in virtual social presence and virtual atmospherics. This project examines how interactive aspects like active and passive web design elements or social dimensions influence the consumer's understanding and appreciation of 'livingness'.

37.

ACTIVE VS PASSIVE

Gambetti and Graffigna (2010) remarked that customers in the post-modern society are looking for satisfaction of composite needs, including the need to play more active roles in the consumption process through, for example, contributing to new product development (Mpinganjira, 2016). In terms of storytelling, interactive visualization which could help with three issues that are important to communication namely: comprehensibility, credibility, and involvement. First, building a story can be enhanced with the ability to let viewers interrupt and control the story to reduce the risk of presenting an overloaded visualization that's poorly understood. This improves comprehensibility. Second, you can improve a visualization if you provide the ability to let consumers verify what it shows. Finally, interaction with visualizations "breaks the fourth wall," transforming the visitors from passive observers to active participants. Unless consumers are actively shopping, much of that exposure appears wasted (Court et al., 2018). Consequently, they'll feel a greater sense of engagement with the content being presented actively and creating a more active consumer role. As seen above, literature provides proof that active participation accelerates consumer engagement on platforms.

NOTED THAT; During research team meetings of

this project, there have been discussions about active elements that could be considered for the digital platform. Personal active engagement can be created by interactive digital elements that provide the consumer with the ability to change and create their own experience. Active elements with a social dimension can contribute to the exchange of information by sharing, liking, etc.

SOCIAL VS PERSONAL

According to a study by Vries and Carlson (De Vries, & Carlson, 2014); the higher a social interaction's value is, the more likely it is to influence consumer engagement in social-commerce activities. Social commerce (s-commerce) uses online networks like Facebook or Instagram to promote or sell products/materials.

" Social influence is the "who" behind consumer behavior and sustainability."

38.

(Gass, 2015)

Next to that, findings from a study researching Mobile Location-based Social Networks show that social interactive engagement has a significant effect on passive usage. This means that the more people experience a deep sense of community, the more they are interested in reading other comments or collecting information (Pagani & Malacarne, 2017). Also in the e-commerce sector, social dimensions are going to play a more important role. Adding this social element to e-commerce platforms can create a competitive advantage. These methods are used to build relationships, engage consumers and create communities whereby users are able to participate in the selling, buying, comparing, and sharing of information (Busalim, 2019).

An empirical study about customer engagement behavior on social commerce platforms shows that customer engagement behavior is strongly determined by social interaction, technological factors as interactivity and system quality, and motivational factors. Among these factors, perceived value and social interaction had the most significant impacts on consumer engagement behavior on social commerce platforms (Busalim, 2019).

Moreover, there is az study that presents the results of a user study that systematically investigates the effects of face-to-face group conversation and physical interactions within a digital cultural storytelling experience at the Neolithic site of Çatalhöyük, with the objective of promoting engagement, learning, and perspective-taking (Katifori et al., 2020). This study examined that if social interaction is purposefully integrated into the story, more conversation is generated, and these interactive prompts do not disrupt the story flow even though participants report awareness of them.

Finally, certain tendencies among users affect their talkativeness and enjoyment, providing future designers of digital stories with guidance to better address audience needs (Katifori et al., 2020). Another study has found that social media increases the predicted quantity of information. Therefore, the study predicts that consumers that use social media are more quality-oriented and responsible (Russo, 2017). Furthermore, the psychological concept of social influence is integrated from the assumption that a person's behavior is heavily influenced by the behavior and presence of others (Rauniar et al., 2014). Therefore, social influence matters because it affects so much of what we think and do (Goldsmith, 2015). Awareness, actions, and responses are part of consumer behavior. This fits with the ideology of new innovative materials that aim for quality and responsibility.

By showcasing these different examples, we can predict that adding social interaction within digital platforms can have a positive impact on consumer engagement. Therefore, the project team discussed investigating how social interaction could play an important role in enhancing the storytelling of innovative materials like textiles made from living organisms and thereby positively contributing to the future consumer's engagement.
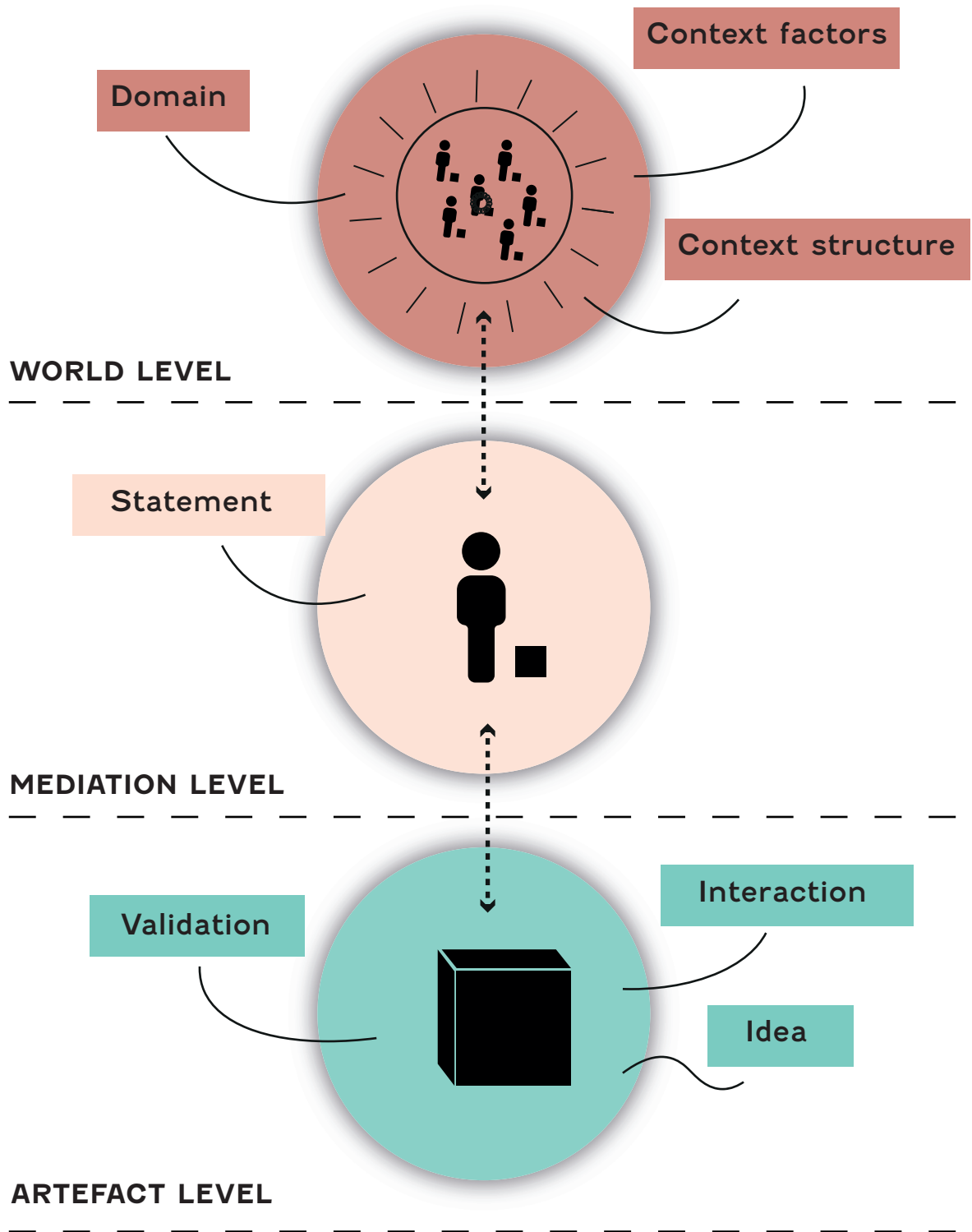
Domain

Context factors

Context structure

WORLD LEVEL

Statement

MEDIATION LEVEL

Validation

Interaction

Idea

ARTEFACT LEVEL

Figure 11

Social interaction design - the stages and steps of the method (Tromp & Hekkert, 2019)

THE EFFECT OF SOCIAL DIMENSIONS //

Our global world is encountering problems on an unprecedented scale. Over the last 15 years, design has boldly moved away from its roots and has taken on the challenge to address the big problems facing society (Tromp & Hekkert, 2019). The human responsibility for those problems keeps getting more undeniable. Lately, in particular our environmental accountability has received a lot of attention. The newest climate report from IPCC holds human society responsible for climate changes that are now visible and states that every part of the world will have its custom-defined problems. So even for common world problems, it can be naive to think that design can solve problems of this scale. Projects of this size do consist of decisions made based on assumptions (Tromp & Hekkert, 2019). Using nature and 'living' artefacts is a smaller part of the solution that contributes to solving bigger issues. Yet the idea is meant to be adopted by a huge part of society. Stephens Goldsmith explains that we are entering the 'fourth phase' of how we deal with societal problems. Hereby the first stage started in the 20th century whereby taking care of each other was only implemented in friends & family relationships. In the second stage, the government took responsibility for the welfare of their people. During the third stage, more and more parts of the welfare state were outsourced to the market, this has led to for example large cost reductions rather than meaningful innovations. The fourth phase of which we are at the beginning is when governments and the public sector harness their power with the private sector in order to transform and innovate (Tromp & Hekkert, 2019). Social design intends to create an intentional social impact, which means the designer has an explicit idea of the effect of the design. Designers, therefore, are taking responsibility because they are creating a positive impact with their designs. As stated before, consumers are becoming more aware of the impact they have, and they are trying to purchase more sustainable products (Mckinsey, 2021). Yet this purchase is only one small part contributing to the total envisioned impact. Therefore the impact is often not visualized during this individual action. Therefore social designers advise looking at the bigger picture. Consumers need to consider impact beyond their own boundaries. Can designers integrate social impact into their design in order to create a sensible story of the impact on a bigger level?

40.

This chapter further describes how design can contribute to the feeling of social responsibility. In order to further describe which social interactions complement this design story.

SOCIAL RESPONSIBILITY CAUSED BY AN ARTEFACT

Imagine the bigger picture! This bigger picture refers to both the impact you aim for, as well as the strategic future you secure through its implementation. To realize impact you have to generate growth (Tromp & Hekkert, 2019), as said in chapter Biodesigned materials, one part of this movement towards a more biodesigned world is scale. Especially in the fashion industry, you will not make a lot of impact with only one consumer, because the size of the artefact will never be big enough. Only when everyone separates their household waste are we able to reuse and recycle materials. Only when a lot of people take their car to work, traffic jams occur and carbon emission really becomes a problem. These examples show that consumer behaviors are not specifically bad or good, but can become beneficial or harmful to the group when many people engage in them (Tromp & Hekkert, 2019). In an online video event about several material innovations organized by the royal society (Mark Miodownik et al. 2021) the following question was asked to the consumer; If a material was able to clean the air from C02, for what artefacts would you prefer for it to be implemented? Examples of answers for this question were: concrete to make buildings and textiles in order to make clothes. A public of more than 80 people voted that the most interesting option for this property would be building blocks, so cleaning air could be integrated in architecture. The least favorite choice was integrating this material into textile so clothes that could clean the air could be made. A possible reason for the unpopularity of this answer could be that it seems like it will have less impact than all the other options and therefore is less preferable. Clothing is a product that is purchased on a very personal level called artefact level in figure 11. You choose your piece of clothing in order to wear and feel confident. This artefact level, therefore, describes the interaction between humans and the artefact. The second level (meta-level) describes the statement meaning; firstly the behavior you wish to support through the artefact, secondly what

SOCIAL SUPPORT

SOCIAL VALUE

PERCEPTION

SOCIAL PRESENCE

SOCIAL INTERACTION

SOCIAL PRESENCE

PARTICIPATION AND SOCIALIZING

RELATIONSHIP QUALITY

SOCIAL BENEFITS

SOCIAL IMPACT

SENSE OF COMMUNITY

(Busalim et al., 2019)

(Schieber, 2020)

(Pagani & Malacarne, 2017)
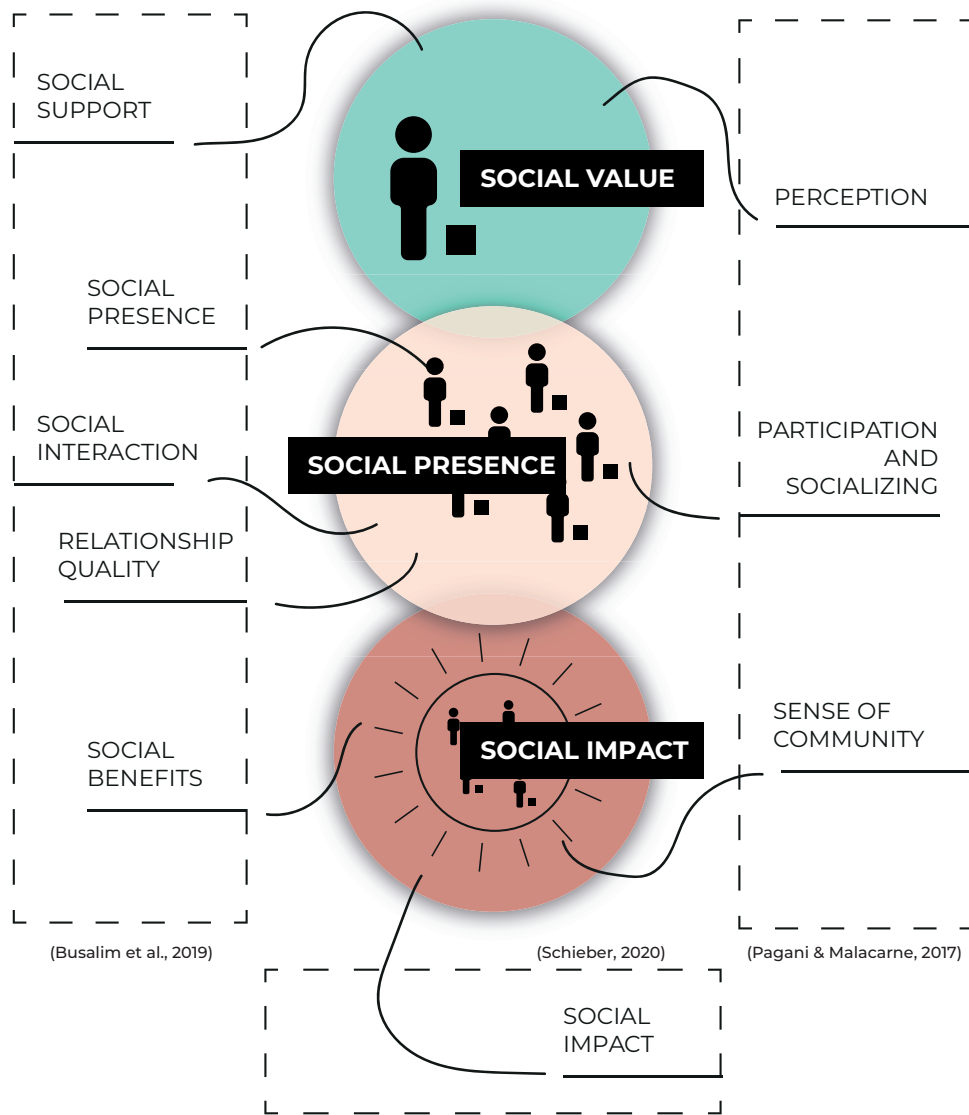
SOCIAL IMPACT

41.

Figure 12

SOCIAL DIMENSIONS (Pagani & Malacarne, 2017), (Busalim et al., 2019), (Schieber, 2020)

this behavior could mean for social implications addressing the collective concerns and lastly it describes the meaning of this behavior for people addressing the individual concern (Tromp & Hekkert, 2019). The third level takes the whole world into account and is therefore named macro-level. Here it is all about looking at the world around you, seeing developments at different scales. Creating a world where not only people but also artefact work together in order to reach world-level goals.

SOCIAL DIMENSIONS

This chapter aims to provide clear guidelines of social dimensions that can be used on digital platforms to improve the consumers' understanding and appreciation. Eventually, consumers are influenced by the different social dimensions. Social influence involves intentional and unintentional efforts to change another person's beliefs, attitudes, or behavior. Unlike persuasion, which is typically intentional and requires some degree of awareness on the part of the target, social influence may be inadvertent or accidental. Social influence can occur when analyzing a message on the basis of sound, attractiveness or other characteristics that do not consider the actual content. Hence, the target may be unaware of the influence attempt (Gass, 2015). Within this field of social interactive engagement studies provide different frameworks for dividing social dimensions. In figure 12 these frameworks are combined.

According to Pagini & Malacarne (2017), social Interactive Engagement is measured by three experiences: perception, participation and socializing, and sense of community. Perception envisions the value of social engagement on the level of understanding and appreciation of information. Participation and socializing determine how much time the user spends on the platform and their contribution to the conversation. Lastly, the sense of community is created by the number of users that contribute to using the platform and have a positive influence on others.

A Systematic Literature Review about Factors Influencing Customer Engagement in Social Commerce Websites (Busalim et al., 2019) presents 5 social factors namely; social support, social presence, social interaction, relationship qualities, and social benefits. In this case, social presence

stands for the established personal, warm and sociable relation established among different users. Social support can be divided into two variables; emotional support and informative support by other users. Social interaction is either interaction with other customers or interaction between customers and the brand or company. Social benefits refer to the benefits derived from the social relationships that develop over time among users. Social benefits can derive from social interaction when problems are solved, discussions are held to make sense with multiple people on a platform. Furthermore, we live in an age of purpose-driven businesses therefore it is critical for companies to create a social impact storytelling strategy that is authentic to both their audience and brand image (Schieber, 2020). Social impact hereby illustrates the effect you could have when acting as a group.

As said, social influence can contribute to the consumers' understanding and appreciation and thereby their behavior. This research points out 3 social dimensions that positively influence consumers' understanding and appreciation as can be seen in figure 12, based on different frameworks. The first dimension is social value, this concept describes the value perceived from a social environment by an individual due to emotional and informative support. Hereby the value delivery is a one-way concept, which the individual benefits of. Secondly, social presence is considered as the second dimension. Hereby the individual benefits from a personal and warm social atmosphere but is also able to interact with other consumers or the brand itself. In social presence, it is about the individual being present in the relationship, to improve the relationship quality and thereby contributing to a social environment where more than one can benefit from. Lastly, social impact is a concept based on social impact and social benefits. This concept goes beyond creating participating as an individual but is based on a feeling of community and what can be achieved with that.

GREEN AESTHETICS //

As said consumers' attitudes are changing and innovators come up with new initiatives, there are a million things that the consumer can consider when buying clothes. Yet beauty and aesthetic dimensions are the most significant when consumers are making decisions about clothing

42.

and designers. The final dimension that this report considers is therefore today's aesthetics. Yet the concept of beauty and aesthetics are closely linked to cultural, social, and temporal context and therefore sometimes in contradiction with radical changes towards sustainability. John Hospers, a researcher in areas of philosophy including aesthetics and ethics, divided aesthetics into two concepts; a thin and a tick meaning. Hereby 'thin' aesthetic are the characteristics visible on the surface, the physical appearance of clothing (1946). 'Thick' aesthetics go deeper and concern the material's values, a deeper association to values and morals of larger groups of individuals or communities. When aesthetic attributes are limited, aesthetic properties can be extended to a 'thick' aesthetic, in this way pleasure and experience of clothes can be experienced broader than only visual appreciation. Clothing appreciation is not only dependent on the individual level, the evaluation is built upon social situations and group association. Aesthetics contribute to communication with others because they affect the way the message is displayed or interpreted (Niinimäki, 2014).

Aesthetics of 'living' textiles goes beyond beauty. In developing those textiles for the clothing industry we need to find new ways to improve aesthetic appreciation. 'Thick' aesthetics can thereby positively influence the consumers' appreciation. The responsibility of including 'thick' aesthetics is up to the designer. If the designer can present a design that shows the relationship between ethics and aesthetics (Niinimäki, 2014), more positive aesthetics experiences can be created.

43.

3.4 KEY INSIGHTS

Based on the exploration in this chapter, it can be validated that the relationship between the innovator and consumer can be improved. This is mainly based on the enormous change in relationship due to certain areas such as; the shift to a digital consumer, the competition around attention, the change in dialogue, the wish for co-creation, and the increased feelings of social, environmental responsibility. Based on these transformations, statements can be made in order to improve the relationship between 'living' textile innovators and their future consumers.

Social dimensions stimulate;

Communication of 'living' textiles can be complemented by social dimensions since they spark the feeling of social responsibility. Furthermore, appreciation of clothing is not only dependent on the individual level, the evaluation is built upon social situations and group association. This project defined 3 social dimensions that could contribute to the communication namely; social value, social presence, and social impact.
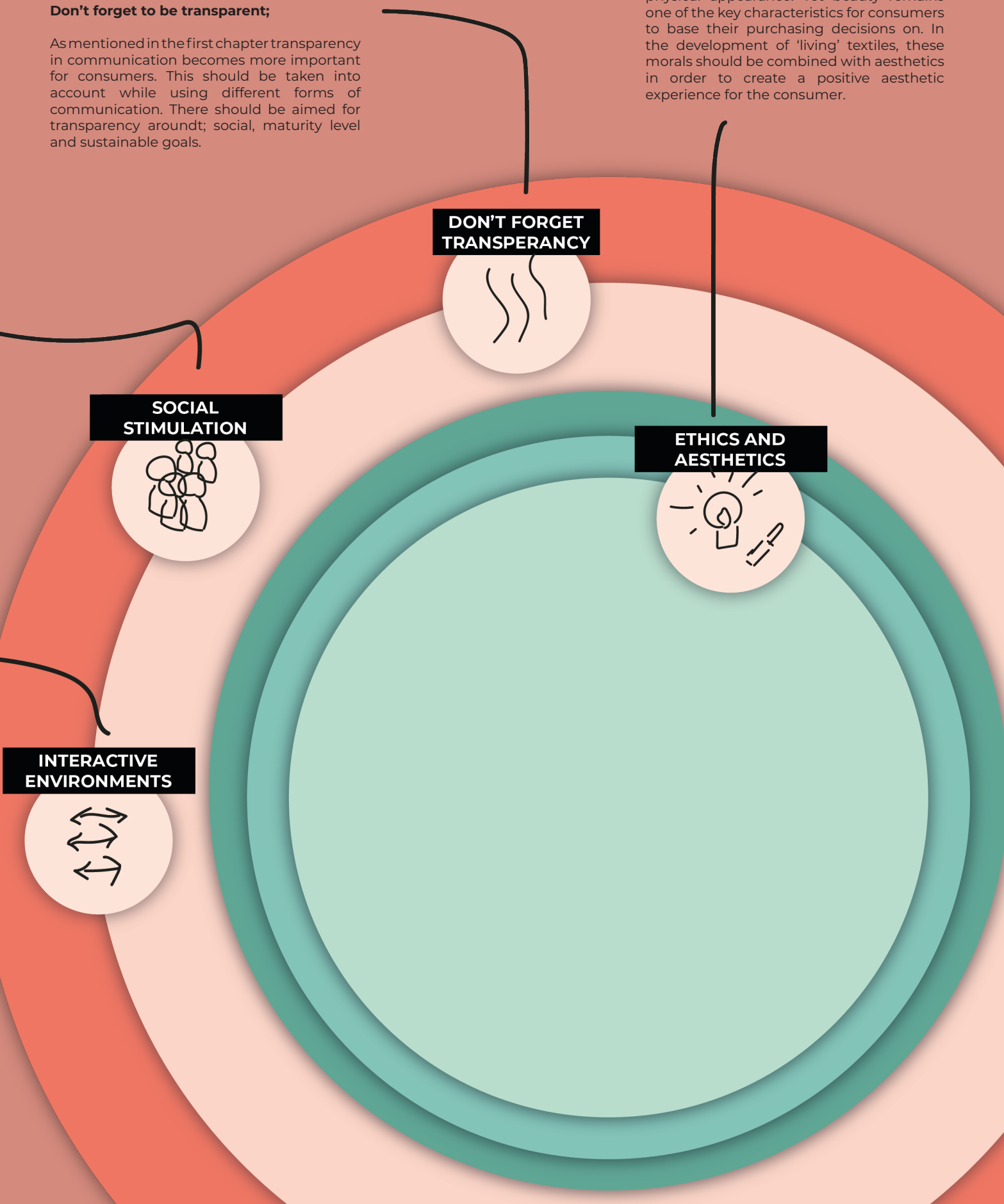
Interactive environments are a must;

Interactivity is an element that consumers currently see as a must in online environments, literature states that it can create positive consumer reactions if it is consciously designed in web environments. Consumers want to have an opinion that matters. Creating space for interactivity will lead to a better appreciation which is followed by a more effective consumer engagement.

Figure 13

KEY INSIGHTS CONSUMER

Don't forget to be transparent;

As mentioned in the first chapter transparency in communication becomes more important for consumers. This should be taken into account while using different forms of communication. There should be aimed for transparency aroundt; social, maturity level and sustainable goals.

Ethics and aesthetics transmission;

Aesthetics of 'living' textiles goes beyond beauty. Especially in the biobased field, morals become more important than physical appearance. Yet beauty remains one of the key characteristics for consumers to base their purchasing decisions on. In the development of 'living' textiles, these morals should be combined with aesthetics in order to create a positive aesthetic experience for the consumer.

DON'T FORGET TRANSPERANCY

SOCIAL STIMULATION

ETHICS AND AESTHETICS

INTERACTIVE ENVIRONMENTS

DIGITAL COMMUNICATION

04

4.1 INTRODUCTION

Since the rise of digital channels, digital communication methods are constantly improving. Therefore websites today are capable of using a large number of tools for communication. Design trends are often influenced by the changing environment around us. This year, we experienced remarkably dramatic changes in the digital design sphere. COVID-19 has put us in quarantine, pushing us to delve deeper into the digital world, and changing the way we live our lives. Web Designers explore new ways of communication that can generate increased levels of engagement (Golzaker, 2021). For example the increased use of data science for personalization, ohni-channel experiences and 3D product simulations for online shoppers. Within this chapter a broad overview of storytelling and communication tools will be discussed, with the aim to improve digital communication of 'livingness' within material innovations. Hereby trends and new technologies are researched, and interesting examples of digital experience are used as inspiration. Furthermore benchmarking of current online representations of livingness will be added. To finally see how the social dimension can be supported by digital tools in order to communicate 'livingness'.

4.2 TRENDS

Since the movement from physical to digital sources of information and experience does not go unnoticed, new concepts occur to complement this. This chapter will point out some trends that can fit with the communication and storytelling of 'living' textiles. The purpose of this chapter is to gain inspiration about how this 'livingness' can be translated into an online environment and match that with trends that currently work well.

HYPER PERSONALIZATON //

Current digital channels must meet a new standard: the 'care of one'. This is contradicting with the social environment as mentioned earlier because hereby platforms need to match the consumer's individual needs. Yet the social and individual aspects do not have to be mutually exclusive. Since technological innovation has enabled the radical reinvention of the operating model as the cost of creating personalized experiences continues to go down. This combination creates an opportunity for companies to double down on hyper-personalization and the care-of-one approach (Amar et al., 2020). For example, e-commerce players have reset the bar by providing personalized offers. Personalization has been a major focus of businesses for the last five years, and with good reason. One study found that 80% of customers are more likely to purchase products and services from brands that offer personalized experiences (Midbari, 2020).

DATA SCIENCE //

Data science is booming, and this will continue into 2021. With the rise of clean data gathering tools that are supported by omnichannel platforms, we are able to gain even more from our data every year. Nothing is unimportant when it comes to customer data. Everything has the power to inform

how we create goals for the business going forward (Midbari, 2020). This trend has been ongoing for several years, which makes it more important to be transparent and share this day with the consumer. So instead of only using data internally, data can also be used within stories externally.

OMNI-CHANNEL APPROACH //

Customers will expect companies to have a consistent voice across all platforms (Midbari, 2020). Companies that successfully adopt a more customer-centric stance and focus on the two or three most important cross-channel customer journeys can create significant value. An omnichannel effort targeted to the top interaction models can dramatically increase the extent to which customers are able to use self-service options. In our experience, some use cases have shown nearly a 20% boost in containment—that is, the share of customers who engage with an automated system such as an interactive voice response (IVR) system, a website, or a chatbot, and have their needs met without assistance from a live agent (Amar et al., 2020).

TRANSPARENCY //

Customers appreciate honest companies. In fact, one study found that 86% of consumers want brands to be honest. In the era of "fake news" and widespread misinformation, consumers just want to know the truth. They don't want to read between the lines when browsing a product or service (Midbari, 2020). Customers understand that their data is valuable to your business. They also understand that by sharing their data they get something valuable in return (a more personalized experience). However, this doesn't mean they are happy to give their data up freely. Many consumers no longer trust companies with their data. In 2021,

we expect to see more companies implementing tighter privacy and cloud security practices and communicating this to their customers (Midbari, 2020).

SEAMLESS SURREALISM //

Many designers have taken the collage art trend even further, designing their websites in a surrealist style. This technique is characterized by how it positions elements upon counterintuitive, unusual backgrounds. Gucci's example places each handbag on a unique, image-based background. Shoppers can then see each item in an entirely different light. Suddenly, there's an added layer of each handbag's look and feel and its fashionable vibe.Surrealism in web design also involves flamboyant colors and textures that present the abstract, artistic mind of the creator. Over time, more and more e-commerce websites are using this trend to present their products in a novel, emotional way (Golzaker, 2021) .

4.3 TOOLS

Within this chapter an overview is presented of digital tools that can be used to complement the storytelling of 'living' textiles. Digital tools are used to help deliver a certain concept to the end consumers. Examples of digital tools are video, illustrations or an app to edit photos. Yet a study on framing of novel materials in Design confirms that the traditional tools remain inadequate in capturing and communicating novel material qualities unfamiliar to society. Biodesign companies rely on conventional ways in presenting the experiential qualities of their materials (i.e., how it touches and feel), for example, with photographs from end users experiencing the material for the first time, or with animated pictures showing the material's response to touch (D'Olivo & Karana, n.d.). Hereby new narratives should be discovered on which (digital) support tools can contribute to communicating the unique qualities of textiles made from living organisms to a wide public. Firstly this chapter will firstly describe tools that can be used for the sensory perception of these concepts. Secondly, some tools that synergize the physical and digital world in order to create a higher level of circularity. To finally give an overview tools that can be used for storytelling and communication in this project and for material innovators.

48.

SENSORY TOOLS //

Currently the use of short videos is most prefered when consumers want to learn about a new product or services as can be seen in figure 14 (Dave, 2021). Complementary to the consumer's wishes, designers are interested in tools that support research, particularly in the early stages of material selection. Video based tools thereby are positively rated because of their ability to convey three-dimensional and textural information (Petreca et al, 2014). Digital tools that are able to show movement contribute to the loose aesthetics of textiles. Additionally presenting 'livingness' goes beyond realistically presenting physical material properties. For example internal change, the 'care' relationship and external influences are not immediately seen in the artefacts appearance. Therefore this chapter describes tools that can be used to broaden the consumer's perceptual bandwidth.

3D TECHNOLOGY

Tools such as virtual sampling, digital material

libraries and 3D rendering of collections for sales, which weren't broadly used before the pandemic, have increasingly become the norm (Amed et al., 2021). Within the fashion industry the focus on 3d modeled garments is rising. 3D modelling is used for several purposes for example to create a product on demand model within the fashion industry. 3D modeling makes it possible to create garments that have never existed in real life.

"I feel like the future lies in materials that are smart and that are able to grow with us or even grow on us, a more sober expression of who we are. And then within the digital world, we can go completely crazy. We can wear a dress made of water or have lights everywhere and change your textile according to your mood."

Amber Jae Slooten of The Fabricant

AUDIO IS THE FUTURE

A bunch of new apps are using audio as the core of their experience, making people connect through voice again. From phone calls to messaging and back to audio—the way we use our phones may be coming full circle. Hereby, the best known version of a social media that is audio-focused is Clubhouse, a talk-show like chatroom (Basu, 2021). Next to this immersive sound can create a new dimension for audio. Immersive audio can evoke emotional reactions beyond visual communication. It is a good bet that 360-degree audio will soon become the norm on all devices and channels from headphones, stereos and smart speakers to laptops, theatres and cinemas (Bridge, 2020) .

INTERACTIVE VIDEO'S OR IMAGES

Just like in the physical world, consumers should be able to interact with products and new novel initiatives. Therefore interactive videos can be a intresting support tool for web-based communication. Interactive video has already proven to be very effective. Research into The Use of Interactive Digital Storytelling Video shows that the quiz performance was higher when students were watching the interactive videos, compared to conventional videos (Shelton et al., 2016) . Next to that, 70% of marketers say interactive video engages audiences "very well," and 68% of marketers believe it will continue to become a super important trend in the video industry

(Rimmer, 2021) . Next to that cinematic images will let consumers experience a new way to interact with products online. According to Maarten Wijntjes, a professor at the TU Delft, these images are too expensive to make for every product yet they could suit only material experiences.

NEW REALITIES

Virtual Reality (VR), Augmented Reality (AR), Diminished Reality (DR) are creating new realities in the digital environment. According to a recent estimate by Goldman Sachs, AR and VR are expected to grow into a $95 billion market by 2025. The strongest demand for the technologies currently comes from industries in the creative economy—specifically, gaming, live events, video entertainment and retail (Hall & Takahashi, 2019).

INTERACTIVE WEB-ELEMENTS

While researching possibilities for web-development we came across functions that are now not always used. A website provides you with a lot more opportunities than social media channels. These active elements can create a deeper layer in the storytelling experience. For example hover functions can be used; Taking a spin on the traditional menu structure, this is what we call a "half hover gallery, half navigation menu". It looks like a regular, standard menu at face value, but then once hovered upon, images appear, revealing a sneak peek of the content we'll see in the next step. Next to that you mouse can be a simple tool within the interaction in various amounts of ways.
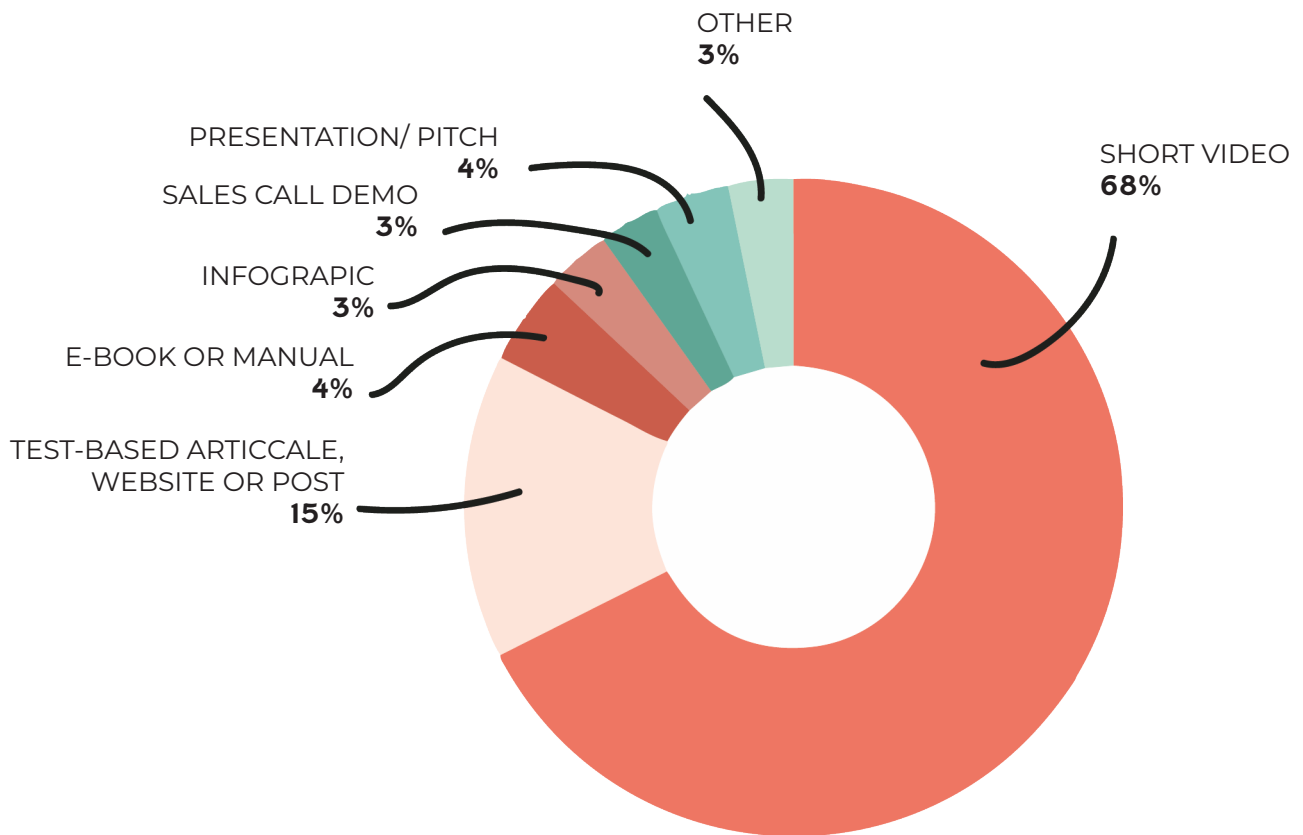
49.

OTHER
3%

PRESENTATION/ PITCH
4%

SALES CALL DEMO
3%

INFOGRAPIC
3%

E-BOOK OR MANUAL
4%

TEST-BASED ARTICCALE,
WEBSITE OR POST
15%

SHORT VIDEO
68%

Figure 14

MOST PREFERED WAY TO LEARN ABOUT NEW PRODUCTS (Dave,2021)

CIRCULAR TOOLS //

Technology can be found in various elements of the fashion and textile industry covering areas like product data and traceability, to logistics, to smart materials and technologies that are part of the garment/textile itself. Thereby technology in fashion has the great power to facilitate circular fashion models using 'digital triggers' (Lijzenga, 2021) in order to reach a wider public.

LIFECYCLE TRACKING

Recently brands are expanding their current business models based on sales only with resale and rental business models, hereby brands need to keep track of their products in order to gain them back into their possession so they can be repaired, reused or recycled. For this life cycle tracking original sales and marketing data are important to estimate prices for following consumers (Lijzinga, 2021). An example of this can be seen in BloomTM, makers of flexible algae based foams for high rebound applications such as shoes, sporting products, and accessories. They have a clear view on how much material they sold and to who, and how much impact is achieved by that.

50.

DIGITAL TRIGGERS

Keeping track of the product's life cycle can be supported by using digital triggers like QR codes added in the label of the product. These QR codes lead to a web environment where care and content information is available. With the ability to track the life cycle of garments/textiles more information can be gained about when the textile needs to be cared for, repaired or recycled. This is important data to improve material properties regarding their use. Currently care and content information needs to be provided in physical labels sewed into the garment/textiles nevertheless our world is modernising towards new legislations where care and content information can be delivered digitally. This fits with the trend that consumers want more transparent information of the product they purchase, digital triggers can allow these levels of transparency providing information about the supply chain journey and the origin of the clothes.

SOCIAL TOOLS //

Social tools include interactions like; text chat, social network functionalities, rating/review systems, liking-features, share systems, and forum/newsgroup/ discussion features (Pagani & Mirabello, 2011) .

OVERVIEW TOOLS //

This chapter gives a brief overview of tools that can be used to create a full experience. Meaning that physical appearance, function beyond appearance and acting in a circular system have been taken into account. Figure 15 gives an overview of these tools and their relations.
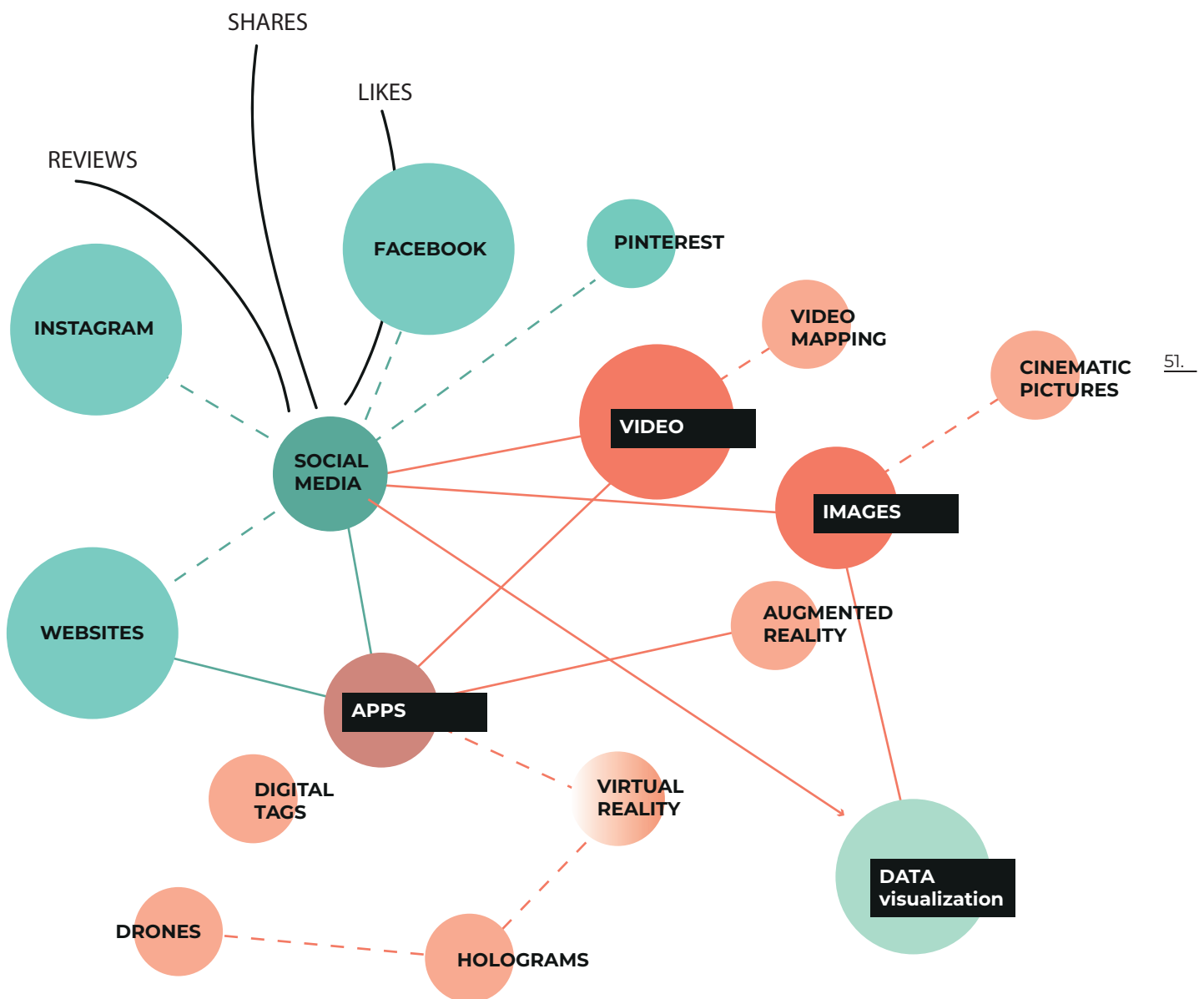

51.

Figure 15

OVERVIEW OF DIGITAL TOOLS

4.4 Benchmarking

In order to link tools to certain aspects of 'livingness' an objective benchmarking analysis provides insights on how 'livingness' of artefacts is currently presented online. This benchmark considers different product categories that are made through biofabrication or bioassemblying. Conclusions of these objective analyses are discussed within the research team in order to verify the results. Furthermore benchmarking is performed on how social elements are included in web based platforms to spark inspiration. In appendix [BENCHMARKING] the images and notes are represented to support the final conclusions of the benchmarks into 'livingness' and social design. You will also find the result from a benchmarking into active and passive elements but these results are not considered in this project. This chapter describes the conclusions of these benchmarks firstly regarding presentation of 'livingness' and secondly regarding the representation of social interaction.

52. ## 'LIVINGNESS' //

This benchmark focuses on the representation of 'livingness' on web-based platforms. The objective analyses structurally looked at online 'livingness' by the elements that are discussed in conclusion of chapter 2 'Bio Designed textiles made from living organisms'. These elements are; Living Aesthetics, Mutualistic care, Habilities, Preconceptions and the place in biobased design. Since in chapter 3 'consumer' is concluded that there is need for transparantie and honesty this analysis states that a platform should intend to communicate all elements in order to be complete, transparent and honest. This will finally lead to a better understanding and thereby a higher appreciation.

LIVING AESTHETICS

Living Aesthetics translate how 'livingness' comes to expression and thereby creates a certain understanding of the artefact. Often 'livingness' is shown as the representation of growth and change over time. Platforms most often use videos to demonstrate growth over time. Growth is often shown in a more 'imaginative nature', displaying mushroom growth instead of mycelium growth. Images can show growth if patterns in the product stimulate the imagination. Realistic animations can create a surrealistic yet fairytale feeling around livingness, growth can be represented by animation in a more clean manner if real life videos

would not look appealing. Internal change is often explained in textual content and not visualized, this is a missed opportunity because digital platforms provide the opportunity to translate this change in different sensorial triggers. For example, photosynthesis can be presented by a breathing sound; this is done by the project Biogarmentry of Roya Aghihi. Yet this presentation of invisible elements lacks attention on various platforms. Change of aesthetics always happens over time, therefore duration is an element that could be used to represent 'livingness'. Realistic videos and video animations are used to show changes over time. Next to that illustrations/drawings/ scenario sketches show the lifecycle of the product. Hereby the actual time is never demonstrated and therefore time is always communicated as a rather vague concept.

MUTUALISTIC CARE

The interaction between a product and the consumer is shown in images and textual explanation. An opportunity to make this more visible is to use interactive web tools to envision this interaction even more. Next to this mutualistic care means showing benefits for the consumer and the product, this can be stretched more in the online world. Since the relation between a product and a 'living' artefact differs from the current consumers relationship, attention should be paid to informing the consumer in positive ways about this relationship. Representing those benefits can also be beneficial for the company.

HABILITIES

The survival of living organisms is not only reliable on the consumers care. Today's society aims to unburden people through products and services. Therefore usp's could be that a product is easy to use and requires less care/time investment. For example if we look at the start-up LOOPTM , they biofabricate coffins by stimulating fungi growth. When they sell their coffins to the user, they don't point out that this fungus is actually still alive. Yet when the coffin is buried fungi will help dissolve the body in order to close the loop. Funeral rituals ensure that the fungi come into contact with nature again. External factors needed are that the consumer provides the fungi with the right environment in order for this process to take place. In this process the consumer does not have to take

care of the product as if it is alive, but the product should be provided with the right habilities in order to function. When products are sold they want to provide an ease of use for the consumer, therefore habilites are not often noted. They are sometimes slightly explained in images or text but the influence of them is often not shown.

PRECONCEPTIONS

A tool trend of surrealism can be used to overcome preconception of unhealthy vision in living organisms. Addressing preconceptions can help overcome pre-conceptions about 'livingness' in product design.

SOCIAL DIMENSIONS //

This benchmark focuses on the representation of social dimension on web-based platforms. In this analysis examples from biofabrication, bio-assembled or 'living' materials are used. But next to this example from other industries are used to broaden knowledge. This benchmark is structured according to the findings in chapter 3.3.3 'The effect of social dimensions'. It uses the 3 social dimensions; social value, social presence and social impact as a base to review web-based platforms. In this chapter the conclusion of these benchmarks will be explained recording the 3 different social dimensions.

SOCIAL VALUE

Social value can often be found in the ability to contact the designer of a website/product. The feeling of support stimulates people to believe in something even though they don't have to interact eventually. The knowledge that people are able to buy products and others have that ability as well, creates a feeling of security if the product is positively achieved. Social value is often based on a private relationship with most often the company.

SOCIAL PRESENCE

Social media is one of the best examples for online social presence. Social media atmospherics are created to stimulate interaction among people. Interactions on these kinds of platforms often

take place by liking, reacting and reposting. If other people in your surrounding post pictures it will stimulate you to contribute as well. Clearly this is not a one- way process, these technologies have changed us. They have given us potential for communication and interaction that we did not previously possess. Social media goes beyond private messaging, it broadens to scale to group interactions (Miller et al., 2016). Therefore social presence makes it easier to spread information in bigger groups, and thereby gain more information from this group. Social presence can thereby be seen as a provider of information that can be interpreted by the consumer. Next to that social presence creates social influence. Companies can harness social media influence to help generate brand awareness, sell inventory and increase customer engagement. They can create online appreciation for their products. This appreciation is visible online and thereby it can stimulate others.

SOCIAL IMPACT

This can be shown by telling the story about all partnerships made in order to create impact together. So an overview of a lot of people from different places really helps to create a feeling of size. Furthermore impact is often expressed in terms like CO_2 footprint, amount of cleaned air or the amount of cleaned water. In social media programs impact can be seen in the amount of likes, reactions and views. Next to that impact is often shown by presenting the current situation which needs to be improved. If the current situation is worse for the environment, presenting some other solution can easily be better. Concepts like impact remain often quite vague in first impression. Hereby questions like this arise, is impact only used to create a feeling of appreciation (impress)? Or also to create an honest understanding (informing)? The company BloomTM has incorporated impact storytelling deep into their core. They translate their impact using visuals like icons that represent cleaned air or water. They state that to ensure their numbers are accurate and trustworthy, they have created a Bloom Certification system to track their impact from factory to the consumer. The example 'What we eat' by Laurie Frick in collaboration with Google arts and Culture tracks impact in a different way. This project explores the CO_2 footprint of diets of individuals. Hereby the sources of impact are the final consumers itself, this makes it possible to track impact on microlevel in order to show impact on

macro level. So in order to use impact storytelling to impress and to inform, information of different stages should be consistently collected. Hereby material innovation should stand in contact with brands, and with their final consumers. This means that impact should be considered from the start even when the size is not big enough to create impact yet. Impact should be measured at different levels in order to be honest and trustworthy.

4.5 PARALLEL PERSPECTIVE

Within the food industry levels the demand for good digital communication is also important. The food industry remains one of the most valuable industries in the current economy. Indeed, it is especially in this segment that there is an increasing level of variability in terms of demand, volume, process, manufacturing technology, customer behaviour and supplier attitude. So the food segment is facing peculiar global challenges that can be met with support by information technologies. This chapter compares the food industry to the fashion industry in order to learn from the challenges they faced creating a more sustainable system.

Food and fashion are a fundamental part of everyday life. They are both in contact with our body's. Food in contact with the lips, tongue, stomach and gut; clothes with the skin, eyes, ears and affecting physical movement and posture. They also satisfy other needs, associated with social interaction, and cultural participation (Fletcher & Vittersø, 2018). Furthermore they undergo the same developments in supply management. The food industry has also recently changed from a supply-based approach to a demand-based approach, the so-called "chain reversal", in which the consumers tell producers what to make (Demartini et al., 2018). A better communication between producers and consumers could overcome gaps and thereby overcome innovation failures. The food industry is almost totally based on organic content, for clothing, organic fibers make up 27% of the global fiber supply (Simpson, 2016). Just as the fashion industry, the food innovations contain 'living organisms'. When looking at an example of the beverage industry 'living' textiles show a lot of similarities with Kombucha. Kombucha is a fermented functional beverage that started as a homemade beverage and grew into a commercial product in the U.S. by the turn of this century (Kim & Adhikari, 2020). After kombucha gained its popularity among consumers, a large number of kombucha companies were established all over the U.S. over a few decades, making finding commercial kombucha products easy even in the local retail stores. As the kombucha industry grew, in 2014 a non-profit organization called Kombucha Brewers International (KBI) was established to help with regulations and legislations related to kombucha. Currently, as of November of 2019, there are 235 companies worldwide that are enrolled as a member of this

organization (Kim & Adhikari, 2020). Consumers are actively looking for alternative beverages to replace soft drinks with healthier options. At this point the food industry differentiates itself from fashion. Food made from 'living organisms' is already perceived as ''good'' and 'healthy' by producers, catering industry and the media. 'living organism' fashion is considered and promoted as 'good' but not as healthy. This might be caused due to the fact that food is eaten and has a more direct effect on human health. Furthermore, eating obliterates food, rendering it invisible. Dressing demands that garments endure and are seen (Fletcher & Vittersø, 2018). Therefore healthy food does not have to look healthy in particular, yet in the fashion industry this becomes even more important. Therefore the fashion industry can be inspired by the online communication of health information regarding the food industry.
The internet is the 4th most important source of health information in Germany. In the future, the internet will gain further importance worldwide, as older people increasingly use it, and more providers offer health information online with a wider variety of accuracy and reliability (Wollmann et al., 2021). A scoping review on the information needs of internet users and their requirements for online health information (Wollmann et al., 2021), presented nice main aspects that can be useful for this project.

55.

AUTHORITY

Authors and editors and creators should be named in order to know who to contact if there are questions. Adding authority will contribute to the reliability of the information.

COMPREHENSION

Text should be well structured and clearly readable. The user should be able to find all information or otherwise it will be perceived as unpresent or lacking.

CURRENCY & EVIDENCE

This concept considers the user's expectation regarding up to date information, and evidence-based information. Health information should be prepared correctly and comprehensively by medically competent writers.

56.

EXCHANGE WITH OTHERS

A large part of the included studies showed that interactivity is very important for the website users. The exchange of experiences with stakeholders or other users is a particular expectation of users.

INDEPENDENCE

From the users point of view advertising should be avoided if possible. Information should be provided from an honest and transparent point of view. Brands often have other strategies behind their communication, namely the upselling of their products in order to sell more. Therefore health information should be provided independently.

PURPOSE

The purpose and target group should be clearly recognizable.

SERVICES

Users appreciate services such as frequently-asked-questions or video tutorials

USER EXPERIENCE

Accessibility is very important for the readers of health information. A fitting web design with appropriate aesthetics is required.

INDEPENDENCE

AUTHORITY
AND
CURRENCY

PURPOSE

EVIDENCE
BASED INFO

57.

USER
EXPERIENCE

EXCHANGE
WITH OTHERS
/ SERVICE

www.Biogarmentry.com/http

Figure 16

PARALEL PERSPECTIVE KOMBUCHA

4.6 KEY INSIGHTS

Websites presenting products, made from materials that contain living organisms, focus more on informing than interacting. Yet today's society provides a lot of tools that not only inform but also interact. This chapter has shown a lot of diversity in digital tools, and what we can see as digital tools. Due to this analysis it can be confirmed that the currently used tools remain inadequate in capturing and communicating innovative materials like 'living textiles'. With this information available, some statements are made on how 'livingness' can be captured online.

Transparency is key;

As mentioned in chapter 1 project description and in chapter 3 the consumer also in digital trends, transparency about information remains a key element in communication. Show your doubts, show your weakness, show your strengths and opportunities.

Complementary personalization;

Next to social environments, personalization is used to especially create more likeliness around products. Therefore it must be noted that even when the consumer is positioned in an online social environment, this should not rule out personalization. The consumer should be considered an individual and as part of a group.

Social dimensions a tool on its own;

In the chapter 3 'consumer' social dimensions are described as different levels/approaches to social involvement. Social dimensions are able to create a better understanding and appreciation of the things around us. In this chapter social tools are more described as social actions, yet these social actions create the same output as social dimensions aim to do. Social dimensions can create a more extensive story that can be shared and reviewed to aim to create a better understanding and appreciation as well. Therefore this report sees social dimensions as a tool on its own. Social dimensions as a tool are not necessarily actions that have to be performed, but they can be complemented by actions. The social dimension tool' aims to use social elements as a storytelling tool. To finally and realistically show us social dimension storytelling data has to be gathered through research, or social tools in order to spread honest information.

Social interaction can be supported by data;

The food industry aims to face global challenges with the support of information technology. Social interaction creates data and thereby information. Currently consumers understand that their data is valuable, therefore honest and effective ways should be found to let the consumer contribute in gathering their data. When this goal is reached, data can be used to track the product and the overall impact of all products together. Keeping track of the product's life cycle can be supported by the use of digital triggers, like QR codes combined with the willingness of consumers to share data of their product and how they use it.

SOCIAL TOOL ON ITS OWN

Video 2.0;

Videos are not the newest and most innovative tools on earth. Yet short videos are considered as most valuable when introducing new products. Therefore this report considers videos as innovative since they are able to be 3 dimensional or even surrealistic. Videos are able to imagine or to be real. They can be passive and interactive. Video 2.0 is the communication tool that is being explored in this report.

'Livingness' in fashion is healthy;

In chapter 2 biodesign it was noticed that preconception about materials made from 'living organisms' exist. They can be considered as unhealthy or filthy. The food industry is an industry that constantly deals with living organisms as a product, yet in this industry it is logically more accepted. Within this industry there is also a big need to communicate healthiness, because we are what we eat right? We also are what we wear! Do our clothes need to be healthy? Yes! We can learn from the food industry and incorporate; currency, authority, evidence, comprehension, exchange with others, independence, purpose and service into our story.
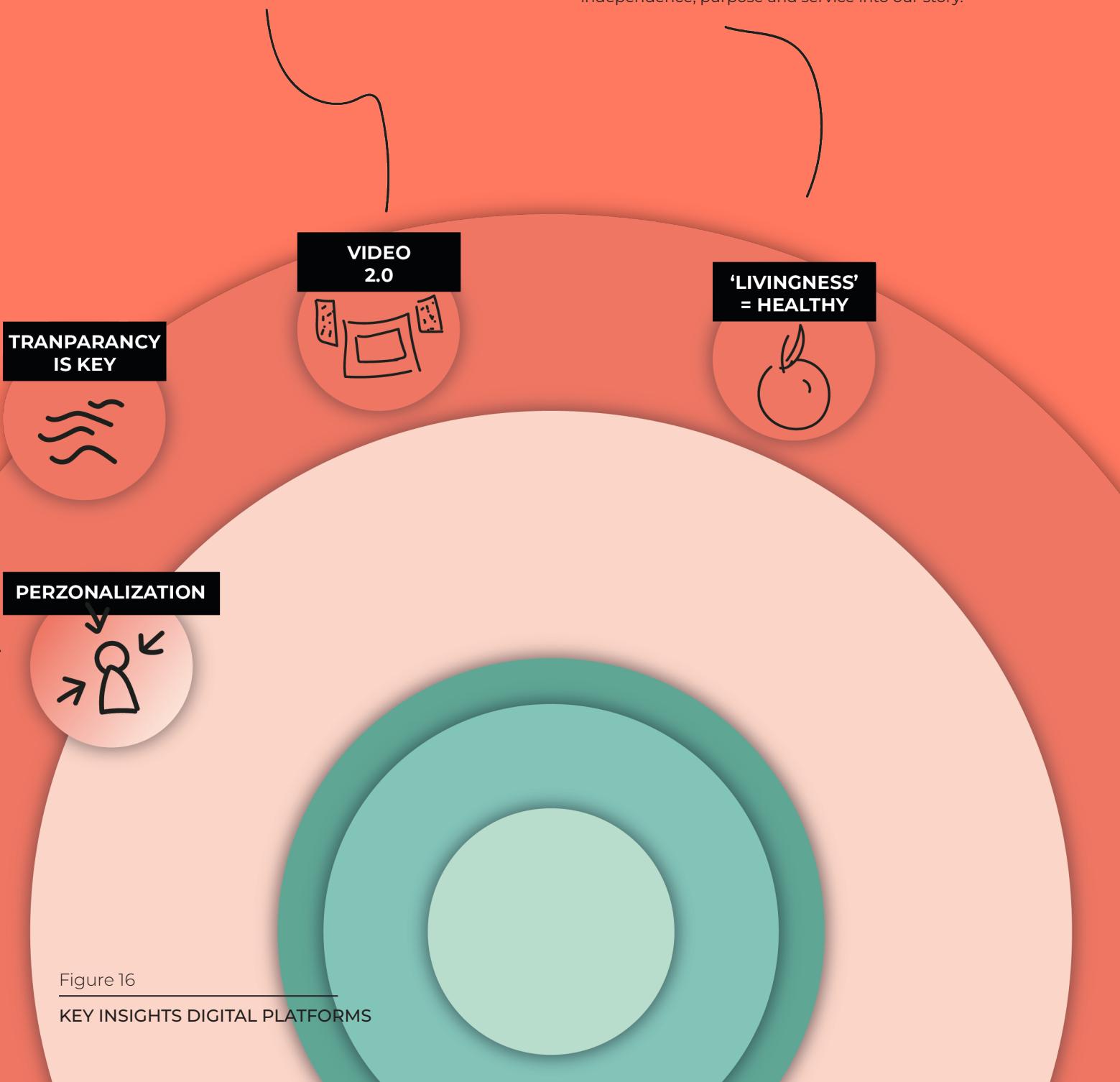
VIDEO 2.0

'LIVINGNESS' = HEALTHY

TRANPARANCY IS KEY

PERZONALIZATION

Figure 16

KEY INSIGHTS DIGITAL PLATFORMS

MATERIAL EXPERIENCE

In order to decrease the gap between material research into 'living' textiles and adoption of them, digital storytelling should be used to create a better understanding and a more positive appreciation. This project uses social dimension to complement the story of 'livingness' in material design. **Social presence** can show diversity within textiles made from living organisms, which will improve the understanding of the livingness aspect. **Social impact** storytelling can enhance the appreciation of consumers regarding livingness within textiles.

VISION 05

61.

Figure 17

COLLAGE MATERIAL EXPERIENCE VISION

BIOGARMENTRY   06

6.1 MICRO-ALGAE

In order to test the material experience vision this project investigates a particular example of a 'living' textile that is currently being researched. From this point on this project will focus on the project Biogarmentry, initiated by Roya Aghighi, which aims to create a biofabricated textile consisting of microalgae. This concept aims to extend 'livingness' into the use phase, by creating a fabric that is capable of photosynthesis. This project is highly suitable to use as a case study in this project due to its remarkable use of 'livingness' as a material property. Furthermore there is still a huge gap to fill between research and consumer adoption since the project is currently being researched. This chapter explains more about the living organism that biogarmentry contains namely, micro algae. Where do they live? What do they need to grow? Next to that it explains how Biogarmentry envisions to integrate micro algae into textiles. Addressing the question; What makes micro algae such an interesting resource for the fashion industry? At the end will be concluded which key insight should be considered when biogarmentry must be communicated digitally to the consumers taking social dimensions into account.

Microalgae are either prokaryotic or eukaryotic microorganisms growing through photosynthesis. Microalgae have a simple cell structure and their growth requires light, carbon dioxide, water, and nutrients (phosphorus and nitrogen as major nutrients). Photosynthetically, microalgae can convert those necessities into energy and use that in cell development (Zullaikah, 2019). They are inhabiting a highly diverse range of habitats from sea ice, sea waters, snow, inland waters to soil. Microalgae are of vital importance to the Earth's ecosystem. They produce nearly half of the atmospheric oxygen together with cyanobacteria through photosynthesis and, therefore, are an important component of the global carbon cycle by sequestering the atmospheric and water dissolved carbon dioxide (Lehmuskero et al.,, 2018). Microalgae are sources of useful biomaterials for biotechnological applications and commercial interests (Milledge, 2011) because of their great flexibility, fast growth rate and adaptability of microalgae to grow in diverse environments ((Zullaikah, 2019). Microalgae are interesting organisms because of their ability to produce a wide range of compounds, such as carotenoids, lipids, hydrogen , protein , and starch. Microalgae are ecologically important as a major primary productivity driver via photosynthetic carbon fixation. As the primary producers and food sources for higher trophic organisms, microalgae can play a crucial role in maintaining a fundamental ecosystem (Yong et al., 2016).

Microalgal growth is highly dependent on the environmental conditions. Factors such as temperature, pH, carbon dioxide, UV radiation, light and nutrient availability can adversely affect characteristics like; the growth, physiology, photosynthetic rate, metabolic rate and biochemical composition of the microalgae (Yong et al., 2016). Carbon dioxide is a carbon source of microalgae cell development. The temperature and pH of the growing culture are maintained in appropriate conditions to support

microbial growth (Zullaikah, 2019). Temperature is a key environmental factor that strongly regulates the growth of photosynthetic organisms. Higher temperature in the environment impairs photosynthetic rate and fluidity of the thylakoid membrane, lowers biomass production and alters biochemical profiles of microalgae (Yong et al., 2016). When algae are light-saturated, temperature impacts the maximum rate at which the dark reactions of photosynthesis can occur and with it, the threshold for light saturation (Bénchet et al., 2013).

The pH is an environmental condition in microalgae cultivation since it determines the solubility and availability of CO_2 and nutrients, and has a significant influence on microalgal metabolism. The pH of microalgal cultures rises gradually during the day due to the uptake of inorganic carbon by microalgae. Each microalgal species has an optimal pH range for biomass and lipid production. Higher pH limits the availability of CO_2, thus, inhibiting cell growth. On the other hand, algae cultivation at high pH can suppress undesired biological contaminants (Qui et al., 2017). Light provides energy for photosynthesis and microbial growth. Light becomes partially polarized and loses intensity mostly at the red, yellow, and purple wavelengths when propagating in water. When light reaches a microalgae cell after having travelled through the medium, the absorption efficiency of the cell together with the spectrum of the incident light field determine the available amount of light for photosynthesis. Absorbed electromagnetic light energy is then transformed into biochemical energy through photosynthesis, and used for cell respiration, growth and other metabolic processes (Lehmuskero et al.,, 2018). The major nutrients needed are phosphorus and nitrogen; however, utilization of inorganic nutrient sources can cause pollution in water. Therefore, applying wastewater in microalgae cultivation is an alternative because it usually contains phosphorus and nitrogen nutrients (Zullaikah,

2019). The function of phosphorus in plants is very important. It helps a plant convert other nutrients into usable building blocks with which to grow.

6.2 MICRO-ALGAE AND FASHION

6.3 IDEALOGY

Within the fashion industry micro-algae are being used or envisioned to be used in a diverse way. The first field of application is to create new novel textile materials. The company Vollebak made a t-shirt in collaboration with Blond & BieberTM from pulped eucalyptus and beech from sustainably managed forests and algae grown in bioreactors which is biodegradable. Furthermore, New York designer Charlotte McCurdy has created a raincoat from a plastic made of algae (Hahn, 2019). The second field of application is the part textile dyes, here Berlin design studio Blond and Bieber uses algae to create colourful dyes for textile printing. The prints change color when exposed to sunlight creating bright and dynamic colours (Howarth, 2017). Lastly, an example that integrates micro-algae into textiles is Biogarmentry. Biogarmentry represents a conceptual project of integration of micro-algae into textiles and keeping them alive. The ideology of this concept will further be explained in the next chapter.

Unlike Mylo and Brewed Protein, Biogarmentry is a material that is still being researched by a small but growing group of innovators. The initiator of this project is Roya Aghighi a Canadian-Iranian designer who made a proof of concept for a biofabricated textile consisting of microalgae (living organisms) that are capable of photosynthesis (Block, 2019). Photosynthesis is a biological process whereby the energy of the sun is captured, and stored. This light energy combined with carbon-dioxide is turned into oxygen.

1. The process of photosynthesis provides an additional function to garments for consumers, such as improving the environment close to the wearer. Alongside that, when a majority of consumers would wear this it could regulate carbon emissions and therefore addresses one of their major environmental concerns namely greenhouse gas emission.

The proof of concept was made in collaboration with a group of researchers from the University of British Colombia (UBC) and Emily Carr University and is still under development by others. The living organisms used to fabricate Biogarmentry is chlamydomonas reinhardtii, a type of single-cell green algae, which are spun together with nano polymers (Block, 2019). The material outcome feels somehow the same as linen or silk depending on the substrate material that is used. The microalgae will cause a color change of the substrate material, by their growth.

2. The aesthetics of the textile are changing over time, creating a unique and diverse appearance for a fashion item.

6.4 HOW FAR ARE WE?

Biogarmentry gives a different dimension to biofabricated materials, where organisms are still alive in the use time of the product. Raising the question what this would mean for the fashion industry and the relationship between consumer and garment (Bruggeman, 2020)?

3.   "The living aspect of the textile will transform users' relationship to their clothing, shifting collective behaviours around our consumption-oriented habits towards forming a sustainable future." Roya Aghighi.

CHLAMYDOMONAS REINHERDTII //

The microalgae species that is used to produce Biogarmentry is, chlamydomonas reinhardtii, a type of single-cell green algae, are spun together with nano polymers. This species of algae is nowadays the most thoroughly studied species and therefore serves as a template for other algae (Salomé & Merchant, 2019). This type of algae is a well studied species of the organism due to the fact that they are easy to culture and it is not difficult to manipulate its genetics. Chlamydomonas reinhardtii offer high signal-to-noise during experiments due to the ease of growth in controlled medium and environments (temperature and light regimes) and the homogenous nature of the cultures, and they grow much more rapidly than classic plant models (Salomé & Merchant, 2019).

The concept Biogarmentry is currently being further explored by one of the researchers from our research team. One of the aims of this material research is to extend the products algae's lifetime during the usefase of the product. Innovations that can contribute to this are for example the change of the substrate material. Currently the material is made of a mix from cotton and micro-algae, researchers as Hazal Ertürkan are looking into materials that can provide micro-algae with the right nutrients in order to grow. Currently the textile is expected to live for around a month, after this month there will be a reduction in growth. The color will change according to the growth of the micro-algae. The change of color during its life is shown in figure 18. First of all the microalgae will have to be activated with water in order to stimulate growth. When activated the first light green color will show after 3 days. From that moment the color will start to get even more green up to 7 days of its life. After 1 month the microalgae will provide a dark green color to the fabric. Next the amount of living micro-algae will start to decrease resulting in a yellow color after 2 months and returning back to white after 3 month, hence closing the loop.

6.5 KEY INSIGHTS

It can be concluded that Biogarmentry is still in an early phase of the design process, therefore consumer/users insights are of big importance. On the one hand to create a better understanding & appreciation for the use of 'livingness' within textiles. On the other hand to gain insights to improve the material in order to develop a better understanding and appreciation in further phases. Therefore it remains important to communicate this innovation even in early stages. This project considers the following elements of the concept as important.

'Livingness' can be found in photosynthesis and color change;

These two properties specifically represent the living aesthetics of Biogarmentry. This means that livingness can not be presented only by visually presenting the material outcome. This project will discover how the social dimensions; social presence and social impact can contribute to representing external and internal 'livingness' of Biogarmentry.

Factors of influence, factors to influence;

'livingness' micro-algae is dependent on a diverse set of factors like; Light, nutrients, water, C02, temperature and PH values. Some of these factors can be taken into account in the use phase by the caring relationship with the consumer, for example providing light is a factor that can be influenced. On the other hand some of the factors are harder to influence in daily life, like PH values and temperature. This relates back to the concept of 'livingness' in the first second chapter, where habilities is divided from mutallistic care. In the storytelling this should be made clear to the consumer.

Impact by photosynthesis;

Microalgae are of vital importance to the Earth's ecosystem. They are responsible for nearly half of the atmospheric oxygen together with cyanobacteria through photosynthesis.

Diversity through color change;

Can we turn this changabitly into something further than growth alone? Can we take the concept of diversity of color back to expression of yourself due to clothes, and in this case due to caring for clothes?
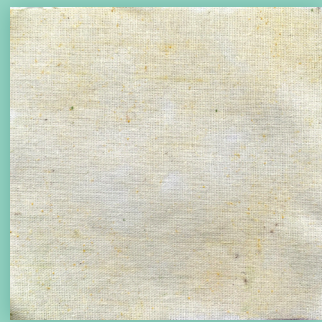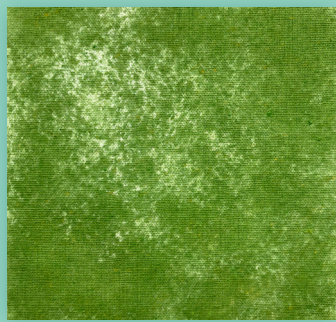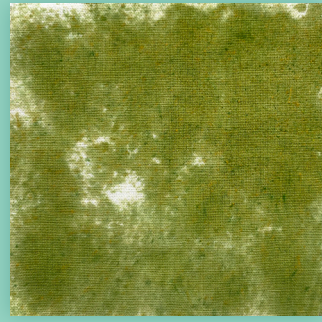
Figure 18

REMAKES BIOGARMENTRY BY HAZAL

DIGITAL PROTOTYPES 07

7.1 INTRODUCTION

Within this research we are looking for ways to communicate livingness within web-based platforms. Therefore we are going to investigate if social factors positively influence the understanding, appreciation and engagement with livingness. Prototypes can be used to envision possible user experiences containing social dimension in storytelling. As discussed with the research team a study will be based on 3 prototypes that aim to generate information about the effect of a social dimension on the communication of 'livingness'. The study focuses on 'livingness' in textiles and therefore takes Biogarmentry as an example. In the following chapters will be explained how the prototypes came into existence, and going into depth about the meaning of each prototype. The first prototype will create a rich story that will include all elements needed for a clear communication of 'livingness' based on this report's findings. This prototype will be used to create a control group. The second prototype will envision the concept of social presence in order to aim for a clearer communication of the 'livingness'. Lastly the third prototypes use social impact in order increase the satisfaction around 'livingness'. The result includes 3 short movie prototypes that are as stimuli in this project. The audio file for the videos can be found in this link; [AUDIOFILE]

7.2 PROCESS

The process towards creating all the prototypes in order for them to be suited for a study has been preceded by a long development process. Along the way collages were used in order to communicate the storyline in the research team. This was necessary to get everybody on the same page, and to improve the story in terms of realisticness, professionality and purpose. Parts of the collages used can be found via this link; [TEST MOVIE SCRIPT]. During the discussion with the research team a couple of decisions have been made. The video will not contain an introduction about the purpose of the material in relation to sustainable problems in the fashion industry, this is extra information, and does not complement the living aspect and is therefore seen as not relevant. Furthermore instead of creating 3 different versions of a digital platform the choice has been made to emphasize the social dimensions by the use of videos. This saves time, and the variables become more controllable. The video can have a maximum length of 5 minutes since the participants attention should not get lost. Furthermore all videos should be around the same length otherwise this influences the results. In all videos the participant is told to imagine that he/she or it bought the t-shirt already, this is done so participants can emphasize the role of future consumers. It creates a sense of ownership and relation with the material.

7.3 PHYSICAL PROTOTYPES

In order to create the movies, a clear visual image should be created of the material itself. This chapter will explain how the material is visualized and what choices are made.

The expression of the material is based on the samples that are provided by a study of Hazal Ertukan, which are shown in chapter 6 Biogarmentry. Since consumers most often buy fabrics when they're designed as a use-product, the movie envisions creating products suited for the future consumer. The products that are chosen for the design are a t-shirt and a curtain. The two products differ from each other in terms of how close the material is to your skin, furthermore they differ in size, where the curtain obviously needs more material. First physical prototypes are made of these use products, 7 all white versions of each product are needed. Thereafter all products are painted in different states of its life cycle. In this way the movie shots of each part of the life cycle could be taken at all times. The prototypes are painted, by using all kinds of paint and textile, water etc. in order to create a realistically living look. Thereafter these physical prototypes are photographed into different scenarios, in order to create the whole intended storyline which is explained in the next chapter.

7.4 THE BASE OF THE STORY

Prototype 1 will have a rich storyline about Biogarmentry only focussing on the individual relationship between the artefact and the consumer. In this storyline social dimensions are completely left out and therefore this prototype can be seen as the control group. Prototype 2 and 3 will contain the whole short video of prototype 1 as well. The short movie of the prototype can be found via this youtube link; PROTOTYPE 1 T-SHIRT. and PROTOTYPE 1 CURTAIN.

Figure 19

COLLAGE EXAMPLE CONTROL GROUP STORYTELLING

1 *package describes the item and its properties (cotten, textile, alive etc.)*

AUDIO ; Imagine you bought a new t-shirt that shows a lot of similarities with the cotton t-shirts you already possess.

2 *package describes the item and its properties (cotten, textile, alive etc.)*

AUDIO ; However, it is distinct in that it is made from a textile that contains living micro-algae.

3 *Show t-shirt that is not activated and is totally white.*

AUDIO ; When you unpack the t-shirt you notice it is white.

4 *Show activation of micro-algea*

AUDIO ; You can activate your t-shirt by spraying a small amount of water, as this action will trigger the growth of the microalgae.

5   *Show color change due to activation*

AUDIO ; This growth is made visible by the colour change on your t-shirt over time.

6   *KEY WORD BREAK*

AUDIO ; This t-shirt has a designed life cycle.

7   *Show timeline graph that explains the life time of the artefact.*

AUDIO ; Your t-shirt is expected to live for approximately 3 months , which equals 91 days.
This graph shows its life cycle and how the color will change over 91 days.

8   Explaination cleaning air in the graph.

AUDIO ; In its life cycle, if your t-shirt is provided with the right conditions it is able to perform photosynthesis and therefore it becomes capable of cleaning the air in its surroundings as shown in this graph.

9   *KEY WORD BREAK*

AUDIO ; Wearing clothing made of textiles that contain microalgae is somewhat unique, as the colors can change and fade when exposed to certain factors.

11   *show t-shirt in clean room*

AUDIO ; The optimal growth temperature for microalgae can vary between 33 - 17 celsius.

10   Showing temprature of 33 degrees + show color change.

AUDIO ; Temperature can differ depending on the environment we live in.

12   up to a temprature of 17 degrees

**AUDIO ;** Outside of this temperature range the growth will slow down.

5

move screen towards a window

AUDIO ; Sunlight provides the energy needed for the photosynthetic process to take place. In this process CO2 and water are converted into oxygen.

6

Hang the shirt near to the window.

AUDIO ; The t-shirt can be exposed to sunlight in multiple ways: for instance by wearing your t-shirt during a walk outside.
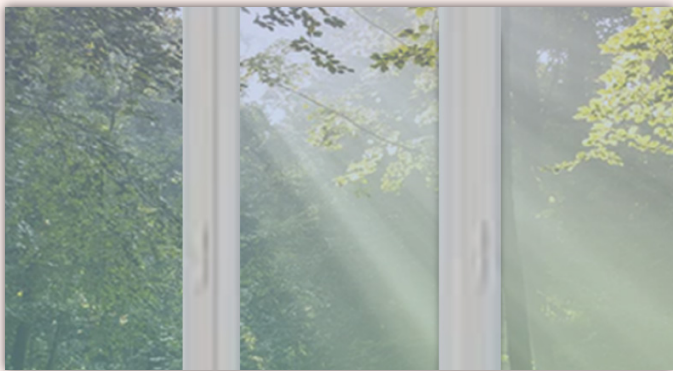
7

Brighten sunlight in window

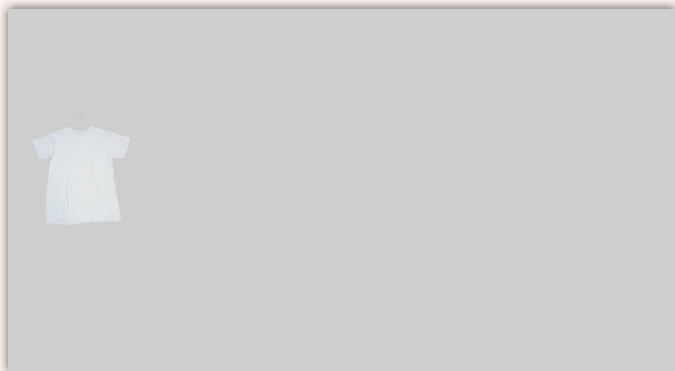**AUDIO ;** Or by leaving the t-shirt in direct contact with the sunlight that comes through your window.

8

move back towards inside the room

AUDIO ; Micro-algae in the t-shirt need water to grow.

9 Spray more water, equilly distributed around the fabric.

AUDIO ; Being exposed to water everyday will help create a bright color to your t-shirt due to the wellbeing of microalgae. This can be done by spraying water on your t-shirt or

11 Take the t-shirt to the door --> see t-shirt in humid enviroment.

AUDIO ; ... by leaving the t-shirt in humid environments, like the bathroom.

10 *Show the start of life again, with a complete white shirt.*

AUDIO ; ....

12 *The activated light green shirt.*

AUDIO ; They influence the t-shirt's function hence its ability to clean the air in your room.

9 *Brightest color green.*

AUDIO ; They influence the t-shirt's 'appearance'

11 *Start showing the end of life. by a color change to almost brown-green.*

AUDIO ; They determine its life cycle by influencing the amount of reproduction and growth of the microalgae on the textile.

10 Color change towards yellowish.

AUDIO ; Your t-shirt gets a brown green tint after 1 month, a yellow color after 2 months,

12 Color change to almost white

AUDIO ; and returns to off-white after 3 months, and hence closing the loop!

7.5 SOCIAL PRESENCE STORYTELLING

The main aim is to explore the impact of showing diversity within a small community. Showing diversity can be achieved by showcasing other use cases of Biogarmentry. Hereby the community feeling will be enhanced and social presence will be achieved. This prototype aims to investigate how social presence and influence influences the understanding and appreciation and engagement of livingness in a web-based communication platform for Biogarmentry. Secondarily the aspect is the impact of involving a community aspect to show diversification on the length of the life cycle of the living organism. Furthermore it investigates if social presence creates social influence in order to get a higher appreciation. The full short video can be found via this link [PROTOTYPE 2 T-SHIRT] and [PROTOTYPE 2 CURTAIN].

Figure 20

COLLAGE SOCIAL PRESENCE STORYTELLING
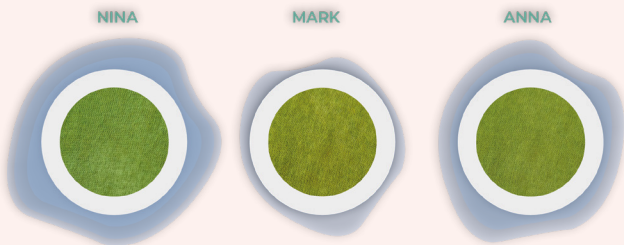
9 *Nina, Mark and Anna bought a t-shirt each made of living textile.*

AUDIO ; The 3 t-shirts look different after they are used for one month.

11 Social presence introducing Nina and her t-shirt.

AUDIO ; I placed my t-shirt next to my window and sprayed it every day with a very small amount of water. Having the t-shirt hanging next to the window, I managed to expose it to constant sunlight.

10 Social presence introducing Anna and her t-shirt.

AUDIO ; I often hang my shirt in the bathroom. In this way it becomes really easy to provide water to the t-shirt.

12 Social presence introducing Mark and her t-shirt.

AUDIO ; I wore this t-shirt once a week usually when I met with my friends in the park. At home, I keep it in my closet.

7.6 SOCIAL IMPACT STORYTELLING

Social influence is defined as the change in an individual's thoughts, feelings, communication or behavior resulting from the thoughts, feelings, communication, or behavior of one or more other people (Kim. et al, 2015). With social impact storytelling is shown how the eventual behaviour of a whole community can benefit the people again. The full short movies can be found via these links; [PROTOTYPE 3 T-SHIRT] and [PROTOTYPE 3 CURTAIN].
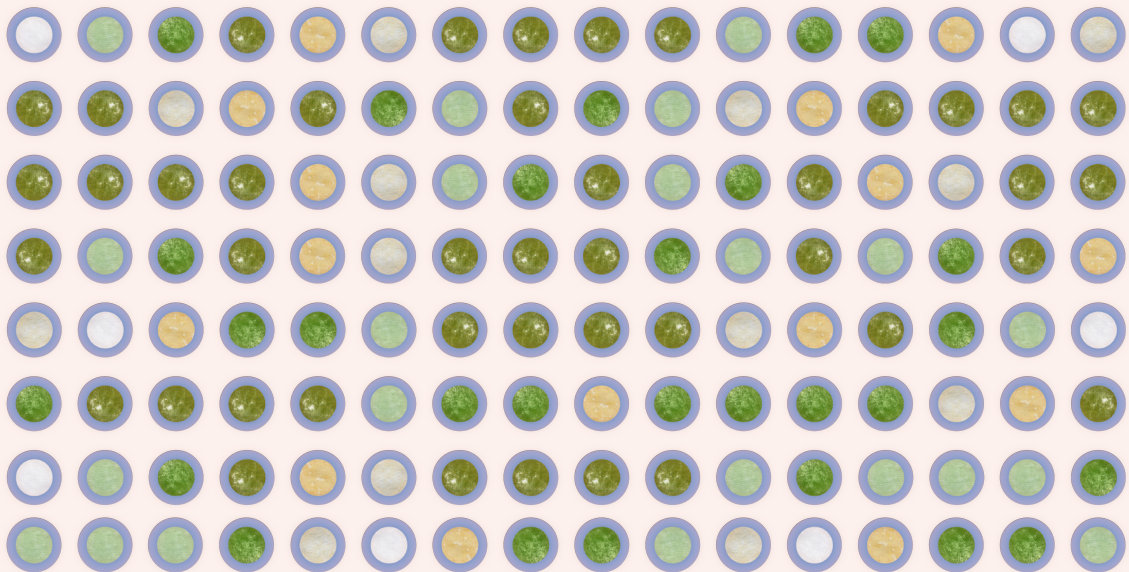

Figure 21

COLLAGE SOCIAL IMPACT STORYTELLING

CASE STUDY   08

8.1 INTRODUCTION

The object of this research is to delve into the knowledge of digital narratives for textiles made from or containing living organisms. The concept of the use of living organisms within textiles is relatively new and will change the consumer relationship with textiles. In order to fill the gap between material research and consumer adoption, digital narratives can be used to feed imagination about a future with 'living' materials. Hereby social influence matters because it affects what we think (appreciate and understand) and do (buy and consume). Social influence can be seen as the "who" behind consumer behavior and sustainability (Goldsmith, 2015). Social influence can be divided into four categories describing different social dimensions (Goldsmith, 2015):

1. Observation of other people present in your environment. We observe how others behave such as what they eat, what they wear. (social presence).

2. Formal, from authoritative sources or as a result of advice seeking. (authorized sources).

3. Information from word of mouth, caught conversations, and informal listening (personal sources).

4. Social groups such as membership in clubs, families, organizations, networks, institutions, and workplaces with coupled rewards. In this way your not acting as an individual but as a group (social belonging, social impact)

These social dimensions are in line with the social dimensions diagram created in chapter 3.2.3 the effect of social dimensions. In this chapter a framework of 3 social dimensions is defined that will be used as the base of a quantitative study,

which are; social value, social presence and social impact. Social value can be seen as the individual experience of, in this case, the living textiles. This can be seen as the most traditional way of communication, when an innovator meets the individual from his/her perspective. Secondly,

social presence can create warm and personal atmospheres so individuals can learn from each other's perspectives. Lastly the concept of social impact lets the individual achieve a feeling of community by creating benefits that can be achieved together. These configured means are used throughout this study in order to find the answer to the main question; How can social dimensions contribute to a digital platform to improve the appreciation and understanding of 'living' textiles?

In previous chapters engagement is mentioned as a factor used next to understanding and appreciation. This is a different variable to measure consumers point of view which is especially used since the digital revolution. Nevertheless this case study will focus only on appreciation and understanding in the digital environment since engagement depends on an extensive amount of constructs which include endurability, perceived usefulness, focus attention, felt involvement, aesthetics and novelty (Masrek & Samadi, 2017). A separate study is therefore needed to professionally analyse engagement. Concluding that this study does not take user engagement into account within the questionnaire.

In the figure 22 you can find a short overview of the envisioned hypotheses of the study. As you can see two hypotheses are visualized and next to that a definition of the control group. The different hypotheses are indicated by H1 (social impact), H2 (social impact).
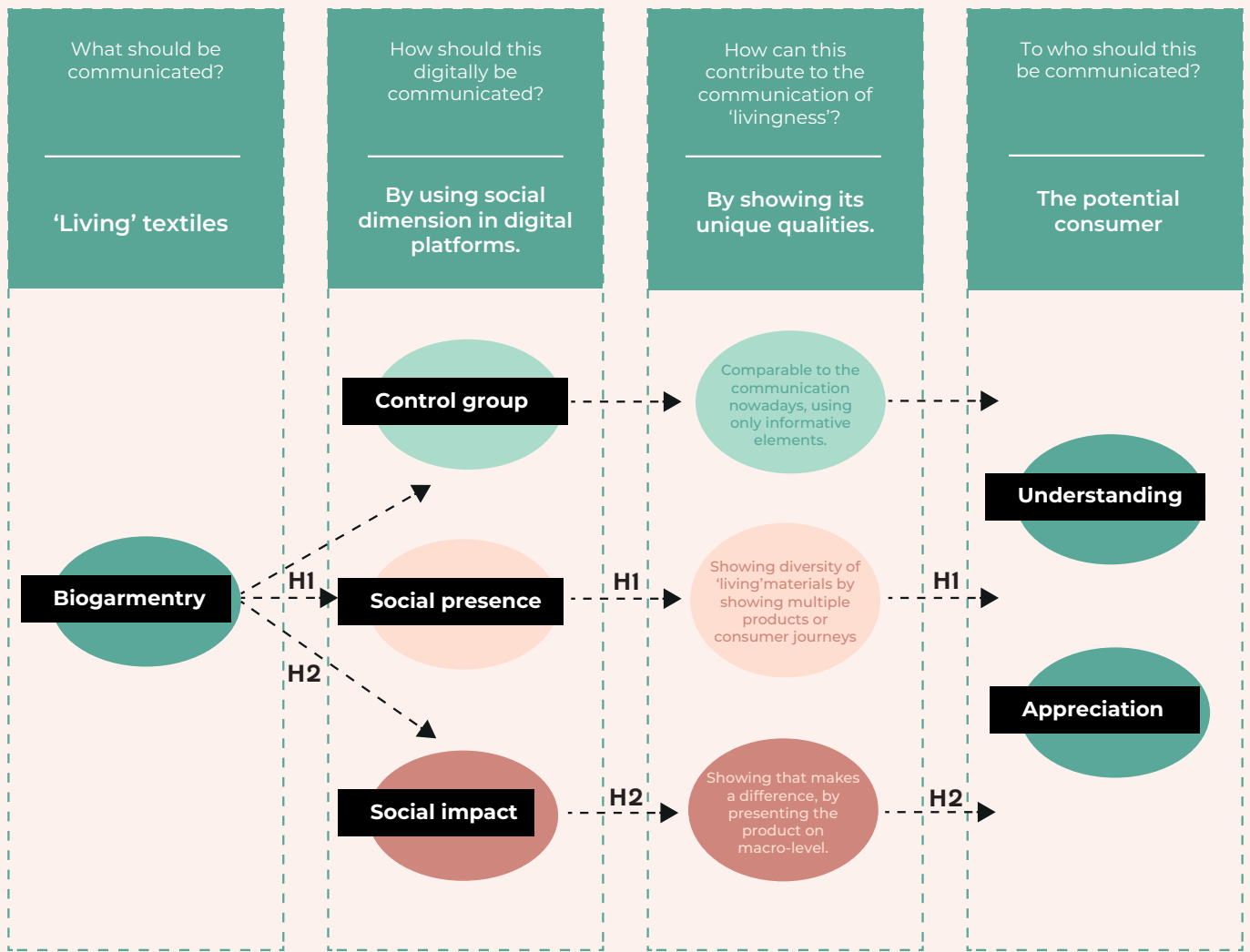
Figure 22

FRAMEWORK QUALITATIVE STUDY

CONTROL GROUP //

Conventional tools used for digital storytelling on a digital platform are not able to communicate 'livingness' within textiles in a proper manner (D'Olivo & Karana, n.d.). Therefore the consumer will not be able to understand, appreciate the unique qualities of 'livingness' on a digital platform when storytelling focuses on the consumer as an individual only. Nowadays digital platforms are often only focussing on informing instead of interacting with the consumer. Creating a one-way relationship between the innovator and the consumer. The digital communication used in the control group will be based on this relationship meaning that 'livingness' is emphasized in the prototype by informative elements that address all aspects; living aesthetics, mutualistic care and habitabilities (Karana et al ., 2020). The storyline of the prototype can be found in chapter 7 The prototype.

GROUP H1 (SOCIAL PRESENCE) //

Consumers are able to understand, appreciate the unique qualities of 'livingness' better by showing diversity within products by using social presence in digital storytelling. Social presence has been conceptualized as the sense of human warmth, sociability, and human contact that can be conveyed through a digital platform (Friedrich. et al, 2019). By showing other product owners your story? will rise above the one-way communication which we are used to; it will create several relations that are not only between the innovator and the consumer but also among consumers. This creates the possibility to show a variety in products, hereby a better understanding of 'livingness' will be created since no living product will be exactly the same as another, even when it is designed to be. Thereafter social presence can lead to social influence. Social influence is defined as the change in an individual's thoughts, feelings, communication or behavior resulting from the

8.2 METHOD

thoughts, feelings, communication, or behavior of one or more other people (Kim. et al, 2015). When social presence leads to positively influencing the consumers thoughts the appreciation will be positively influenced. The storyline of the prototype can be found in chapter 7 The prototype.

GROUP H2 (SOCIAL IMPACT) //

Consumers are able to understand, appreciate the unique qualities of 'livingness' better by showing diversity within products through adding the social dimensions; social presence & social influence. Social presence has been conceptualized as the sense of human warmth, sociability, and human contact that can be conveyed through a website (Friedrich. et al, 2019). Social influence is defined as the change in an individual's thoughts, feelings, communication or behavior resulting from the thoughts, feelings, communication, or behavior of one or more other people (Kim. et al, 2015).

These hypotheses will be tested by means of a quantitative study in order to develop new digital tools for the communication of 'living' materials. In this chapter the method will be discussed, used for this study. Thereafter will be explained how the data is analyzed in order to give insight in the results at the end.

82.

This study collects and analyzes quantitative data in order to answer the research question. The research will be conducted through an online questionnaire. The method that is used is experimental research whereby one variable (social dimension) is systematically manipulated to see the effect on the outcome variables: understanding and appreciation. Understanding of the materials 'livingness' will be assessed by the factors that construct 'livingness' following the paper written by Elvin Karana which are; living aesthetics, mutualistic care and habitabilities. Appreciation will be examined by questions around topics related to user experience of the material, including topics like; concerns, preconception, attitude and feelings towards the material. User experience questionnaires are a common quantitative measure of user experience (Lazer. et al. 2017). User experience questionnaires are characterized by the fact that they measure the subjective attitude of the user towards the test object. The respondent evaluates statements (items), for example by selecting a suitable category from the value range of a rating scale (Hinderks. et al, 2019).

Since this study analyses the value of social dimensions, the changing social dimension is seen as the focus variable. This makes a quantitative approach suitable since the study has a very specific outline. Furthermore it is a digital project, which makes it easier to reach a certain number of participants that fits with a quantitative study. All 3 hypotheses are tested by different participant groups in order to prevent the study from bioses. This will be explained further in the chapter around participant groups. Furthermore, in this chapter we discuss who the participants are, which sample is used and what stimuli were needed.

SAMPLE //

To recruit participants a national online survey panel is used, this panel is named Prolific (Prolific, 2021). The main reason for choosing this panel is because it ensures that the right participant goals can be achieved. Furthermore it allows you to have an extensive number of participants in a short time. This study established quotas to achieve a sample that included approximately equal proportions of respondents for age.
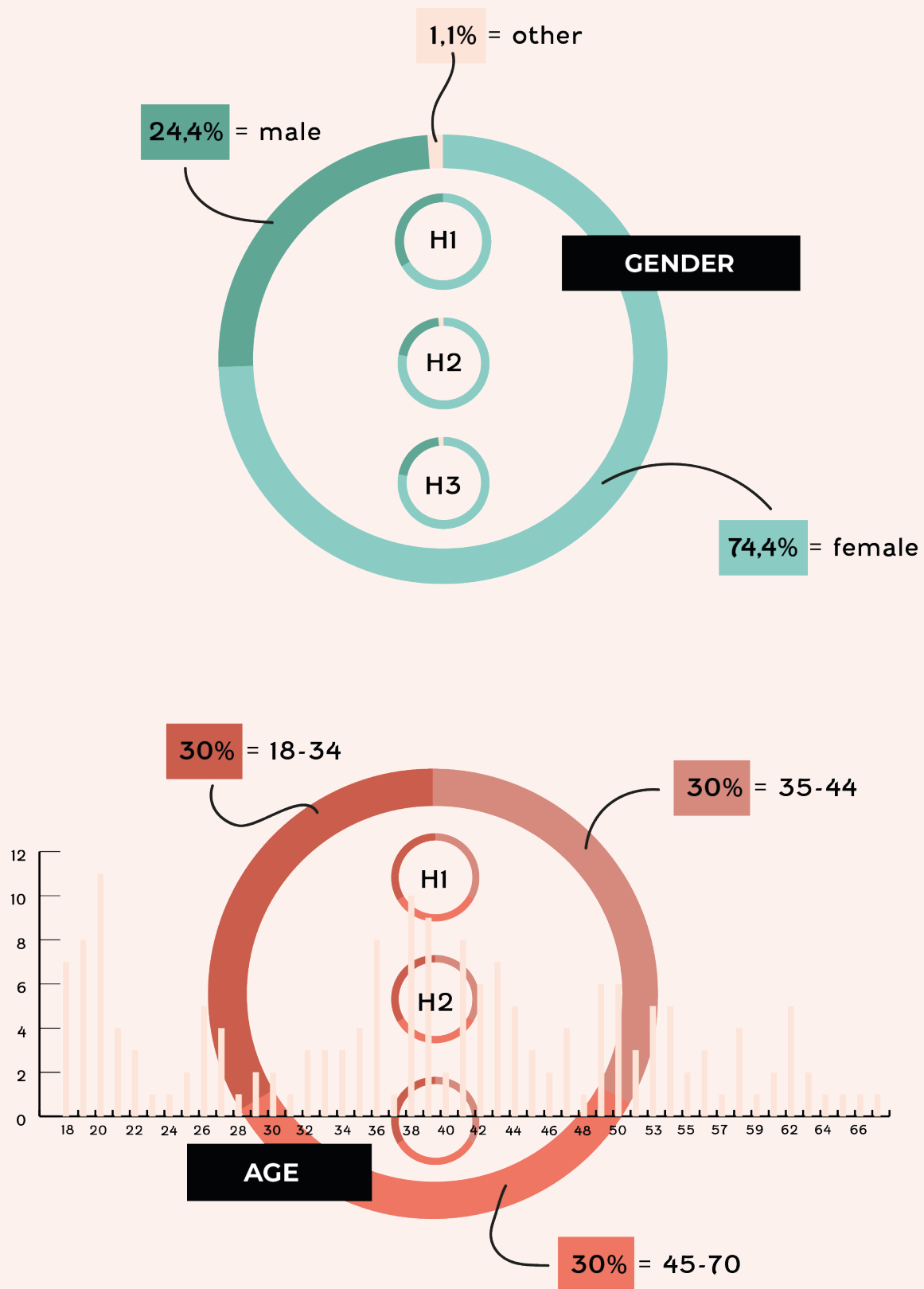
1,1% = other

24,4% = male

H1

GENDER

H2

H3

74,4% = female

30% = 18-34

30% = 35-44

H1

H2

AGE

30% = 45-70

Figure 23

QUALITATIVE STUDY DIVIDE GENDER AND AGE

PARTICIPANTS //

This study has the ambition to establish a participant panel that gives a clear representation of the potential consumers in the UK. In order to do this inclusive criteria are set up regarding gender, age and origin. First of all participants are residents of the United Kingdom (UK), since most of the platform's active participants are from the UK. Besides, the origin of this research was conjointly set up with a researcher from the UK.

Secondly the aim of the research was to present a gender balance of these origins; the gender balance of the participants performing the survey should be around a 50-50 ratio. Approximately the same ratio was counted in the United Kingdom namely 98 men to 100 women (Knoema, 2020). Since nowadays gender is not only based on physical characteristics, participants that identify with a third gender are also included.

Thirdly, the participants will be divided within age groups depending on their generation. The case study focuses on generations; G and Z (9-24 years), Millennials (25-40 years), Gen X (41-59) (Beresford Research, 2020). Following Eurostat data 72% of G and Z (16-24 years) and 66% of Millenials and Gen X (25-59 years) purchased clothing online, a much higher%age than older generations (60+) where 50% made online purchases (Eurostat., 2021). The data platform statistica shows that within the clothing and sportswear e-commerce, 64,3 % of people ages 12-25 years, 73,9% of people aged 25-45 years and 55% of people aged 45-59 years purchases online. Therefore the first two age groups become most important if we look at digital communication for 'living textiles' within the fashion industry (Statista, 2020). By the reason of the platform's allowance of participants only above the age of 18, this is a feature that should be taken into account. Based on this knowledge the final participant groups are divided into three age groups. A majority of the participants will be aged between 18-45 since they make most online purchases. Hence two out of three groups will be aged in this range resulting in one age group consisting of participants 18-34 years old and the second age group containing participants ages 35-44. In addition to these groups the third group will consist of participants aged 44 and above resulting in all age groups being included in the study to clearly see the differences.

Taking time and cost into account the total participant amount is set at 180 participants.

84.

Underneath a total of 400 participants the platform can't ensure all guidelines given. In order to ensure that every prototype version, containing a different social dimension, is seen by different ages, the study is uploaded as three separate studies. The three separate questionnaires use the same questionnaire but only address people from a different age group. 60 participants will be aged from 18-34, 60 participants aged 35-44 and 60 participants older than 45. In figure 23 is shown how the participants that joined this study were divided in terms of gender and age. Furthermore we must avoid that there are large differences in knowledge between participants therefore this case study excludes occupations that engage designers.

RESULTS

In figure 23 you can find the actual participant panel achieved with the final study. This graph shows the distribution regarding gender and age in the overall group, the control group, H1 group and H2 group.

STIMULI //

The stimuli that are used in this study are 6 different versions of a video which aims to communicate 'livingness' of the studies chosen subject, iogarmentry. Currently the use of short videos is most prefered when consumers want to learn about a product (Dave, 2021). Next to that videos can provide digital samples that inform the consumer about the movement and texture of the textiles (Petreca et al., 2014). Currently video viewing times between 2-5 minutes or 6-30 minutes are most popular (Statista, 2021). On top of that statistics say that videos under 5 minutes will generally garner the most user engagement (Comscore, Inc., 2014). To engage the participants optimally the maximum length of the video must be less than 5 minutes.
The used prototypes are the videos which can be seen in chapter 7. The first variable of the videos are the social dimensions. All tree videos consist of the same video that is used in the control group, also known as the personal informative approach. In the second video is added a small part that emphasizes social presence on top of the informative approach. The third video adds a storyline of social impact on top of the video used for the control group. Furthermore chapter 7 shows that imaginative products are used to
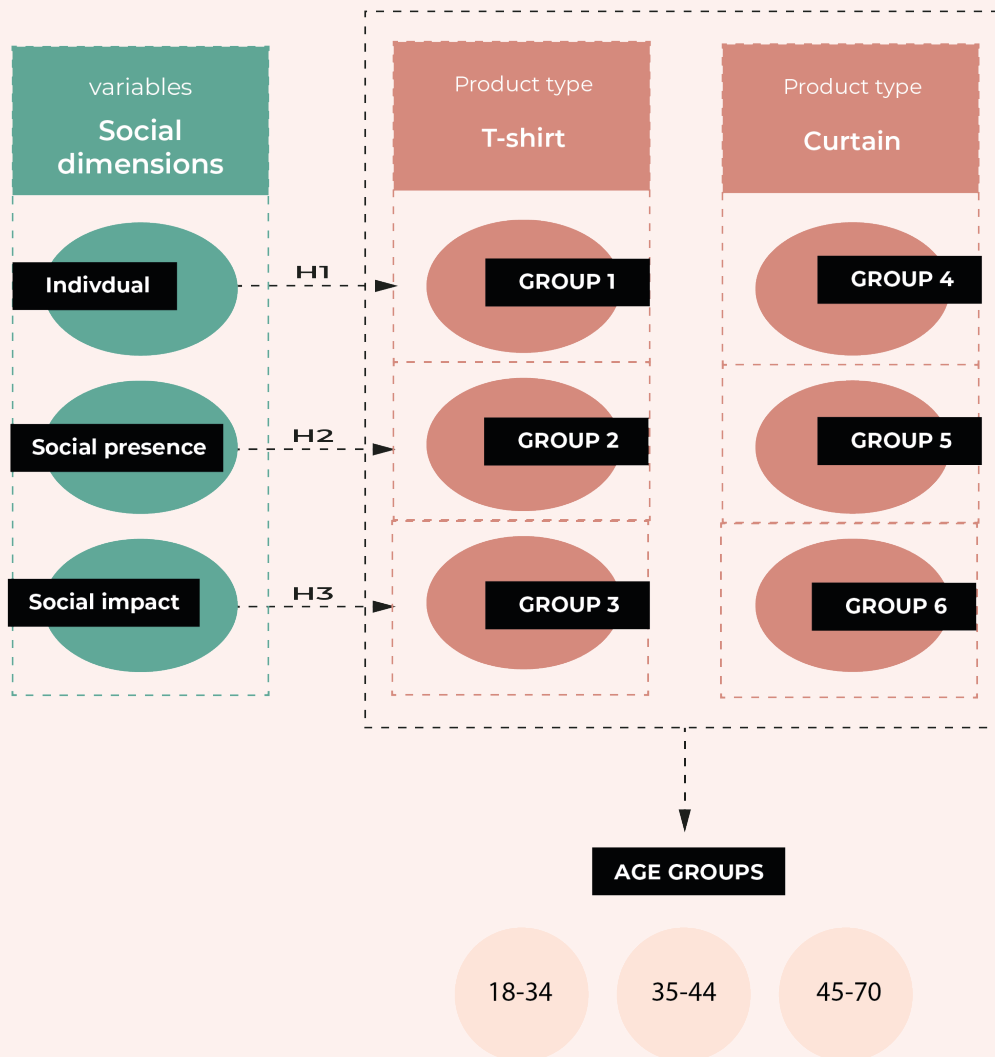
Figure 24

QUALITATIVE STUDY FRAMEWORK PARTICIPANT GROUPS

give the material shape in order to create a more representable future image. To overcome biases within the test two products are used namely a t-shirt which is close to your skin, a personal item that only the user touches, and curtains which envision a more static approach and everyone in the building can touch them. This is done because the aesthetics of the product should not play a role within the outcome.

PARTICIPANT GROUPS //

The participants are divided into six groups as can be seen in figure 24. Group 1-3 received a prototype that is built upon the concept of a t-shirt made from a 'living textile'. The other groups (4-6) a curtain made from 'living textile' is shown within the prototype. Group 1 and 4 , the control group, who

are shown a version of the video without any social features. We used this "zero" treatment condition to investigate if the absence of social features indeed leads to less understanding and appreciation. Secondly group 2 and 5 is shown a second version of the prototype where social influence and presence are added to the first prototype without providing other extra information. Lastly group 3 and 6 will also see exactly the same as group 1 and 4 but on top of that different added social dimensions namely social impact storytelling. In the questionnaire a randomizer is used to make sure that every video is shown the exact same amount of times. Lastly 3 age groups are addressed to make sure that participants vary in all ages, meaning the videos that differ in social dimension are equally distributed among different age groups.

8.3 DATA ANALYZING

DATA COLLECTION //

At last a questionnaire is used to create data about the participants' understanding and appreciation. The same questionnaire is used for all target groups to create data that is trustworthy and consistent in all groups. The questionnaire consists of 5 point likert scale questions and a few open questions. Studies show that data from likert items becomes significantly less exact when the number of scale points drops below five or above seven (Bouranta, 2009). The complete questionnaire can be found in appendix B Set-up questionaire. This questionnaire is based upon the knowledge from an ongoing research project of Hazal Ertukan into understanding and appreciation of 'living' materials. The questionnaire is divided into 4 subjects namely; appreciation, the understanding of material properties, the understanding of processes and the future use for the material.

PROCEDURE //

The survey is administered using Qualtrics online software (Qualtrics, 2021). The study is conducted individually. All questions and stimuli were in English. The expected completion time of the survey is around 15 minutes in order to have focussed participants. The participants have firstly seen a small introduction of the project without mentioning the aspect of 'livingness'. Secondly the participants were asked to give a consent statement followed by a set of general questions to gain insights on who the participant is. Thirdly the participant is shown one of the movies that are explained in depth in chapter 7 'prototypes' which took around 3 to 4 minutes. All participants were asked to watch the movie once. After watching the movie, the participants were asked to answer a set of questions. Most questions use a 5 point Likert scale in order to create quantitative data. The set of questions is based around the concept of appreciation. The second set of questions contain 32 items that emphasize material property meanings. They are presented in groups of ~10 and presented in randomized order. Thereafter a question about the appreciation is added. Followed by questions that ask the participants about their understanding around the material change. Lastly the questionnaire asks about the prefered future use of the material. The whole questionnaire and the correct order can be found in appendix B. After completion of the questionnaire a code will appear that the participants can use as a verification tool for their contribution.

The data was gathered via the Prolific platform, when you achieve the data you need to check if your data is filled in correctly, if not you can reject the participant, this was checked by looking at the response time and the open questions. In order to analyze the data correctly the data is cleaned and all useless answers are removed. Next to that missing data should be added, such as creating a new variable that shows which movie was watched by which participant. Besides, all variables that are rated from strongly agree (1) to strongly disagree (5) are converged into the opposite ratings, resulting in variable data where strongly agree = 5 to strongly disagree = 1. This is done to create data that is better understandable. Since 5 point Likert-scale questions are used, all answers are assigned with a point value ranging from 1 to 5 and all outcomes will be presented in this scale as well. With these results the most common response (Mode) and the average response (Mean) can be found.

As said before, the data is going to be analyzed by dividing the question into 4 different concepts; appreciation, understanding material properties, understanding the process and the future use, this is visualized in figure 25. All concepts are analyzed by using variations of the following methods; descriptive statistics, ANOVA and MANOVA in order to find the influence of social dimensions (social presence, social influence) and the use product (t-shirt, curtain) on the appreciation and understanding. Alongside these analyses make it possible to find correlations regarding the different variables; social dimensions, use-product, age and gender.
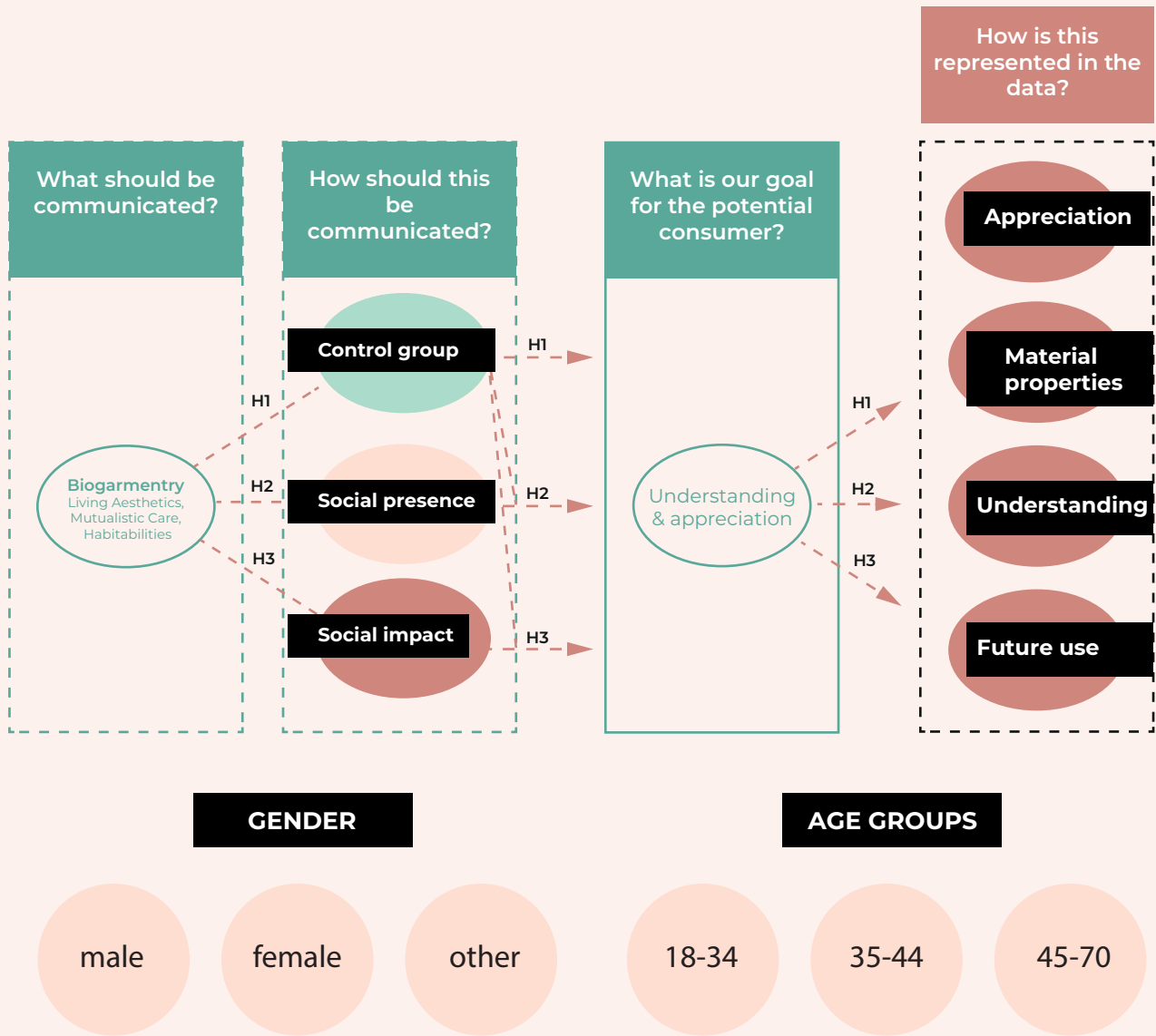
What should be communicated?

Biogarmentry
Living Aesthetics,
Mutualistic Care,
Habitabilities

How should this be communicated?

Control group

Social presence

Social impact

H1
H2
H3

What is our goal for the potential consumer?

Understanding & appreciation

H1
H2
H3

How is this represented in the data?

Appreciation

Material properties

Understanding

Future use

H1
H2
H3

GENDER

male

female

other

AGE GROUPS

18-34

35-44

45-70

Figure 25

DATA COLLECTION DIAGRAM

8.4 RESULTS

This chapter will present the results of the quantitative study. To structerize the results this chapter is divided into 4 different concepts revolving around the subject addressed in the questionnaire namely; appreciation, understanding of qualities, understanding of the processes and the future use of the product. Together these questions will address what the influence is of social dimensions and use products on the appreciation and understanding of 'livingness' of textiles. The subchapters consist of 4 subsections. Firstly the overall data is being analyzed meaning all participants are included. Secondly the data is analyzed by comparing the participant groups that were presented with different use-products to each other. Thirdly the results that compare the different groups exposed to different social dimensions to each other. Lastly a cross-analysis will integrate all 4 fixed variables (use-product, social dimensions, age, gender) with each other.

88.

RESULTS APPRECIATION//

This chapter discusses the questions where the subjects consider meanings comparable with appreciation. In appendix B you can find the whole questionnaire, here questions used for this part of the results are highlighted. In appendix C you can find the extensive tables regarding appreciation.

Firstly all scores related to the appreciation of the participants were transferred into data sheets in order to perform a factor analysis, to classify the 7 values. This classification is presented in a rotated component matrix (table 01) which conceptually relates the values to each other. Two concepts (components) were revealed with an eigenvalue greater than 1. The different concepts are shown by a color divide in the table. Concept one is characterized by high values for meanings positively related to appreciation. The second concept is negatively related to appreciation and therefore categorized under the term 'doubt', including one meaning only namely 'mixed feelings'. In further analysis all meanings are taken into account to analyze appreciation.
Looking at the descriptive statistics, the mean score and the standard deviation of each item can be found in appendix C. The pink bars represent items related to a positive appreciation, the green bar represents the item with mixed feelings and therefore has a more doubting meaning. The horizontal dotted line in the figure 26 represents

the overall mean score of all positive items (M=3,34). To further study the appreciation, a multivariate analysis of variance (MANOVA) is conducted. A MANOVA is similar to an ANOVA yet more dependent variables can be added at the same time and differences between the dependent variables can be detected. The MANOVA statistics around likeliness can be found in appendix C appreciation. This report uses Wilks Lambda as a test statistic of the MANOVA, since this is the most standardized statistic used, it addresses differences between the means of identified groups or subjects taking a combination of dependent variables into account. This analysis pointed out a significant difference between groups regarding exposed to different use products, the t-shirt and the curtains when considered jointly on the variables curiosity, positive towards, like, favourable, love, emphasize with and likely to use, Wilk's $= 0,951$ $F(7/156) =$, p = 0,049. A separate ANOVA is conducted for each dependent variable focussing on the variables like, positive, curiosity and mixed feelings. Firstly the likeability is used as a dependent variable (M=3,39 ; SD 1,326), this shows no significant difference between the likeability of the t-shirt (M=3,45; SD=1,21) versus

Table 01

Rotated component matrix appreciation

Rotated component Matrix[a]

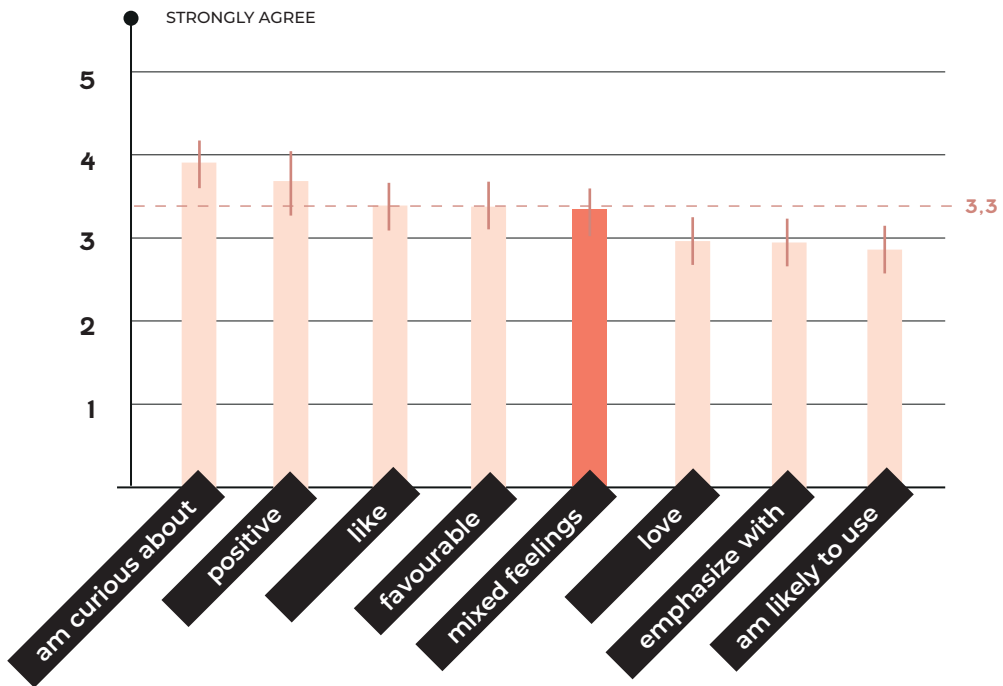| APPRRECIATION	Component	
	1	2
Like	0,914	
Love	0,891	
Positive	0,877	
Favourable	0,747	
Emphasize	0,707	
DOUBT Curious	0,685	0,526
Mixedfeelings	-0,463	0,819

Figure 26

Graph appreciation all participants included.

Figure 27

Graph appreciation fixed factor use-product

STRONGLY AGREE

PERSONAL

SOCIAL PRESENCE

SOCIAL IMPACT

am curious about, positive, like, favourable, mixed feelings, love, emphasize with, am likely to use

Figure 28

Graph appreciation fixed factor social dimensions

90.

Age; 45-70

Age; 35-44

Age; 18-34

PERSONAL

SOCIAL PRESENCE

SOCIAL IMPACT

3,47   2,98   3,72

3,33   3,20   3,58

STRONGLY AGREE

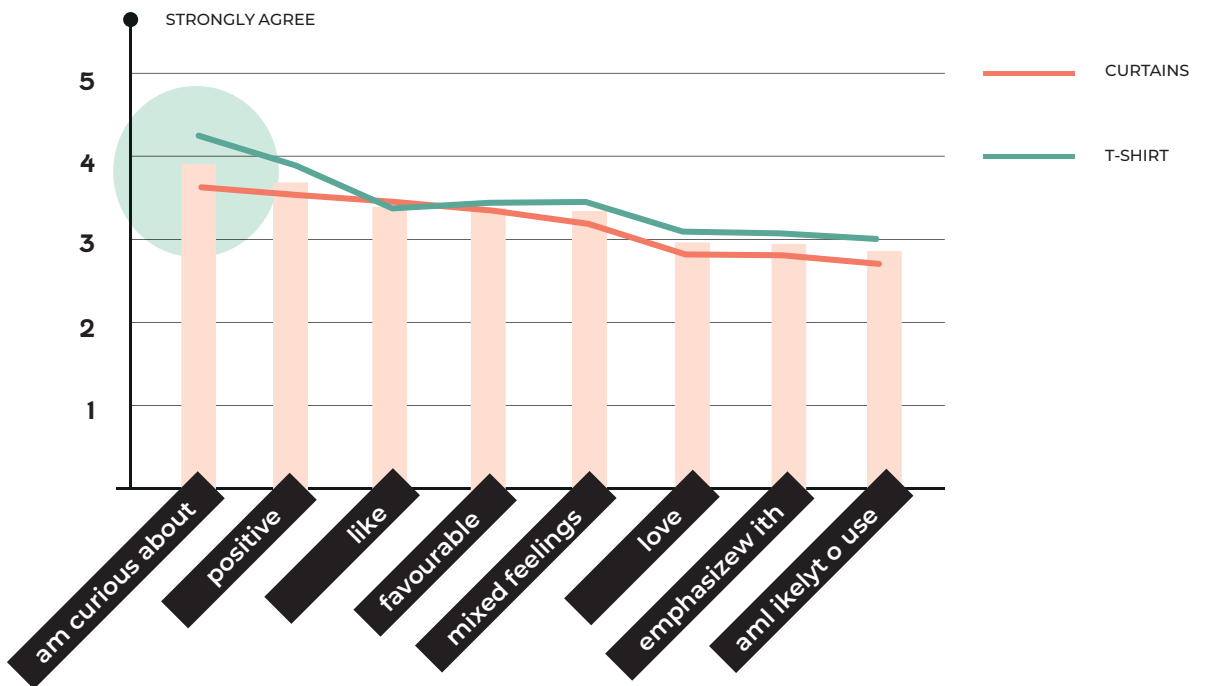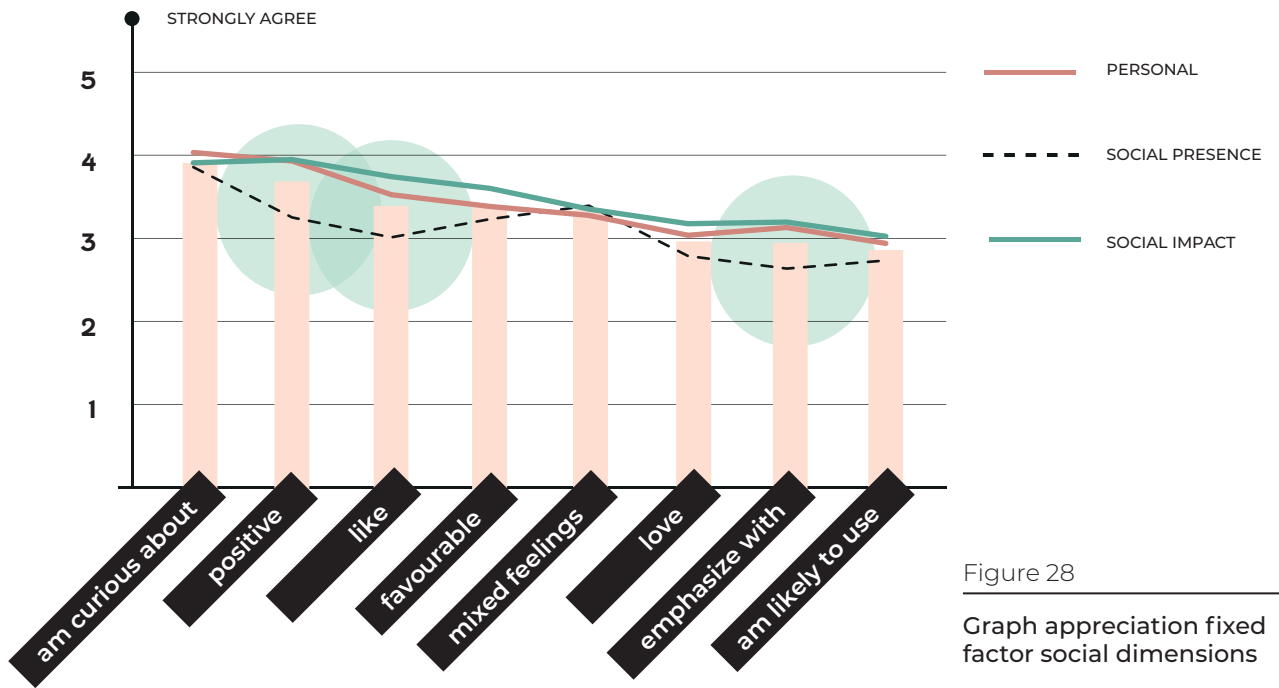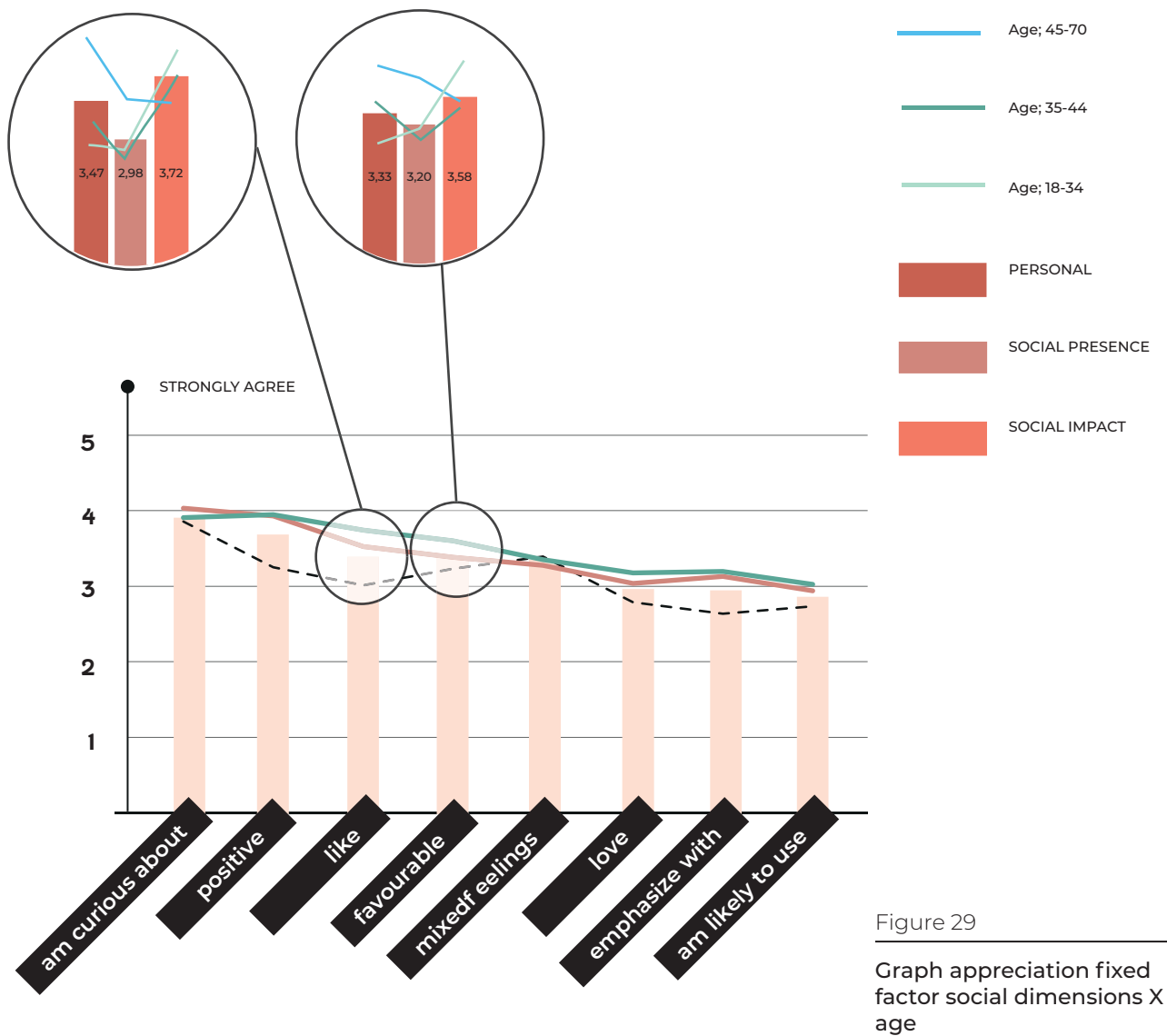am curious about, positive, like, favourable, mixedf eelings, love, emphasize with, am likely to use

Figure 29

Graph appreciation fixed factor social dimensions X age

the curtains (M=3,33 SD=1,02). Yet participants are significantly more curious about the material if the product is designed as a t-shirt (M=4.16; SD = 1,06), $F_{(1,174)} = 9,19$, p = 0,003. Furthermore there is no significant difference found between telling the story with a t-shirt (M=3,40) or curtains (M=3,21) and the fact that people would have mixed feelings about the material.

Besides a significance has been found related to the social dimensions comparing the control group, social presence and social impact storytelling when considered jointly on the variables curiosity, positive towards, like, favourable, love, emphasize with and likely to use, Wilk's = 0,835 $F_{(7/156)}$ =, p = 0,011. These factors are again assessed looking at the results of the ANOVA. As can be seen in figure 28 significances can be found when looking at a positive attitude, like and emphasizing. Looking at the graph it can be seen that people like the material less when exposed to social presence (M=2,98; SD = 1,42), $F_{(2,180)} = 5,26$, p = 0,006 compared to people exposed to personal (M=3,47; SD = 1,31) or social impact storytelling (M=3,72; SD = 1,33). Participants

who saw the social presence movie also think less positively about the material (M=3,22; SD = 1,30), $F_{(2,180)} = 7,44$, p = 0,001 than participants who saw social impact (M=3,93; SD = 1,06), or personal storytelling (M=3,88; SD = 1,22). Furthermore, participants exposed to social presence do not emphasize as much with the material (M=2,60; SD = 1,24), $F_{(2,180)} = 3,96$, p = 0,021, as participants exposed to no social dimension (M=3,07; SD = 1,21) or social impact storytelling (M=3,17; SD = 1,19).

Lastly, significance has been found in a correlation between two fixed factors; social dimensions and age, Wilk's = 0,747 $F_{(28/563)}$ =, p = 0,015. The younger age group particularly liked and favoured social impact storytelling (M=4,11; SD = 1,10), $F_{(4,180)} = 5,36$, p = 0,011, (M=3,84; SD = 1,16), $F_{(4,180)} = 2,69$, p = 0,033, above social presence (M=2,81; SD = 1,26), (M=3,23; SD = 1,51) or no social dimension (M=3,00; SD = 1,08) (M=2,75; SD = 1,07). On the other hand participants aged between 45 and 70 years old liked and favoured social impact storytelling less than the only personal approach.

UNIQUE MATERIAL QUALITIES//

This chapter discusses the questions where the subjects consider meanings fitting with the subject material properties. In appendix B you can find the whole questionnaire, here questions used for this part of the results are color coded.

Firstly all scores related to the appreciation of the participants were transferred into data sheets in order to perform a factor analysis, to classify the 31 items. This classification is presented in a rotated component matrix (table 02) which conceptually relates the values to each other. First five concepts (components) were revealed with an eigenvalue greater than 1. The first one all items are related to the material outcome, this concept contains both positive and the opposite, negative material properties like frustrating and calming. The second concept is more related to the living organism in the material and that the material changes over time; including items as changing, growing and unique. The third variable focuses on the relationship between the material and the consumer and is described as mutualistic care. The fourth variable describes the temporality of the material since it is dying, decaying or perceived as fragile. Finally the fifth variable/concept contains items grouped under the last concept called other related meanings which includes items like; engineered, synthetic, natural, interactive, and

dynamic.

Secondly, descriptive statistics are evaluated to view the overall rating of the material qualities related to 'living material'. The results of this analysis are shown in figure 30, the dotted line shown in this figure represents the overall mean of all items (M=3,41). As can be seen, participants in general most relate the materials to qualities as unique (M=4,56), changing (M=4,35), living (M=4,34), biological (M=4,31), advanced (M=4,22), fascinating (M=4,14), Growing (M=4,06), natural (M=3,96), interactive (M=3,93), engineered (M=3,86), dynamic (M=3,77), sustainable (M=3,57), fun (M=3,50), decaying (M=3,35). Material properties rated under the middle point of the Likert-scale are common (M= 1,56), harmful (M=2,03), disgusting (M=2,30), primitive (M=2,31) and frustrating (M=2,35).
To further study the unique material properties , a MANOVA is conducted followed by analyzing the results with an ANOVA. The MANOVA and ANOVA statistics related to the unique qualities can be found in appendix D.
In the concept material outcome pointed out a significant difference between groups regarding exposed to different use products, the t-shirt and the curtains when considered jointly on the items functional, frustrating, enchanting, fun, calming, beautiful, fascinating, smelly, disgusting, confusing and dirty, Wilk's = 0,825 F(11/152) = 2,92, p = 0,002. A separate ANOVA highlights that participants find the material more fun when the product
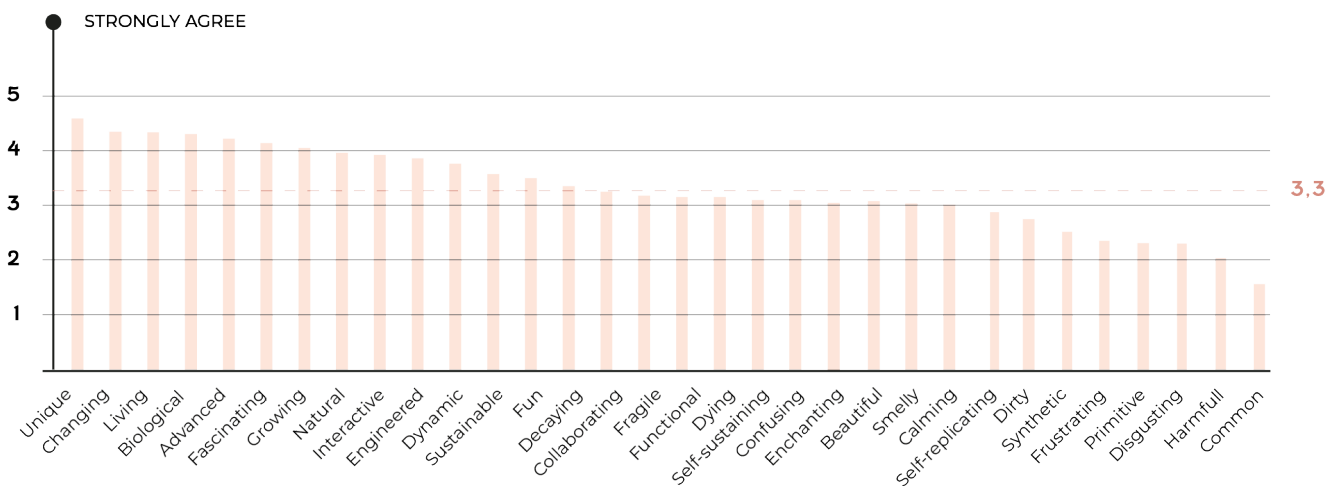
Figure 30

Graph material properties including all participants

Table 02

Rotated component matrix material properties

		Component				
		1	**2**	**3**	**4**	**5**
MATERIAL OUTCOME	Disgusting	-0,732			0,352	
	Dirty	-0,731				
	Beautiful	0,731				
	Calming	0,693		0,342		
	Enchanting	0,667		0,349		
	Smelly	-0,657			0,313	
	Fun	0,630		0,310		
	Harmfull	-0,607				
	Confusin	-0,544				
	Functional	0,539				
	Frustrating	-0,535				
THE LIVING ORGANISM	Changing		0,719			
	Unique		0,706			
	Living		0,649			
	Biological		0,601			
	Fascinating	0,515	0,563			
	Common		-0,559			
	Advanced	0,453	0,526			
	Growing		0,489		0,401	
MUTUALISTIC CARE	Self-sustaining			0,633	-0,346	
	Self-replicating			0,626		
	Primitive	-0,372		0,570		
	Collaborating			0,543		
	Sustainable			0,515		
TEMPORAL	Dying				0,784	
	Decaying				0,738	
	Fragile				0,376	
OTHER	Engineered					0,652
	Synthetic		-0,431			0,529
	Natural		0,420			-0,523
	Interactive		0,432			0,449
	Dynamic		0,324	0,398		0,433

93.

in the movie is designed as a t-shirt (M=3,74; SD = 1,05), F(1,162) = 8,70, p = 0,004 over the design of the curtains (M=3,25; SD = 1,19). Furthermore a significance has been found in the concept of temporality linked to the use-product, Wilk's = 0,95 F(3/160) = 2,84, p = 0,04. This shows that participants think the material decays more when the product in the movie is designed as a t-shirt (M=3,59; SD = 1,14), F(1,180) = 7,80, p = 0,006 over the design of the curtains (M=3,10; SD = 1,12).

When analyzing the concept of other containing items such as interactive, dynamic, synthetic, natural and engineered, a significance has been found in relation with the social dimensions; Wilk's = 0,886 F(10/316) = 1,97, p = 0,036. When participants are exposed to social impact storytelling they perceive the material as less interactive (M=3,65; SD = 1,05), F(2,180) = 4,52, p = 0,012 when no social dimensions (M=3,97; SD = 1,07) or social presence (M=4,17; SD = 0,77) storytelling is used. Looking at the ANOVA results more significance is found related to the social dimensions. One being that people exposed to social presence storytelling considered the product significantly more smelly (M=3,37; SD = 1,00), F(2,180) = 5,51, p = 0,007 than people exposed to no social dimensions (M=2,87; SD = 1,03) or social impact storytelling (M=2,82; SD = 1,05). Furthermore, participants, exposed to social presence storytelling, considered the material significantly less calming (M=2,68; SD = 1,11), F(2,180) = 3,87, p = 0,023 than when participants saw no social dimensions (M=3,18; SD = 1,20) or social impact storytelling (M=3,12; SD = 1,01). Lastly the material is perceived as more frustrating by participants who were exposed to social presence (M=2,65; SD = 1,22), F(2,180) = 3,38, p = 0,036 compared to no social dimensions (M=2,27; SD = 1,10) or social impact (M=2,13; SD = 0,99).

Next to that a significant correlation can be found looking at two fixed variables the use-product and the social variables as can be seen in figure 33. The t-shirt is perceived as more calming when exposed to social presence and the curtains are perceived as most calming when presented with social impact storytelling F(2,180) = 6,81, p = 0,001.

In the concept related to the living organism in the material, a significant difference is found when different age groups are considered while jointly looking at the items living, changing, growing, unique, biological, fascinating, advanced and common, Wilk's = 0,847 F(16/155) = 1,68, p = 0,05. Participants aged between 45-70 considered the material significantly more advanced (M=4,02; SD = 0,87), F(1,162) = 3,44, p = 0,035 than participants aged between 18-34 (M= 4,39, SD=.0,78). Next to that a significance is found by analyzing jointly the age groups and the concept of mutualistic care (self-sustaining, self-replicating, sustainable, collaborating and primitive)Wilk's = 0,853 F(10/316) = 2,52, p = 0,006. Participants aged 18-34 find the

material significantly more primitive (M=2,59; SD = 0,96), F(2,180) = 2,51, p = 0,003, as participants aged 45-70 (M = 1,93, SD = 1,13). Furthermore the age group from 44-70 (M=3,42; SD = 1,21), F(2,180) = 6,21, p = 0,003 considers the material as more beautiful than the age groups between 18-34 (M=2,69; SD = 1,06) and 35-44 (M=3,00; SD = 1,12). Thereafter participants aged between 45-70 consider the material as less confusing (M=2,68; SD = 1,23), F(2,180) = 5,56, p = 0,004 in contrast to the age groups between 18-34 (M=3,34; SD = 1,12) and 35-44 (M=3,27; SD = 1,15).

Researching unique qualities considering a correlation between the three fixed variables; social dimensions, age and use-product a significant relation can be found in the unique qualities advanced (F(4,162) = 2,46, p = 0,048) and frustrating F(4,162) = 2,71, p = 0,032. Participants aged between 18-44 think curtains are more frustrating (M=3,20, SD = 1,35) than a t-shirt (M=1,80, SD = 0,632) when exposed to no social dimension storytelling. When this age group is presented with social impact storytelling they perceive the curtains as less frustrating (M=1,60, SD = 0,83) than the t-shirt (M=2,56, SD = 1,33). The opposite can be found in the age group between 45-70 where curtains seem more frustrating (M=2,67, SD = 0,78) than t-shirts (M=1,75, SD = 0,74) when shown social impact storytelling. When looking into the perceived advanced level, a significant difference can be found in the age group 18-34; these participants think the t-shirt (M=4,50, SD = 0,58) is more advanced than the curtains (M=3,50, SD = 0,71) when non-social dimension storytelling is used. Furthermore, this age group considered the curtains (M=4,20, SD = 0,79) more advanced over the t-shirt (M=3,79, SD = 1,09) when shown social impact storytelling. The large age group overall thinks the material is more advanced when shown the t-shirt as a use-product, this becomes significant when social presence (M=4,40, SD = 0,70)or social impact storytelling (M=4,50, SD = 0,67) is used compared to the curtain in social presence (M=3,89, SD = 0,93) and social impact storytelling (M=3,89, SD = 0,93).
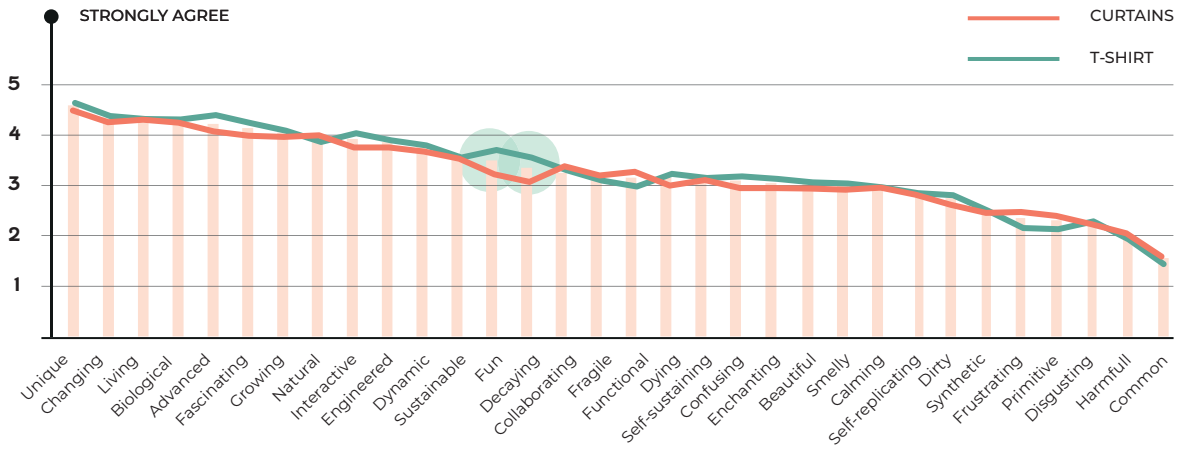
94.

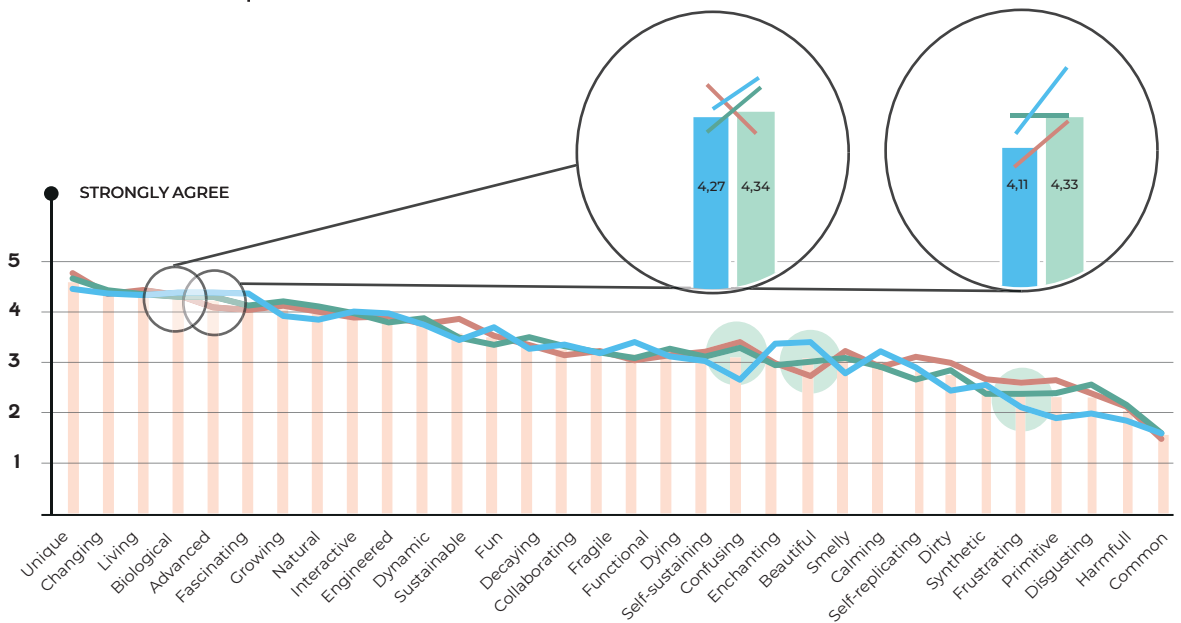|	Age; 45-70		PERSONAL		CURTAINS
	Age; 35-44		SOCIAL PRESENCE		T-SHIRT
	Age; 18-34		SOCIAL IMPACT		
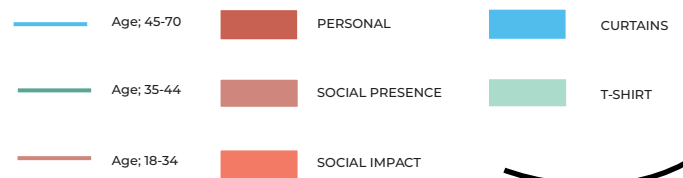
Figure 31 | Use-product
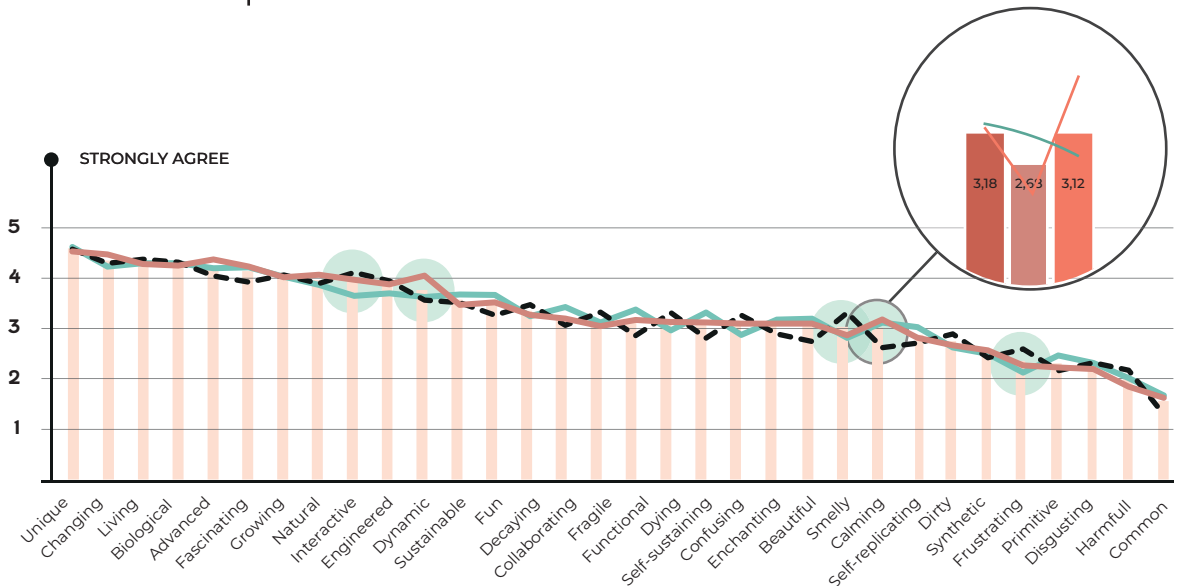

Figure 32 | Age / Age + use-product zoom.

Figure 33 | Social dimensions / Social dimensions + use-product zoom

95.

Table 03

Pleasant frequences / frequences social dimensions

PLEASANT FREQUENCES					
		Frequency	Percent	Valid Per-cent	Cumulative Percent
Valid	Sustainable, environmentally friendly	50	15,7	27,8	27,8
	Feeling and looks of the material	15	4,7	8,3	36,1
	It's function to purify the air	63	19,8	35,0	71,1
	The durability	3	0,9	1,7	72,8
	The color change	34	10,7	18,9	91,7
	That it is alive	7	2,2	3,9	95,6
	Nothing	8	2,5	4,4	100,0
	Total	180	56,6	100,0	
Missing	System	138	43,4		
Total		318	100,0		

96.

	SOCIAL IMPACT		SOCIAL PRESENCE		PERSONAL	
	Responses	Percent of Cases	Responses	Percent of Cases	Responses	Percent of Cases
Sustainable	16	26,7%	15	25,0%	15	25,0%
Feeling and looks	8	13,3%	3	5,0%	3	5,0%
Cleaning the air	29	48,3%	19	31,7%	19	31,7%
Durablility	1	1,7%	0	0,0%	0	0,0%
Color change	3	5,0%	17	28,3%	17	28,3%
Alive	2	3,3%	2	3,3%	2	3,3%
Can't think of something	1	1,7%	4	6,7%	4	6,7%

Next to the closed questions about the items considering meanings about material properties, participants are asked about their opinion on the most pleasant, disturbing and unique material property in a more qualitative manner using open questions. All qualitative material quality questions are coded in order to analyze the results. This is done by analyzing all values separately and afterwards adding values suiting to the answers. Firstly the participants were asked what the most pleasant material quality was. In table 03 all codes used for the most pleasant property can be found on the right side. As can be seen the participants considered the following qualities as

most pleasant; that it purifies the air (35%), that it is sustainable since it is organic, compostable etc (27,8%) and that the color changes (18,9%). When participants are shown with social impact storytelling, half of the participants pointed out that the quality of purifying is the most pleasant quality (48,8%) and that the color change was less noticed since it decreased to 5,0%. Next to that the%age of participants that could not think of one pleasant quality is the lowest when social impact storytelling is used (1,7%). Both in social presence as in non-social dimension storytelling 28,3% of the participants thought the color change is the most pleasant quality.
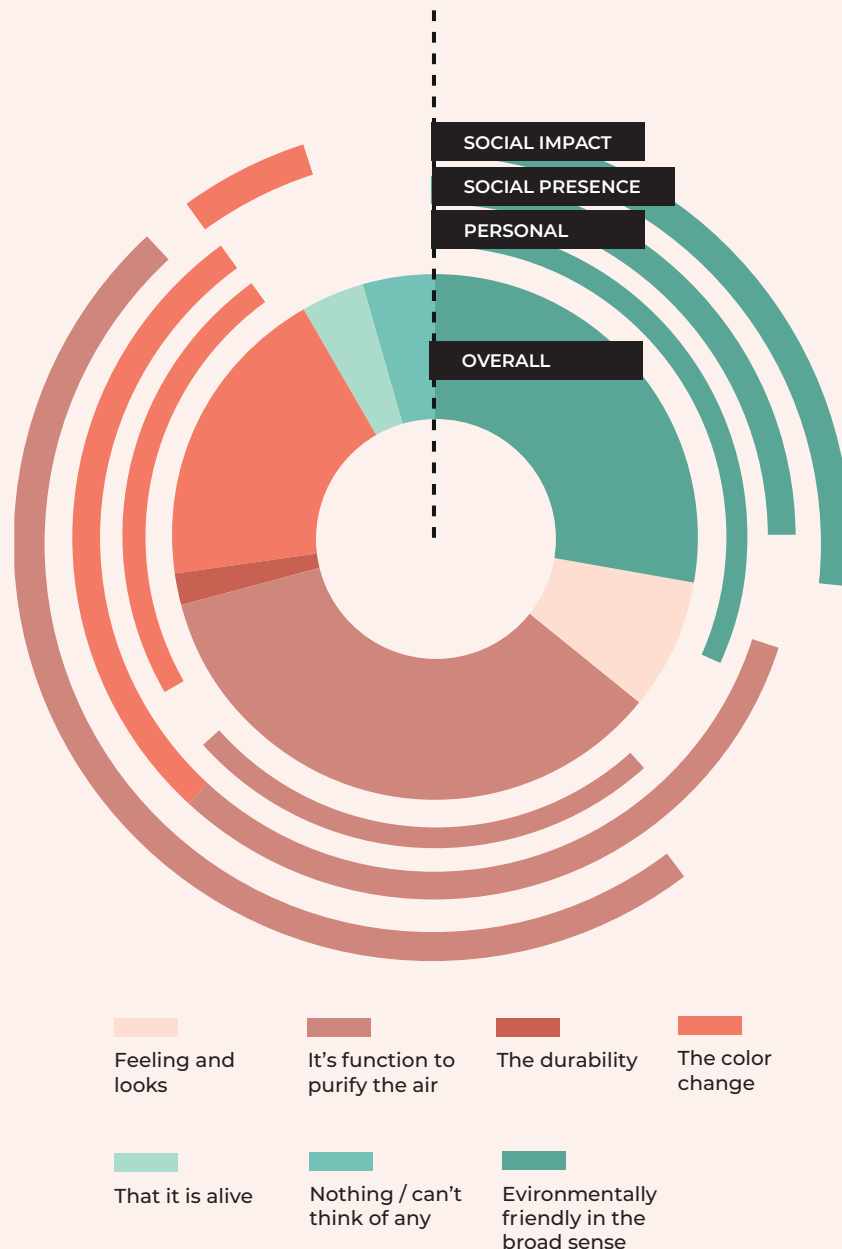

SOCIAL IMPACT

SOCIAL PRESENCE

PERSONAL

OVERALL

Feeling and looks

It's function to purify the air

The durability

The color change

That it is alive

Nothing / can't think of any

Evironmentally friendly in the broad sense

Figure 34 | Percentages pleasant material qualities

Table 04

Disturbing frequences / frequences social dimensions

		Frequency	Percent	Valid Percent	Cumulative Percent
	DISTURBING FREQUENCES				
Valid	That it is alive	54	17,0	30,0	30,0
	Non-hygenic or unhealthy	12	3,8	6,7	36,7
	The color and color change	15	4,7	8,3	45,0
	That it is dying	42	13,2	23,3	68,3
	That it might smell	24	7,5	13,3	81,7
	Pattern and material structure	3	0,9	1,7	83,3
	Does not match the purpose	5	1,6	2,8	86,1
	Extra work	10	3,1	5,6	91,7
	Nothing	13	4,1	7,2	98,9
	Costs	1	0,3	0,6	99,4
	Not enough proof	1	0,3	0,6	100,0
	Total	180	56,6	100,0	
Missing	System	138	43,4		
Total		318	100,0		

	SOCIAL IMPACT		SOCIAL PRESENCE		PERSONAL	
	Responses	Percent of Cases	Responses	Percent of Cases	Responses	Percent of Cases
That it is alive	17	28,3%	17	28,3%	20	33,3%
Non-hygenic or unhealthy	4	6,7%	6	10,0%	2	3,3%
The color and color change	5	8,3%	5	8,3%	5	8,3%
That it is dying	15	25,0%	13	21,7%	14	23,3%
That it might smell	5	8,3%	11	18,3%	8	13,3%
Pattern and material structure	1	1,7%	1	1,7%	1	1,7%
Does not match the purpose	1	1,7%	3	5,0%	1	1,7%
Extra work	5	8,3%	1	1,7%	4	6,7%
Nothing	5	8,3%	3	5,0%	5	8,3%
Costs	1	2%	0%	0%	0	0%
Not enough proof	1	2%	0%	0,0%	0	0%
Total	60	100%	60	100%	60	100%

Thereafter the participants were asked what they consider as the most disturbing material quality. This question is structured using different codes that can be seen on the left side of table 04. That the material is alive (30%), that it is dying (23,3%) and that it might smell are considered as the most disturbing material properties. Next to that there are participants that did not notice any disturbing quality while watching the videos (nothing = 7,2%). That the material was alive was considered more disturbing among participants exposed to non-social dimension storytelling (33,3%) in comparison to participants exposed to social presence (28,3%) or social impact (28,3%). That it might smell was less considered when participants were exposed to social impact storytelling (8,3%) versus social presence (18,3%) or non-social dimension storytelling (13,3%). The material was considered most unhealthy/unhygienic when exposed to social presence storytelling (10%) versus no-social dimension storytelling (3,3%).
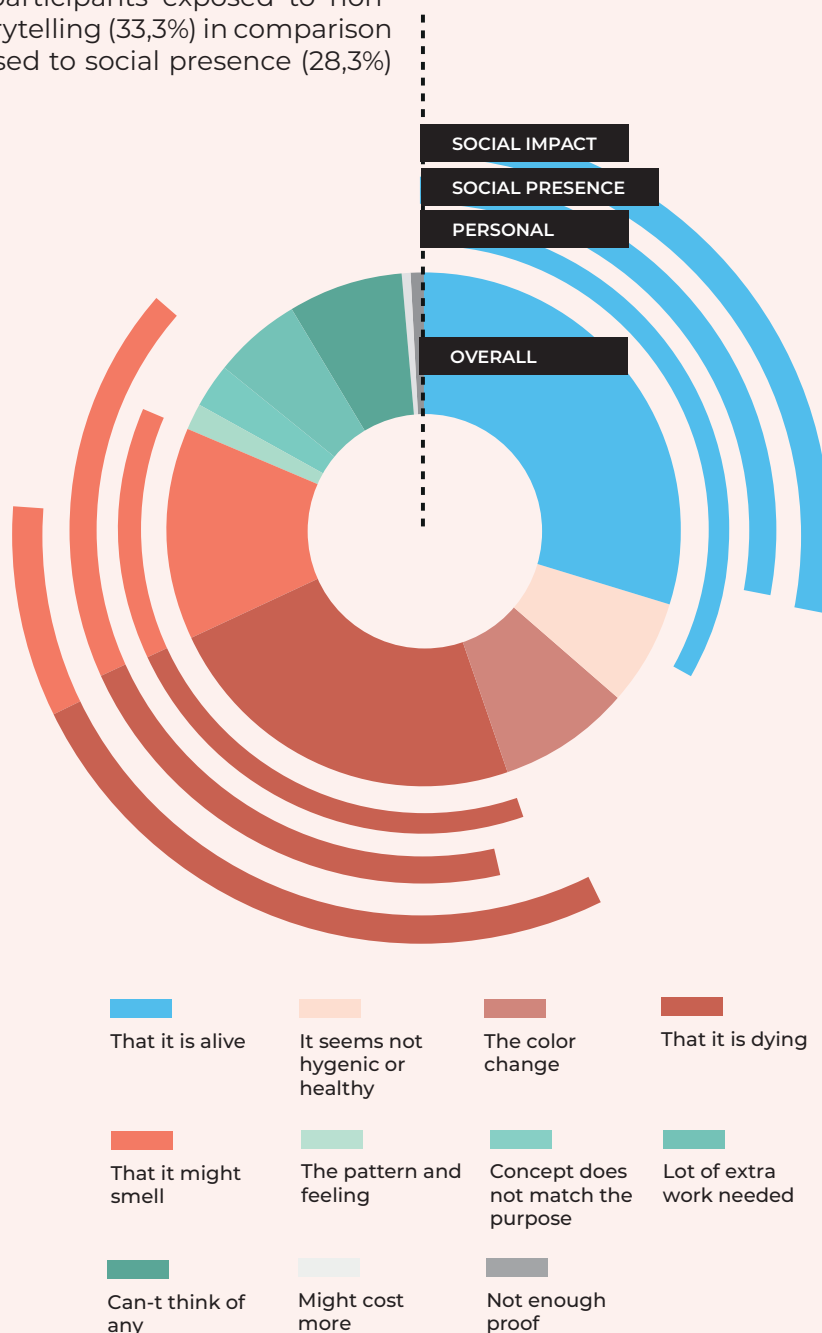

Figure 35 | Percentages disturbing material qualities

Table 05

Unique frequences / frequences social dimensions

		UNIQUE FREQUENCES			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Innovative	18	5,7	10,0	10,0
	Environmentally friendly	12	3,8	6,7	16,7
	That it is alive	58	18,2	32,2	48,9
	The color change	49	15,4	27,2	76,1
	The design	4	1,3	2,2	78,3
	The durability	2	0,6	1,1	79,4
	The caring	1	0,3	0,6	80,0
	Benefical because it cleans air	33	10,4	18,3	98,3
	Don't know	3	0,9	1,7	100,0
	Total	180	56,6	100,0	
Missing	System	138	43,4		
Total		318	100,0		

	SOCIAL IMPACT		SOCIAL PRESENCE		PERSONAL	
	Responses	Percent of Cases	Responses	Percent of Cases	Responses	Percent of Cases
Innovative	6	10,0%	4	6,7%	8	13,3%
Environmentally friendly	4	6,7%	4	6,7%	4	6,7%
That it is alive	18	30,0%	22	36,7%	18	30,0%
The color change	15	25,0%	18	30,0%	16	26,7%
The design	2	3,3%	2	3,3%	0	0,0%
The durability	1	1,7%	0	0,0%	1	1,7%
The caring	0	0,0%	1	1,7%	0	0,0%
Benefical because it cleans air	13	21,7%	8	13,3%	12	20,0%
Don't know	1	1,7%	1	1,7%	1	1,7%
Total	60	100%	60	100,0%	60	100,0%

Thirdly the most often recognized unique quality of the material by the participants where that the material; is alive (32,3%), changes color (27,7%), that it is beneficial for the users and its surrounding since it cleans the air (18,3%), and it is innovative (10,0%) as can be found in table 05. Furthermore the pie chart in figure 36 shows the overall outcome compared to the outcomes of the different social dimensions. This chart shows that when participants are exposed to social presence storytelling, they think the material is less beneficial for the user since it cleans the air (13,3%) and it is less innovative (6,7%) compared to participants exposed to non-social dimension storytelling (Clean the air = 20%, innovate= 13,3%).
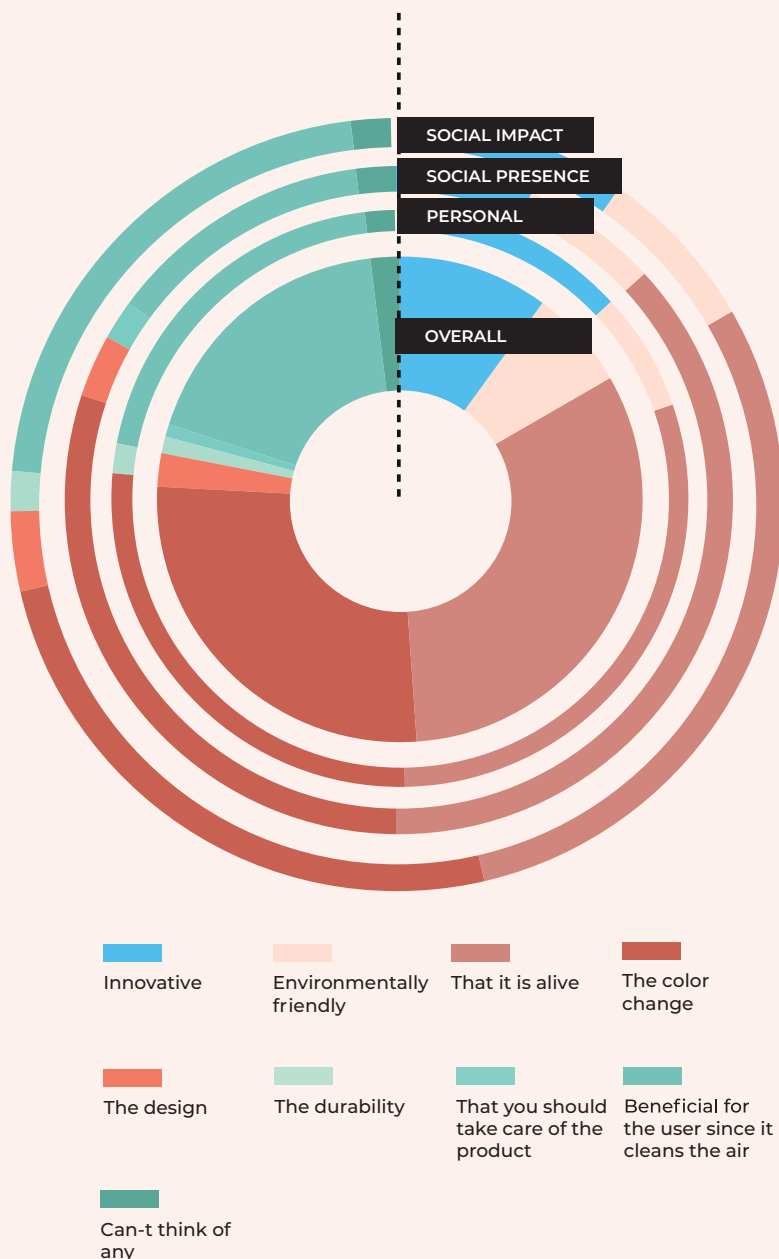

Figure 36   Percentages unique material qualities

UNDERSTANDING //

This chapter discusses the questions where the subjects consider meanings comparable with appreciation. In appendix   E you can find the whole questionnaire, here the questions that are analyzed for this chapter are color coded.

Regarding the understanding of the material, the questionnaire focused on the change over time, specifically the color change. Participants were asked if they understood this, and what the reason behind it was. The participants generally disagreed with having difficulties to understand the reason behind the color change of the material over time (M=3,90 out of 5). They also disagreed to have difficulty understanding how this material changed over time (M=3,7 out of 5). These values are complemented with the values of the follow up question showing a result that generally participants agreed to understand the changing over time (M=2,21 out of 5), and agreed to understand the reason behind it (M=2,11 out of 5). Furthermore there are no significant differences found considering social dimensions, use-product and age. There are also no significant differences found by analyzing correlation between these fixed factors.

102.

FUTURE USE MATERIAL //

This chapter discusses the questions that ask the
This chapter discusses the questions that ask the
participants about their opinion about the most
relevant future use of the material. In appendix B
you can find the questionnaire with color coded
subjects. Furthermore all tables that are used for
this analysis such as descriptive statistics, MANOVA
and ANOVA results can be found in appendix E.

Firstly this question is analyzed by looking at the
overall descriptive statistics meaning that all data
of all participants is included. The participants
rated the sun shade for outdoors as most relevant
design for the material (M = 3,72 ,SD = 1,41) followed
by, the cushions for outdoors (M = 3,57 , SD = 1,33),
thirdly the curtains (M = 3,20 , SD = 1,55), fourthly
the t-shirt (M = 2,78 , SD = 1,55), fifthly the yoga mat
(M = 2,46 , SD = 1,32), sixt wallpaper for indoors (M =
2,27, SD = 1,41), seventh bed linen (M = 1,92, SD = 1,19)
and lastly for a couch (M = 1,88, SD = 1,18).
Related to the concept of relevant future use
considering the items; sunshades, cushions, yoga
mat, t-shirt, curtains, bed linen and couch jointly,

a MANOVA shows significance looking at the fixed
factor; use-product (t-shirt/curtain), Wilk's   = 0,544
F(9/154) = 14,35, p = 0,00.
Then the ANOVA results display a correlation;
which is that when the designed product in the
movie was shaped as a curtain, participants would
significantly think curtains (M = 3,73, SD = 1,34)
or wallpaper (M = 2,55, SD = 1,48) would be more
relevant than participants who saw the movie with
the t-shirt (M = 2,71, SD = 1,58), (M = 2,00, SD = 1,29)
which can be seen in figure 37. On the other hand
participants who saw the t-shirt movieclip would
think a t-shirt (M = 3,52, SD = 1,41), a yoga mat (M
= 2,71, SD = 1,32) or cushions (M = 3,78, SD = 1,33)
would be more relevant over participants who
were shown the movie with the curtains (M = 2,00,
SD = 1,29),(Yoga Mat /M = 2,19, SD = 1,27), (Cushions /
M = 3,35, SD = 1,45)(figure 38).
In the ANOVA result a correlation can be found
between the social dimensions and the future
use of the material. This shows that social impact
storytelling improved the relevance of the future
product being a t-shirt (M = 3,15, SD = 1,48 , F(2,162)
= 3,81, p = 0,024) compared to social presence (M = 103.
2,45 , SD = 1,50) or non-social dimension storytelling
(M = 2,75 , SD = 1,50). Furthermore bed linen is
considered as (M = 2,37, SD = 1,31 , F(2,162) = 6,92, p
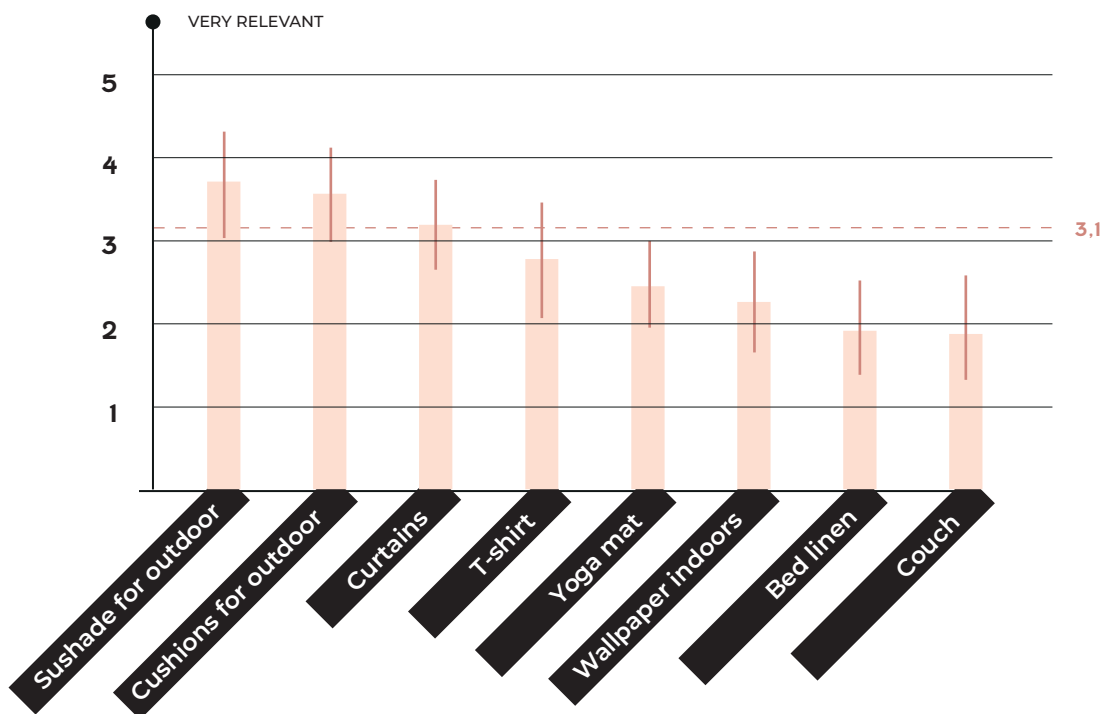

Figure 37 | Graph future use including all participants

= 0,001) is considered more relevant due to social impact storytelling versus social presence (M = 1,62 , SD = 0,99) and non-social dimensions storytelling (M = 1,77 , SD = 1,10). Lastly the relevance of the yoga mat is rated higher by the social impact participant group (M = 2,80, SD = 1,31 , $F_{(2,162)}$ = 3,91, p = 0,045) than by social presence (M = 2,32, SD = 1,29) or non-social dimension storytelling (M = 2,25, SD = 1,30).
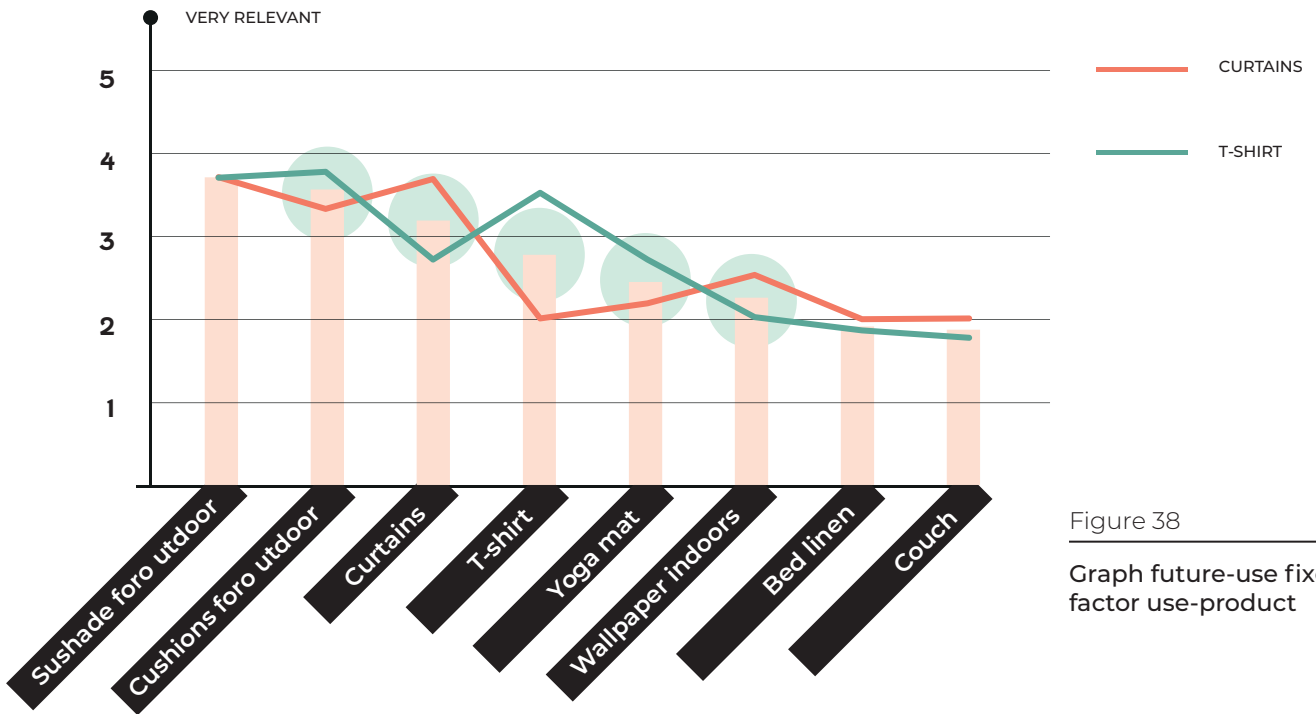
104.

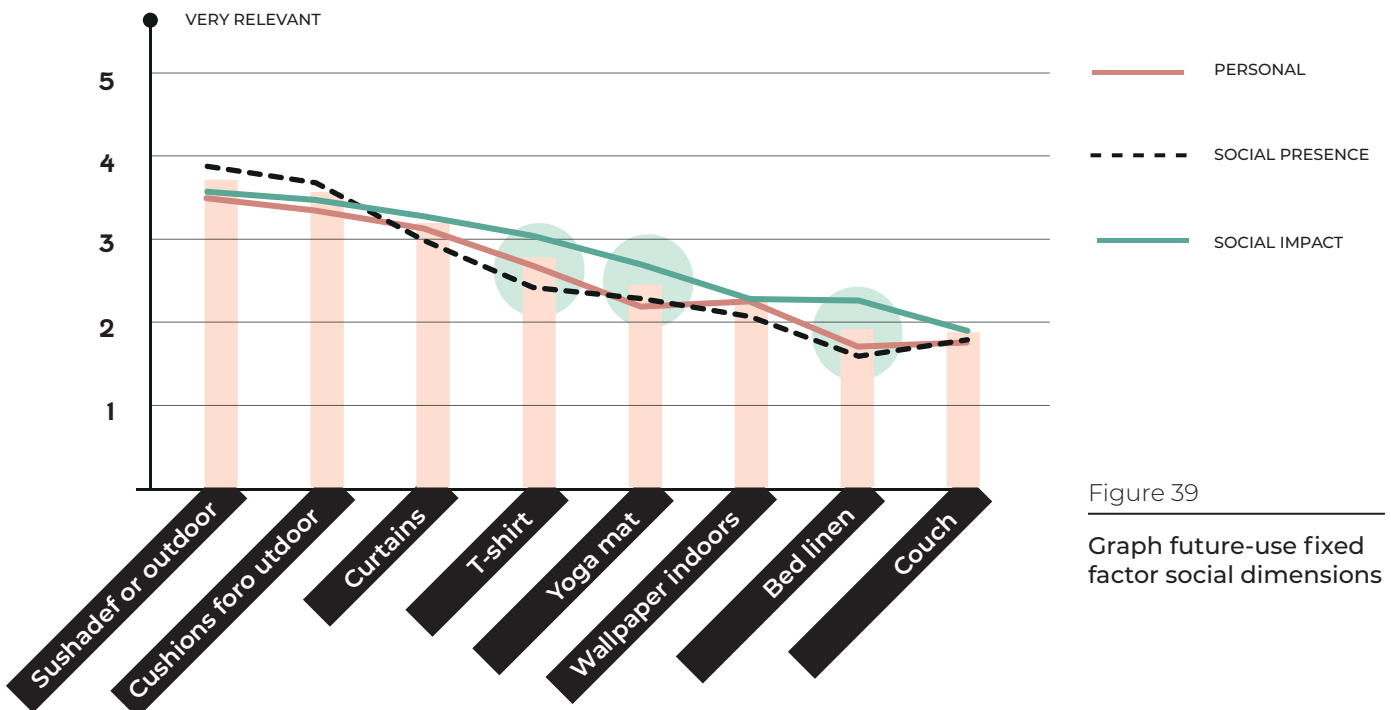

Figure 38

Graph future-use fixed factor use-product

Figure 39

Graph future-use fixed factor social dimensions

8.5 CONCLUSION

This chapter emphasizes a general conclusion about the understanding and appreciation of living textiles. Thereafter, this chapter concludes how social dimensions can influence the understanding and appreciation of living textiles and thereby contribute to digital storytelling.

The general conclusion , which jointly includes all social dimensions, is that the appreciation is high rather than low for this 'living' material. More than 50% of the participants generally appreciate the material positively according to the rating on the 5-point Likert scale question. However, there are still many different replies, some of which are also negative. Yet it is surprising how open people are for this new innovation. The most suited material qualities determined by the future consumer are; unique, changing, living, biological, advanced, growing, natural, interactive, engineered, dynamic, sustainable, fun and decaying. Living is rated in third place this leads to the conclusion that participants understood the material is alive. Video storytelling in general can be perceived as a great manner to communicate 'livingness' in terms where living aestatics are envisioned by meanings such as growth, changing and dynamic. Mutualistic care and habilities are covered by the meaning interactive. When meanings related to the material outcome are considered, participants consider it most as biological and natural.

Furthermore participants relate the material to meanings as advanced and engineered when shown digitally. This could mean that the early adopter phase of consumers framed in Rogers innovations theory is already completed. Yet in those next phases pre-conception around smell, health and hygiene are leading into taking consumer adoption into the next phase.

The most pleasant qualities according to the participants are that it purifies the air, it changes color and it is sustainable. Opposed to this the color change is on the one hand perceived as pleasant while others (a much lower percentage) also state this quality as disturbing. The attention for these qualities has to do with the way the story is put together, this mainly highlights the quality that it cleans the air and that it changes color. In parallel the results show that future consumers think the material is currently most suited for outdoor use, like sunshades or cushions.

Yet the aim of this study was not to test the adoption grade of living materials, but instead it should test how social dimensions can contribute to the communication of living materials. The results obtained are not entirely in line with the hypotheses set for this study. The first hypothesis being; consumers are able to appreciate 'living' materials more and understand the unique qualities of 'livingness' better by using online social presence to show diversity between products. The results on appreciation show quite the opposite for this hypothesis. Consumers show less appreciation for the material when shown social presence storytelling. Social presence caused consumers to think that the material was more smelly, less calming and more frustrating compared to the other social dimensions. This also manifests itself in the results considering the future use of the product. Social presence caused participants to think products that are in close contact with the human body are less relevant. Therefore the conclusion is that social presence does not overcome preconception in the stage of innovation today.

The second hypothesis; the understandability and appreciation of the unique qualities of 'living' textiles is improved by showing the impact of living products on a macro-level through social impact storytelling, is better supported by the results. Taking all age groups into account social impact storytelling does not cause a higher level of appreciation among future consumers. Yet it can be found that social impact increases the level of appreciation among potential consumers aged between 18-34. This is completely the opposite for the age group 45-70, they are rather negatively influenced by social impact compared to the control group according to the results of the appreciation.
Considering meanings related to material qualities, social impact storytelling causes future consumers to think the material is less interactive and dynamic in regard to non-social dimension storytelling.
Social impact storytelling however does ensure an increasing appreciation of the material quality, purifying the air. Almost half of the future consumers who were shown social impact storytelling thought this was the most pleasant quality. However social impact storytelling diverts attention from the potential positivity that could exist around the color change but it helps to appreciate the overall look of the material. Lastly, social impact storytelling contributes to the feeling of relevance for products that are closer to your skin such as yoga mat, t-shirt and bed linen

all products that are very interactive with the user. Nevertheless this is not reflected in the results that consider the cushions for outdoors or the couch.

Since the implied product, a t-shirt or a curtain, results are very close to each other when it comes to appreciation, the assumption is that the product does not affect this conclusion and thereby is related to the material only. Yet the effect of the implied product does influence the level of curiosity, where a more provocative product like a t-shirt which is for example more close to your skin, evokes more curiosity by the consumer than the curtains. This is complemented by the result that the material seems more fun when the implied product is a t-shirt. This could mean that participants of this study were generally more interested in products related to clothing. It is difficult to generalize these findings since the ways of storytelling only used two product types. The implied product must fit the preference of the user. The implied product used in storytelling does have a huge influence on what the consumers find relevant purposes and therefore prefer. By molding the material in the form of a product, the consumer will be able to better imagine that product in our society and is therefore more willing to accept, appreciate and understand this material overall.

So considering the question; can social dimensions contribute to the communication of 'living' textiles?; the main focus would be on how to use social impact storytelling, since it should certainly complement unique material characteristics caused by 'livingness' when it is used. In addition, different strategies need to be devised for addressing and involving consumers in different age groups. Furthermore, social presence storytelling is often not prefered when it is done in the way this case study is supplemented. It raises questions and causes preconceptions. A possibility could be seen in the use of social presence in combination with addressing those preconceptions in a more clean and controlled manner.

To conclude, social dimensions should be used carefully. Innovators should be very specific in what they exactly want to communicate. Social presence can lead to a less professional story since the innovator is not the only source of information anymore. Furthermore, innovators should clearly decide to whom they communicate since different groups could be addressed differently. For social impact storytelling this mainly applies when

distinguishing between different age groups as there is a lot of difference in what kind of relationship they have with the digital world. The digital world can be a notably broad playground for communication. Let's design a place that stimulates creativity by giving shape to a material and its 'livingness'. A world where preconceptions around health, smell and hygienics can be addressed. A world where we can try something new, together.

106.

8.6 DISCUSSION

This chapter will be discussing all factors that could have been of influence on the study. Limitations will be addressed and evaluated.

The study shows that results differ per age group especially in the case of social impact storytelling. The results mainly show a differfication between the age group; 18-34 years old which are positively influenced by social impact as opposed to the age group of 45-70 years old. However, it remains hard to compare these age groups with each other since one of them, being 45-70 years old, has a more extensive range than the age group 18-34. Therefore it can occur that a higher variation in age phase will lead to different perspectives towards digital communication. For future studies the result should be checked if there would be a significant difference in answer within the age group 45-70. To resolve this problem by forehand, age groups can be divided equally, and based on their relationship with digital design. For future studies regarding creating new digital narratives it is important to have clearly defined age groups, and all age groups should contain a high number of participants so relevant and realistic conclusions can be drawn around how to address different age groups.

Furthermore, this study's participants group does not equate to the gender division in the United Kingdom. Because of this divide gender is not included as a factor of influence during the study. This means that the results of this study are 74,4% based on women's perception. A study into 'gender differences in modeling the influence of online marketing communication on behavioral intentions' shows that; women prove to have more positive attitudes towards stories in line with their interest and trigger confidence. Furthermore, women are more invested in getting extra information. Men have more positive attitudes towards stories when they perceive the story's purpose and relevance (Perju-Mitran & Budacia, 2015). Yet the results show no visible differences between men and women regarding appreciation taking multiple factors like; like, positive, favourable, emphasizing, likely to use, love and curiosity into account. In addition to men and women, people who did not identify with either of these two genders also participated, their appreciation rate towards the material is significantly lower than the results of men and women. Since only two participants, who identified with the third gender, participated in this study this can not be seen as a significant result.

The study focussed on the attitude from consumers that are currently based in the United Kingdom. This means that the results are based on a perspective from the Western world. It is commonly known that different cultural backgrounds influence the results. Speculatively it could be that participants originated from more suburban places are already more in touch with nature and would appreciate living materials more. In addition, cultures represent the beliefs of different groups, society presents all people who share those beliefs. In this way the design of the social dimensions stated in this report could differ per culture. In future studies participants should be asked what their cultural background is so the influence of it can be measured.

Finally this study emphasizes social dimensions in forms that are really converted. Since only the smallest of differences can be tested in order to create significant results, this project visualized social impact and social presence in a flattened and minimalistic way. How this is visualized is influenced a lot by the style of the creator of this project. A major part of the discussion around the visualization was to what extent the prototype should be clean and to what extent it should be realistic. On the one hand you want to create a story that overcomes preconceptions such as the thought of the material as dirty, but on the other hand you want to create a transparent story that shows the decaying and color change of the product. This dilemma has also become visible in the end result of the prototypes since social presence storytelling is more realistic than clean, and social impact storytelling is more clean than realistic. This dilemma could influence that social presence articulates less positive attitudes towards living materials. With regard to design, there is also an important point to consider in subsequent studies on living textiles: All use-products must contain the same fabric structure. In this study, the curtain referred to a pattern in the cotton and the t-shirt did not, this may have influenced the participants' opinion as patterns influence the customer's experience. Some like patterns and others don't, this bias should be excluded so that its influence is not visible.

DISCUSSION & RECOMMEN

9.1 DISCUSSION

This chapter will be discussing the level of appreciation for living textiles and the understanding of its unique qualities and the influence of social dimensions on these aspects. Next to that it will talk about what this means for future studies.

At the start of this project it is found that current digital tools are not able to properly communicate 'livingness'. Insights found that currently digital platforms which communicate new innovations in the area of biodesign are primarily focused on informing the consumer.Yet the consumers currently ask for interaction with the innovator, in order to become part of the innovation. This research framed focus on social dimensions could be used as a tool to support this interaction on different levels. Yet the research project got simplified since all external factors of influence should be excluded in order to fairly compare the social dimensions to a control group. Through this process interaction became less visible in the experience since a video was used as stimuli to interact instead of a complete web-site with information. This means that there can be speculation if social presence really felt like intended. This raises the questions: can video storytelling on its own indeed create a warm, sociable feeling? And how can this be checked? Future studies should test if this interaction element is of high value in the creation of a social present atmosphere.

This study shows that social presence (present digital society that helps to show diversity between products made by living organisms) does not positively affect the understanding and appreciation of living materials. In order to speculate about the reasons behind this negative influence, we compare this concept with social media. Social media has its ups and downs. Social media is able to influence consumers buying decisions, making them spend more. Furthermore, it amplified the impact of digital word-of-mouth, thereby new innovation can be

spread immensely fast among consumers and innovators are able to connect with their audience (Barysevich, 2020). On the downside, social media is also able to create a negative impact due to this effective way of word-of-mouth, like complaint behaviour. This can lead to a huge outrage within a few hours when a questionable statement is made (Pfeffer et al., 2013). Including social presence into storytelling therefore needs to be used carefully especially when the material is still in an early phase of research. When statements can't be made, it's also hard to create an imaginative image, how do you stay transparent while creating positivity online? The prototypes of this study used examples in social presence storytelling that were neither positive nor negative, this finally resulted in a more negative outcome. Can this be the cause of the perfection that is pursued on social media platforms? Is only the perfect picture good enough? Is it fair to create a perfect picture in early research phases when the outcome is not yet well supported? Is this contradicting with the fact that living things will always be different and never be perfect? Isn't their imperfection what makes them perfect? In the future innovators should get a grip on how to transparently communicate product imperfections, which will lead to positive online interaction.

Furthermore, it can be discussed that when communicating living materials, different generations should be addressed differently. Social impact storytelling positively influenced the appreciation and understanding among young consumers. `The Digital Fairy' is a research agency from the UK which presented their view on generation Z. They state that this generation is more pessimistic, especially concerning problems around sustainability. Gen Z is kind of coming to the conclusion that the world is ending and they have the idea that they have no control over this (The Digital Fairy, 2020). Taking this into account social impact storytelling can help the young generation to take back control, to empower their

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9.2 RECOMMENDATION

individual actions by acting as a whole. The young generation should be addressed in ways that they can get a grip on situations again. Taking this into account, future studies should build upon the fact that different generations should be addressed by different digital narratives since their relation towards sustainable goals and digital platforms differ from each other.

Another interesting finding of this study is that; scent is an element that makes future consumers hesitant, even when the smell is present in the digital world. How can people judge smell when it isn't even there? Should we allow consumers to judge the smell? Is that beneficial for the appreciation? Since smell is not included in the means of communication, it can be said that excluding smell still leads to preconceptions about it. Therefore future communication on living materials should include tools that are able to communicate the smell in online platforms. Based on this a new studie can look into how to digitally overcome preconceptions like smell, answering the question; How can create a better understanding and appreciation of living materials by creating a digital smell?

Altogether we can keep speculating about how social dimensions can be used as new digital narratives for living organisms, and there are probably hundreds of points untouched. This shows that it remains important to think about how and to whom we are communicating, since we eventually don't want to lose control and want to create change for the better.

This final part is a letter addressed to future innovators in the field of living materials. What fantastic work has been done in this area. Simultaneously, multiple innovations are popping up, which makes it hard for the consumer to understand what has been presented to them. It is a relatively new idea for them that a future where materials are alive is near. When innovations are communicated we should focus on the good aspects of these materials, while at the same time be honest about all aspects of the materials. They may not fit into daily life today, yet we need to break through this wall of habituation in order to move forward. Here social presence can visualize the changing and living aesthetics of living materials, yet this is not something that is appreciated by the consumers quite yet. Social impact storytelling can create the hope of a positive impact which is considered as beneficial by the consumer, yet this is mainly positively appreciated by the young age group. Social impact storytelling can complement the communication of internal processes of living materials. This report may not have found the overall solution for communication yet, but it shows that different tools can be used to complement different living material qualities. These tools should be selected carefully. Furthermore, one tool is probably not enough, a set of tools should be created so all beautiful aspects of living can digitally come to life.

109.

This study shows that social presence (present digital society that h products made by living organisms) does not positively affect the unders things. Does it lead to the same problems as social media? Is only the this contradicting with the fact that living things will always be

Social impact (including the whole context in order to show benefits created by and for society) storytelling positively influenced the appreciation and understanding among young consumers. That raises the question; do we need to address age groups differently when using social dimensions in storytelling?

When consumers understand, do they stay engaged?

Digital platforms are deployed in a way that is primarily intended to inform consumers, but to get consumers involved with an innovation it is important to go beyond this level and design a proper digital interaction with them. This can be done by including social dimensions in storytelling, to create a social and interactive environment.

FOR LIVING TEXTILES

helps to show diversity between
tanding and appreciation of living
perfect picture good enough? Is
different and never be perfect.

The textile industry is moving towards
a more biobased future. Innovators aim
to source raw materials from living
organisms, produce materials with
living organisms and possibly create a
material that is still alive in the use
phase.

Scent is an element that makes
future customers hesitant, even
when the smell is present in the
digital world. Based on new studie
can look into how to digitally
overcome preconceptions like
smell, answering the question; How
can create a better understanding
and appreciation of living materials
by creating a digital smell?

REFLECTION

112.
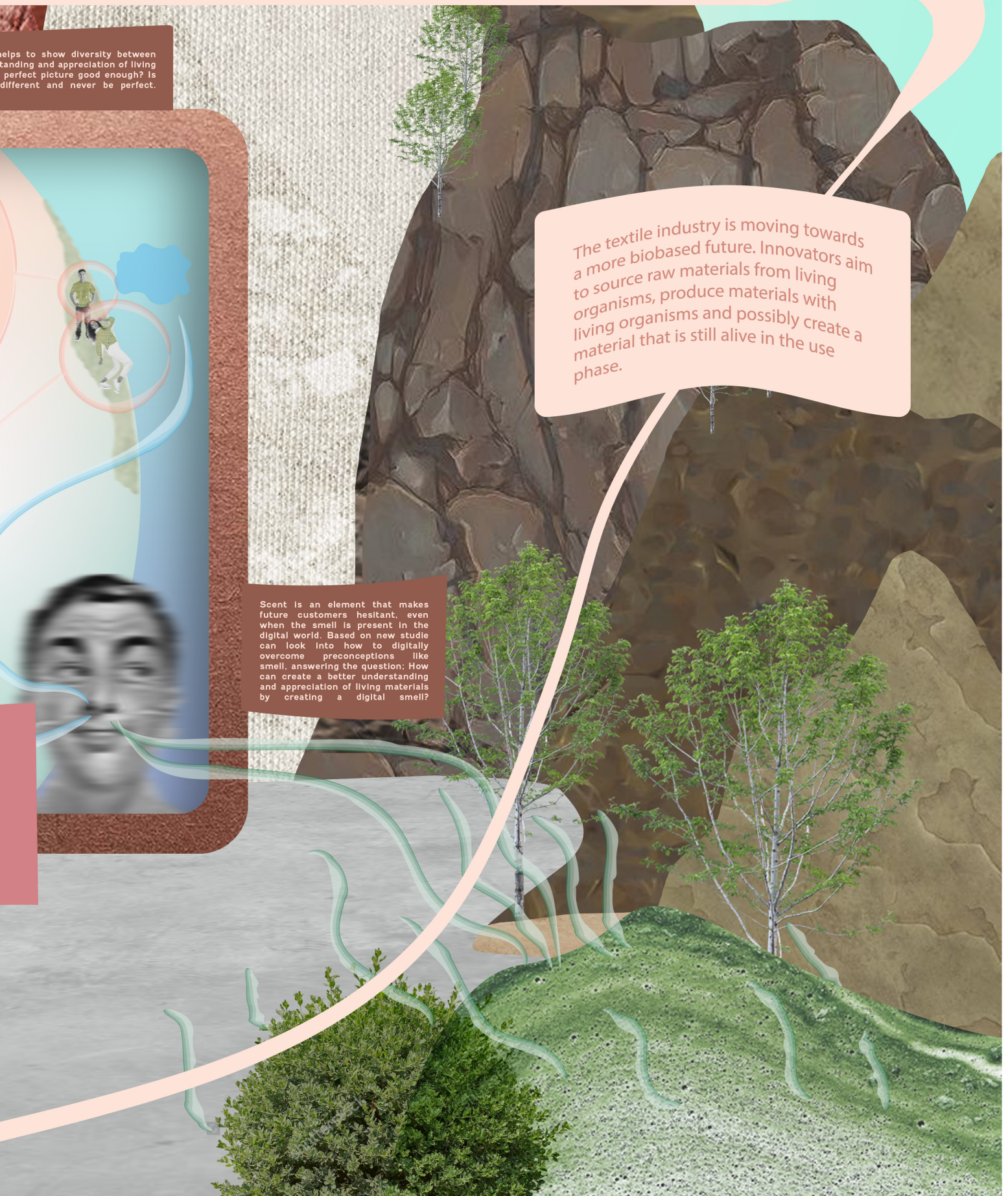
This chapter creates an overview of how I have experienced this project. This experience is structured by the most commonly used method for reflecting on our own actions, the STARR method. STARR stands for situation, task, action, result and reflection. I will describe three tasks that have stayed with me and from which I have learned wise lessons.

First situation was around the time of my mid-term. (S) At that time we probably met a couple of times with the whole research crew. After a meeting that was just after the mid-term and right before the deadline for finishing the prototypes, we met online with the team. I always like these meetings since they create a lot of feedback and get me enthusiastic again because of the atmosphere. (T) I always make presentations before these meetings since it is my job to keep them structured to retain as much feedback as I can in the time to improve my project. (A) I used storyboard visualization with collages in my presentation to clearly represent the storyline that I wanted to use in each prototype. I did this because I wanted everybody's opinion even on the finest detail, explaining the story in only text would not be enough to go that much in depth in the discussion. (R1) As a result the storyline was clearly communicated and the discussion was nice and fruitful, yet due to the large team and the short time (which I did not watch), I could not finish my presentation. Therefore the translation of collages into real time images was not discussed in the meeting, with the whole team. This mistake was found a week later, when I sended the first version of the prototype to the whole research team. The choice to use real-time videos / images was made in a meeting with only me and my mentor. When I discovered this miscommunication I must say I panicked a little bit. I felt guilty, as if I had let anyone down. A discussion arises around what should be better, use real images (more realistic) or use collages (more professional). The hard part was that I understood the arguments for them both, it took me a while to make a decision on my part,

because I wanted everybody to be content with the result. I think I needed some time to get my own arguments together, because my first reaction was that I wanted everybody to feel okay with the end result, therefore I forgot my own opinion for a second. (R2) In essence I learned that it is not the end of the world if you do not act on a problem in one day, there is time to gather arguments and form an opinion. The most important thing is to stay communicative with everybody who is involved in order to solve the problem. Furthermore I have learned that it is important to keep to a time schedule in important meetings, and that it is okay to take the lead in this.

(S) The second situation revolves around choosing the material for the prototype using the curtains as an implied product. I went to the market to look for fabrics that I could paint, in order to create a realistic image of curtains as if they were alive. (T) My task was to find a fabric that was white and did not include any elements that could cause bioses in the study. (A) I found a white fabric on the market that consisted only of a ticker string of cotton, which kind of caused a pattern. Since I wanted to start right away, I still bought the fabric, with the idea I could make it totally straight with the use of photoshop. (R1) Of Course this turned out not to be the case, editing the images, in order to diffuse the pattern, made them look less realistic. Therefore the decision was made to use prototypes where the pattern was still visible. This created another factor of influence during the studie, that differentiated the t-shirt from the curtains on another level than envisioned. (R2) I think I should handle this situation with more patience. I consider it as a strength that I want to work hard, and handle things fast. Yet in some situations, I should take rest, in order to save time later in the process.

(S) At the end of the project I noticed that I found it particularly harder to concentrate. Sitting behind my laptop sometimes felt purposeless. I noticed that working at home influenced my ability to

ask for help. I think the working at home situation did not allow me to get out of my comfort-zone enough. Because I noticed this working situation did not help me to be my best self, I started to take on other projects; like a job as a strategy design consultant at Fronteer, besides that I aimed to create my own brand, that converts post-consumer clothing into new clothes again and next to that I also worked one night a week at a restaurant. (T) I always imagine that I can handle every situation at the same time, yet I noticed that planning is always dependent on others, therefore situations sometimes can get quite stressful. (A) I did every project okay, yet I of course could have done every project a little bit better since, I was distracted in my head with all the other things I still needed to do for the other projects. (R1) Coming to the end of the graduation, I think the result is that I can handle multiple projects at the same time, I can get inspired because of one project, and use this in the other project, in this way having a busy life is beneficial. But I do think it would have been a little bit better for my health if I had skipped only one of these jobs/projects. (R2) In the future I want to divide my time better, and make sure that there is also room for leisure time such as sports, as I also find this important. In addition, I will choose a project / job which will probably reduce the pressure in my head.

Overall, my main learnings are; that I am a doer, I like to make, create, design etc. these are the parts of the design process that stimulate me the most. I want to be a little more analytical, and I think this project helped me do that. Yet I notice that I gain the most joy when these findings are taken one step further into a design. I am a big believer in the trial by error approach, yet this is something I like to work in teams, and I feel responsibility for the team to work smoothly. A team motivates me to take further steps, which I think I will need throughout my life, since I like to be around people. By doing a research based project, I learned to be more patient and careful with decisions. My argumentation

improved, when I became more thoughtful and patient as well. These elements I definitely want to take with me when I am hopefully going to design even more things in the future.

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