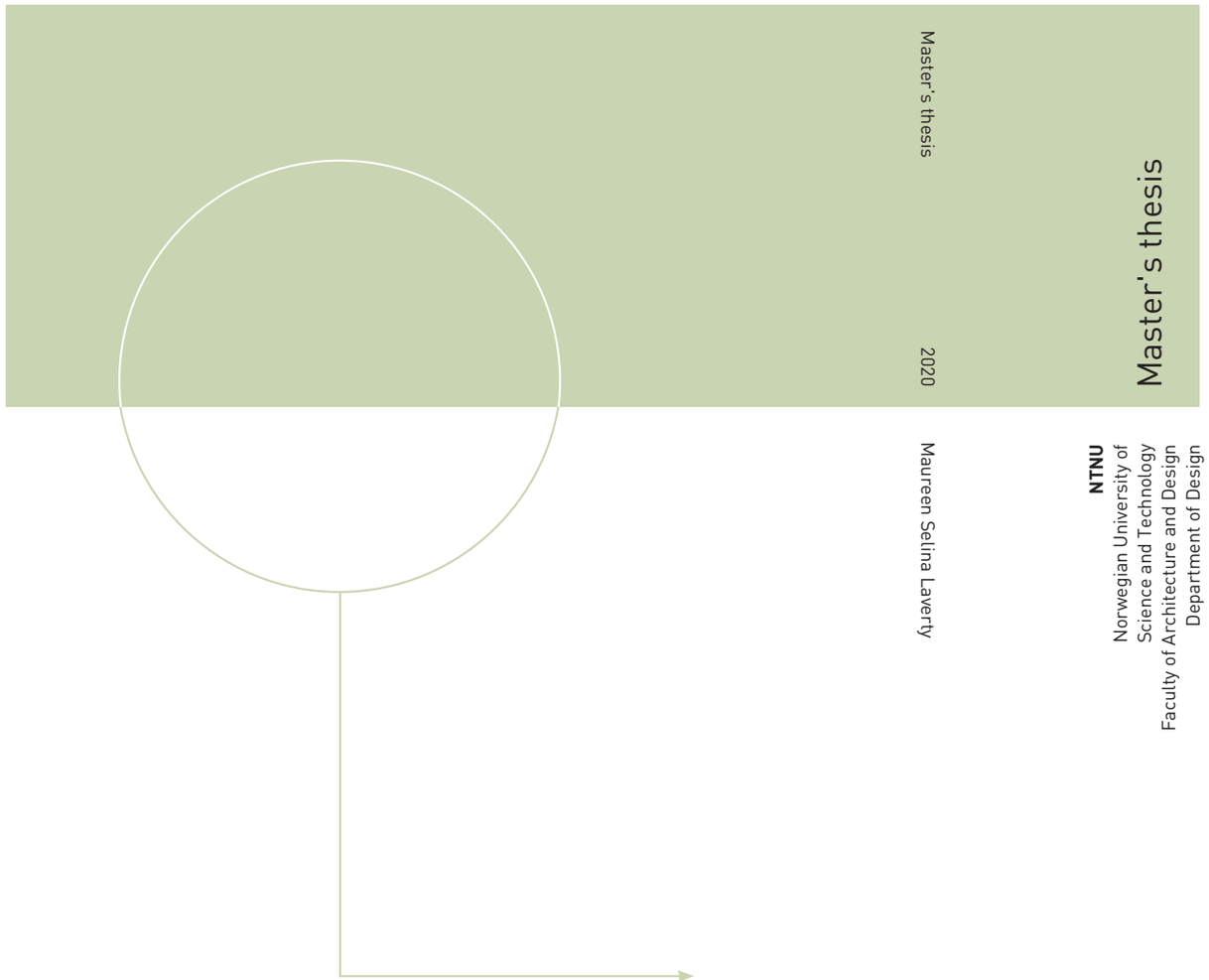


Maureen Selina Laverty

# Affording tactile sensory pleasure

Exploring an autist's tactile sensory experience through the development of a 3D digitally knitted tool that is to be shaped by the individual to support their body and emotional needs, that offers customisable tactile qualities and affordances.

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## Maureen Selina Laverty

Industrial Design Engineering
Submission date: January 2020
Supervisor: Nils Henrik Stensrud

Norwegian University of Science and Technology
Department of Design

# Abstract

This project aims to understand an autists' tactile sensory experience through the development of a tool that invites and inspires the user to explore and take ownership of their experience.  It is to be shaped by the individual to support their body and emotional needs.

Through co-design with an autist, the project tests and develops customisable knitted textures that do not evoke tactile defensiveness but elicit pleasure.  It then builds stimulatory 3D textures that calms and refocuses the user.

Through participatory workshops the project explores how we can use the embodied experience of textiles for self-regulation and allow users to create what they need rather than imposing a form.

The learnings embedded in this project hope to inspire other designers to consider how we might create more pleasurable universal sensory experiences for everyone.

# Acknowledgements

I would like to thank the following people who made this project possible.

Jóhannes Blöndal Sigurjónsson for finding a way for me to stay at IPD.

My supervisor Nils for the chats full of difficult questions, and allowing me to explore what I am passionate about.

My family in Northern Ireland and Spain, who don't really understand what I do, but nonetheless full-heartedly support me, even when I gave up my full-time job to study in a foreign country.

My adopted Trondheim family for all their support, especially my flatmates, who kindly welcomed a knitting machine into our apartment, and my friend Lisa Spaak for her willingness to play and explore movements with me, the deep conversations on the art of hugging, and keeping me energised with nutritious food in my last few weeks.

Pauline van Dongen for taking a chance on me and the endless inspiration.

Ekornes and Møbelkraft for the use of Tom Daykin's expert skills.

Camilla Bruerberg at KHIO for all her knitting insights and valuable time.

NTNU library for locating all my weird and wonderful requests, in particular Dr A. Jean Ayres' writings on sensory integration which are out of print, but they managed to borrow a copy from Washington University.

All the workshop participants, for trusting and playing with me.

Autismeforeningen Møre og Romsdal, especially "Herman" and his mother. Thank you for welcoming me into your home and sharing your experiences with an open-mind.

# Preface

This has been the most challenging and rewarding design project that I have had the privilege of undertaking.  It has been exhausting  and energising in equal measures.  I fully embraced the opportunity to explore topics that I am fascinated by and passionate about: knitting, materials, making, movement, diversity, and the human body's interaction with its surrounding,.  I also embraced the opportunity to explore new design methods such as embodied design, rapid prototyping, participatory workshops and research through design.

This thesis is presented as part of my final masters project at the Institute for Design at NTNU Trondheim, conducted over 20 weeks.  It is the written accompaniment to the many physical knitted samples that were made and tested throughout, involving travel between Sykkylven, Oslo and Trondheim.

It was necessary to travel to Sykkylven to work with the 3D digital knitting machines in Ekornes and Møbelkraft's knitting technician.  The project was not sponsored by Ekornes as my research topic of autism was not aligned with their areas of research, however I hope that I have made many discoveries which are of benefit to their future design process.  Ekornes generously allowed me to use their space in return for consultancy on another project.

Sykkylven also unexpectedly became my main location for testing and understanding the sensory needs of users with autism, thanks to the support and open-minds of Autismeforeningen Møre og Romsdal.

Another unexpected support was the offer to use the knitting room at the Kunsthøgskolen i Oslo (KHIO).  Moving between Ekornes' rural industrial setting and the city art school of KHIO gave another dimension to my project.

Financially it was necessary for me to work two student assistant jobs to support this project.  Although time consuming these positions greatly fed and inspired me.  I supported professor Brita Fladvad Nielsen on supervising her students with their Relational Welfare projects, which I subconsciously used as a framework for my own process.  I could relate to the students' frustrations recruiting participants for their workshops but I was equally motivated by them, to keep going, when I saw the value they created in facilitating the participants in guiding designers through their unique life experiences.



I also took my supervisor Nils Stensrud's Design in Wood class this semester, which he thought was crazy, but also greatly informed my design process. Through the class we learned the value of working with the material in hand before moving to machining which was reinforced by my experiences with mechanical and digital knitting.  We were also encouraged to work iteratively 1:1 scale to get a sense of proportions, comfort and usability.  I used this same approach in my workshops and actually worked with my Design in Wood partner, Jacob Jørgensen, to develop my proportions and form in this project.

# Contents

# Introduction

*Figures 1 & 2: Below is Wendy Jacob's Squeeze Chaise Lounge inspired by Temple Grandin's 'Hugging Machine'. Above is the 'squease vest' a commercialised version.*



# *starting point*

From when we are swaddled at birth until we are shrouded at death, textiles surround us. Their primary functions are to shelter us through the clothes we wear, comfort us through the seats on which we sit and calm us through the layers we sleep between. However, current manufacturing practices do not provide the opportunity to consider users with sensory sensitivities. As a result I believe that both designers and consumers have lost our tactile sensibility.

In my summer job at the Holst Centre in the Netherlands I came across the vest in figure 1 whilst doing some research. It is a compression vest that applied deep pressure stimulation (a firm hug) to users with autism. This is one of the more aesthetically pleasing models on the market. I was struck as to how inconsiderate the design is to the holistic sensory needs of autists. It can fulfil the function of applying pressure to the body but it rarely has the opportunity to do so because no one wants to wear it. This hypothesis was confirmed during my visit to Melhus Sansesenter which I discuss in chapter 1.

A product cannot fulfil its function, even if clinically approved, if the intended user does not want to use it because they do not feel good using it. The nuances of how material choices can influence the look, feel and emotion of the user must be considered for a product to be declared useful. My initial goal was to develop a better material/ textile for this product and improve the user experience through 3D digital knitting, a prototyping and production process I had already discussed with the furniture company Ekornes.

I came to understand that sensory therapy is a lot about normalising textures and sensations for sensitive users. This wasn't exactly what I wanted to do. In trying to understand the theory behind the design of compression vests I came across Wendy Jacob's chair, shown in figure 2. She designed it with Dr. Temple Grandin an inventor who has autism which has had a profound affect on her sensitivity to sensory stimulation, in particular touch. Human touch was too much for her. “Small itches and scratches that most people ignored were torture...like sandpaper rubbing my skin raw. As a child, I craved the comfort of being held, but I would pull away when people hugged me. When hugged, an overwhelming tidal wave of sensation flowed through me.”(1) So she developed her own pneumatic hugging machine that she could control which brought her great relief and pleasure. I knew immediately that the expression on the face of the user in figure 2 is what I wanted to achieve with my design.

NTNU
Fakultet for arkitektur og design
Institutt for design

**Masteroppgave for student Maureen Selina Laverty**

**Title** Sensory therapy through 3D digitally knitted structures

3D digital knitting is a sustainable automated manufacturing process that facilitates the programming and production of varying textures and mechanical properties in one textile structure.

Within the context of furniture design, this project aims to explore how 3D digital knitting can produce a textile that is beneficial for sensory therapy through:

1. tactile raised surfaces for sensory stimulation
2. comforting compressive structures to calm and refocus
3. shelter from over stimulating surroundings.

It will focus on how the body responds and interacts with various tactile and compressive knitted structures. Iterations of the textile should be tested and developed with user groups that benefit from sensory therapy, for example users with autism or dementia.

Oppgaven utføres etter "Retningslinjer for masteroppgaver i Industriell design".

Ansvarlig faglærer (hovedveileder IPD): Nils Henrik Stensrud

Faglig veileder: Nils Henrik Stensrud
Eventuelt biveileder:
Bedriftskontakt:

Utleveringsdato: 2. Sept 2019
Innleveringsfrist: 24. Jan 2019

Trondheim, NTNU, dato

Navn
Faglig veileder 2.9.2019

Ole Andreas Alsos
Instituttleder



# *motivation*

I started my design career as a tailoring apprentice on Savile Row where we worked with the material in hand to create a bespoke customised product for the client. Every part of the collaboration, making and wearing was about pleasure. After a couple of years I became a prototyping technician for a medical wearable device company. Everything was manufactured in China and was focused on lowering cost and optimising production. The designs were never a pleasurable experience of the user. Rather than embracing the body and exploiting our senses, the products fought against the very body they were trying to measure and heal.

Frustrated with this, I returned to study design engineering. Firstly in the UK where I was disappointed that design was taught merely through computer simulations. I came to Norway on exchange and stayed because it still embraced students' need to form with their hands. But at times I feel it does not fully embrace the human body; its changing movements and sensory experiences. This is something I really wanted to explore with this project, and understand where it can fit in to design education.

I was motivated that my masters project would in some way keep alive the need to form with our hands, to touch and understand materials, but also use the very valuable service and interaction design methods we are privileged to be taught at NTNU.

During my fashion education I took a course in mechanical machine knitting and continued to use this production method throughout my degree. This was an aesthetic choice and I had not considered the control that is possible over the mechanical properties and tactile qualities of the material the machine produces. I only started to explore this in the last 2 years when a classmate found a very old mechanical knitting machine in Fretex. I experimented with it my bedroom and the programming was done manually by me pushing needles in and out of position. I knew absolutely nothing about digital knitting or 3D knitting before my visit to Ekornes last March and was motivated to learn about more about this production method through my masters project.

# 3D digital knitting in Sykkylven, Norway

Knitting is an additive forming process that feeds a continuous horizontal strand of yarn, looped on needles to form vertical columns. This looped structure has an elastic-like behaviour, making it stretchable in many directions. The elastic properties are dependant on the yarn, stitch structure & needle gauge and tension. Knitting is common and cherished Norwegian past time with a rich culture. Machine knitting has mechanised this process and digital knitting has made it possible to program varying properties within one textile. 3D digital knitting machines enables the combination all of the above in one 3D form.

*Figure 3: Nike's 3D knitted upper, before assembly to the sole, demonstrates a combination of mechanically varying structures knitted seamlessly in one piece.*





Since 2012 Adidas & Nike have digitally knitted their *Primaknit* and *Flyknit* footwear ranges respectively, allowing them to almost fully automate their manufacturing processes and seamlessly produce comfortable materials with different areas of support and breathability in the desired shape (2), shown in figure 1. A few explorations in furniture design include Vitra's high end *Slow Chair* in 2006, figure 4. However it is a relatively under exploited process in furniture production. I am told by knitting technicians that such designs did not progress because, although the technology is there, the knowledge of how to program it and the intimate understanding of how to push it to its limits, and explore the possibilities, is not there within the furniture industry.

*Figure 4: Vitra's early collaboration with Ronan & Erwan Bouroullec, 2006*

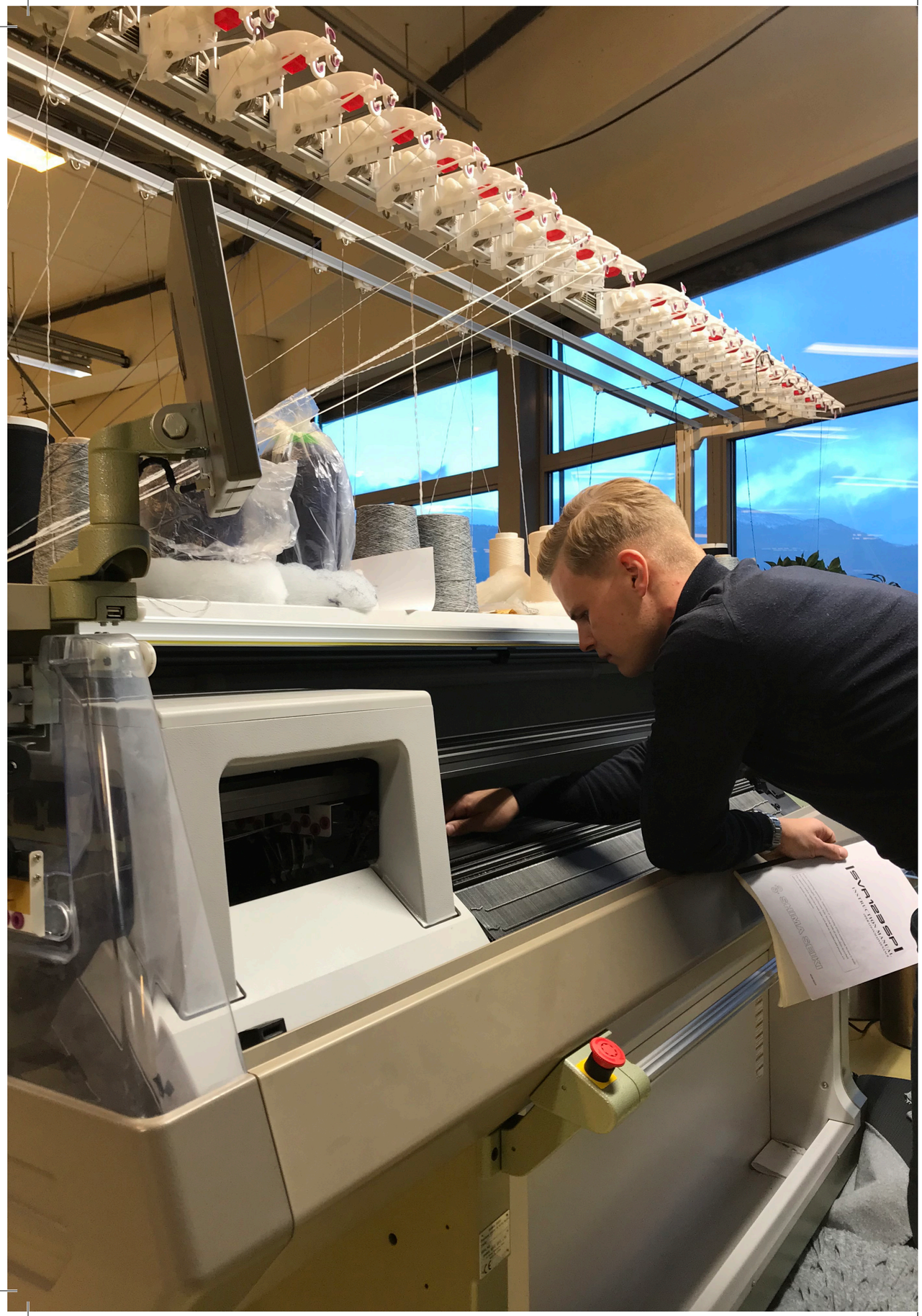

But this knowledge, understanding and exploration of 3D digital knitting technology is rapidly growing in Norway, with its main hub located in Sykkylven, a remote area famous for furniture manufacturing. It is quite remarkable that furniture production has remained in the area despite the competitive manufacturing costs from abroad. This is a source of great pride among locals and also a unique selling point for customers who buy quality furniture produced in a Norwegian fjord and shipped directly to their door.

The retention of production in Sykkylven is possible through impressive automated production lines and a mutually beneficial collaboration between local companies. Møbelkraft is a cooperative platform that introduces new technologies to manufacturers in Sykkylven. They recognised that the biggest production cost is the labour required to upholster the furniture which is currently done by cutting fabrics and stitching them together, also producing a lot of waste. Amatec, a neighbouring company, became an agent for Shima Seiki, a Japanese manufacturer of digital knitting machines. Together they invested in two knitting machines that could be borrowed by local companies. Ekornes, has thus been the biggest user of these machines, recently investing in their own.

Despite having been bought by a Chinese company, Ekornes are adamant that production remains in Sykkylven, because of the skill-set of their operators. Optimisation of the production line is crucial and each operator is highly skilled in craftsmanship. Even though they are not hand crafting day to day, they understand quality, what it feels and looks like. Their production line is not simply about pushing a button, it demands an eye for detail and respect for the machinery, understanding how to tweak it just right. Developing this same respect for the 3D knitting machine is very important for Ekornes.

I visited Ekornes last March to learn about their explorations in 3D knitted structures and became curious about how the body interacts with the structures and textiles they showed me. When researching textiles for sensory therapy, I recognised an opportunity to use 3D knitting. I approached Ekornes in August with my idea and they generously allowed me the use of their machines, technicians and surplus yarns.

*Figure 5: A Shima Seiki digital knitting machine in snowcapped Sykkylven*



# *knitting expert*
# Tom Daykin

Tom Daykin is a 3D digital knitting technician from the UK. He started his career as an apprentice with Shima Seiki, the company that manufactures the 3D knitting machines. He then worked for 8 years in the fashion industry, producing prototypes based on garment specifications from designers. He knows everything there is to know about Shima Seiki 3D knitting machines!

Daykin moved to Sykkylven in the October 2019, to develop 3D knitting in Norway with Møbelkraft, but such is the growing interest in 3D knitting in Norway, they have set up a subsidiary called *3D knitting & technology*, whose goal is to promote 3D knitting around Norway across all industries, not only furniture. Many Norwegian companies are willing to invest in the technology but the main stumbling block is the lack of knowledge and experience in the operation and programming of these machines. Møbelkraft have been flying over experts from Japan and the UK for the last year. Daykin is now officially the first 3D knitting industry expert living in Norway!

These machines are rapid prototyping at its finest, but they are also delicate mechanical and electronic masterpieces that require fine tuning and intimate knowledge of how each component interacts with another to build up the 3D textures and shapes. The digital program is complex and not particularly intuitive. 3D printing programming, which we are more familiar with, requires the designer to produce a 3D CAD model, then the printer software generates a code to print the 3D shape. 3D knitting programming is quite the opposite, it requires the technician to build up a 2D simulation in the software, telling each needle what it needs to do to build up the 3D shape. Whilst this might not seem like the ideal operation, it allows the technician to have control over every single stitch that is knitted and hence more control over the properties and qualities of the material and shape that is produced.

This is a highly skilled task, one I certainly did not have time to perfect in the 10 days total that I spent knitting during this project. I was extremely fortunate to meet Tom on his second day in Sykkylven and he has been an invaluable resource to me, programming all my digital samples at Ekornes. I discuss my experience working with Tom in chapter 2 and our conversations and reflections on the benefits and future of 3D knitting in chapter 4.

*Figure 6: Tom Daykin changing the needles on the Shima machine in Sykkylven.*


# *knitting expert*
# Camilla Bruerberg

An unexpected and very welcome addition to my project was Camilla Bruerberg an artistic PhD candidate in digital knitting at Kunsthøgskolen i Oslo (KHIO). Bruerberg made contact with me the very first day of my project as she was interested in learning about how to integrate technology into a knitting process. She was also excited to expand her digital knitting network within Norway.

I travelled to Oslo for a two day workshop where I showed her what I knew about conductive knitting and in return she introduced me to KHIO's knitting room. She kindly allowed me to come back to KHIO several times during the project to use both their mechanical and digital machines.

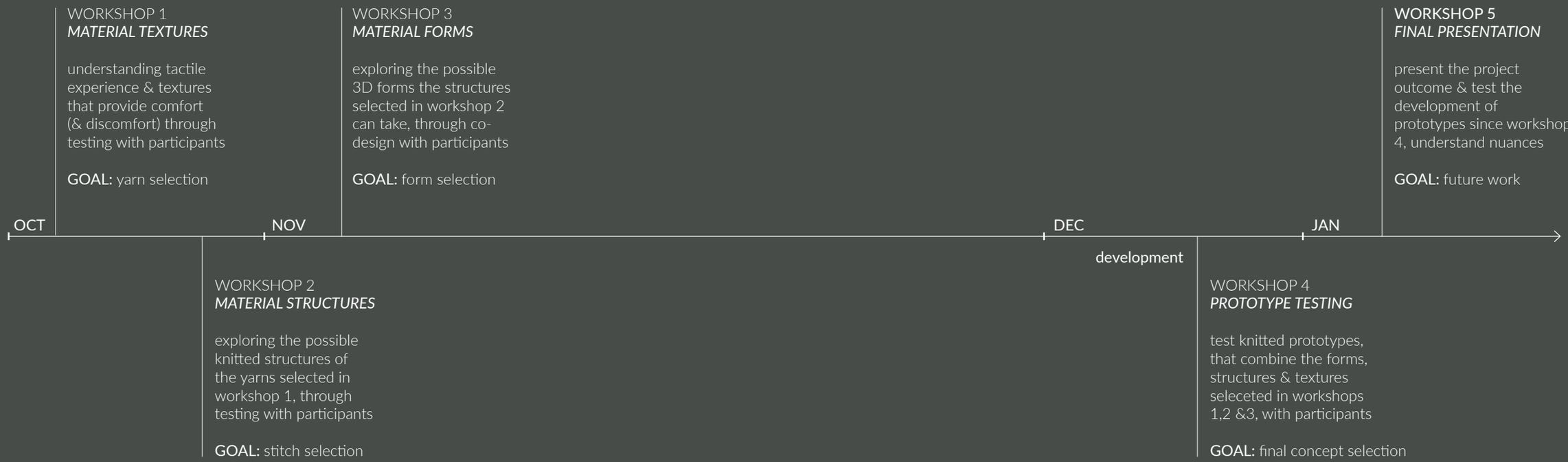
KHIO is a beautiful space and atmosphere to work in. I found it a very useful place to refine my sample development. Bruerberg completed both her bachelors and masters at KHIO and then worked as their knitting room technician, so she knows every machine inside out. This knowledge was invaluable to me. She also has developed a wonderful understanding of materials, their movements and qualities, the emotional possibilities embedded within knitting as an artistic expression rather than simply a functional and commercial sense, as is Ekornes' main focus. So she completely got what I was trying to achieve with this project and pushed me beyond what I even thought was possible, especially with the soft stimulatory textures in chapter 2.

Bruerberg and her own work was also very inspiring to me. She generously shared many of her insights such as digital vs mechanical making processes which fed into my own project. We also shared a mutual love of Anni Albers writings which are peppered throughout this thesis.

*Figure 7: Camilla Bruerberg's Shima Seiki machine in the knitting room at KHIO*

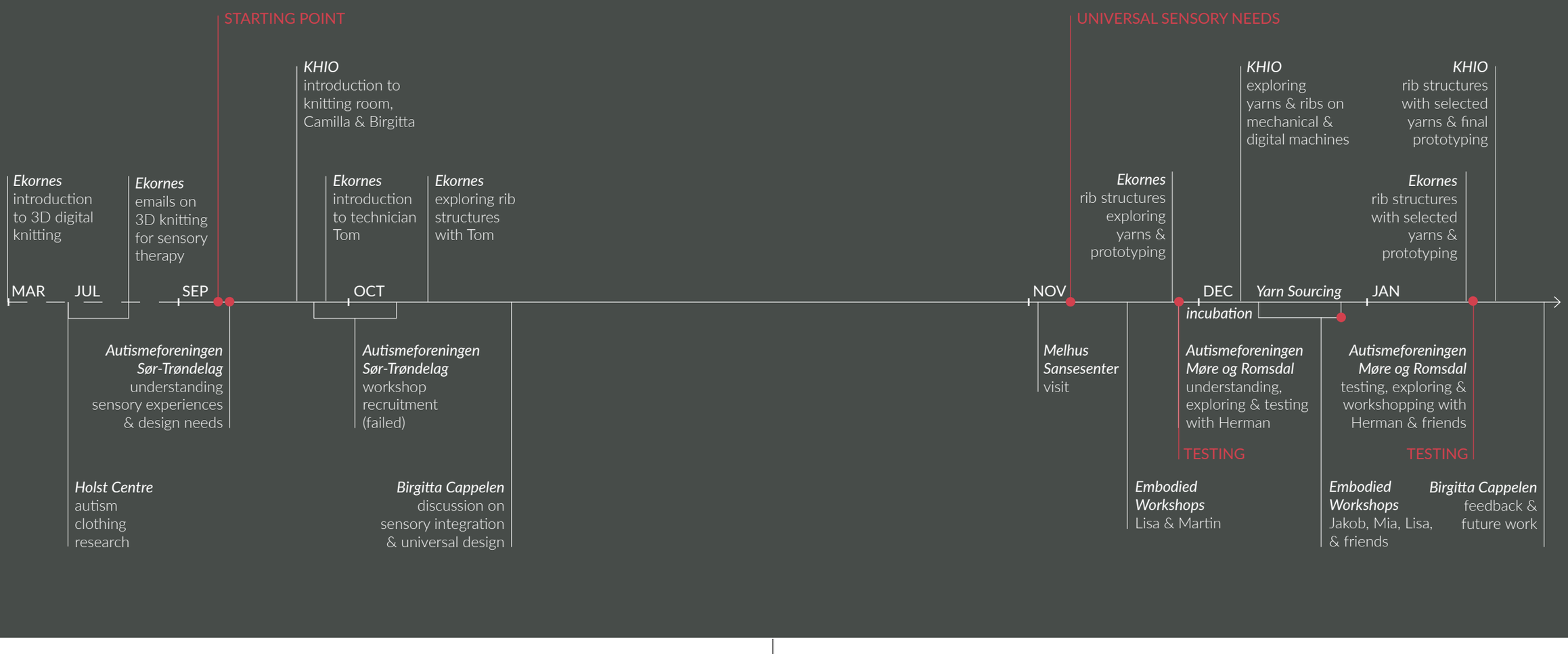
# initial co-design process proposal
## *with autismeforeningen*

*Figure 8: Timeline for my original project plan that didn't work out*



# actual project timeline

*Figure 9: Overview of my project timeline*



1

# Universal Sensory Needs

Before beginning this project, I prematurely defined my users as those that benefit from sensory therapy. The largest beneficiaries of sensory therapy fall within the autism spectrum, characterised as having an *unusua*l sensory profile. They can be irritated by, or avoid, certain tastes, smells, sounds and lights, with an aversion to certain materials against the skin or human touch. Each autist has a sensory profile unique to them.

However, the more I began to understand autists' sensory experience of the world, the less I seemed to understand what the world considers a *usual* sensory profile. The more I discussed my project with others the more I realised that we all have sensitivities. Each of us have unique sensory profiles, but perhaps not with the same intensity as those with autism.

Designers output sensory information into the world. We are trained to be sensitive to textures, forms and materiality. This chapter will discuss my realisation that if we design to consider those with more extreme sensory profiles then we create a better universal design that can benefit everyone.

# The Autism Spectrum

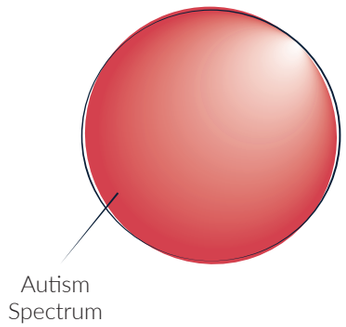



*Figure 10: The autism spectrum covers a wide range of experiences and intensities, it is "a big continuum from non-verbal all the way up to brilliant scientists and engineers." (3)*

In its simplest terms, autism is a neurodiversity, diagnosed by its characteristics that include challenges with communication and the processing of sensory information. An autist experiences the world around them with great intensity, affecting how they relate to other people and their environment. Autism is a different, rather than deficient, experience of the world.

The autism spectrum is so diverse, covering a wide range of experiences. Its definition and our understanding is still evolving. Each person on the spectrum is unique in their pattern of characteristics. The same characteristics can be both a gift and a disability, depending on the individual, the context; with whom they are interacting, the environment, the particular moment in time.

At present the autism spectrum includes Asperger syndrome and attention deficit hyperactivity, as well as more profound learning disabilities. In other words, those whose brain works a little differently to what the medical profession considers neurotypical. It is not a disorder that requires a cure, rather, it is a normal human difference that requires understanding.

To deepen my understanding of autism I began reading biomedical literature but quickly became disheartened by its one-dimensional view of autists. Whether neurotypical or neurodiverse, we are all complex human beings, unique and individual in our characteristics, personalities and personal tastes. Whilst there are common threads that weave through the spectrum that can assist with a diagnosis, I didn't agree with the concept of placing everyone into a specific box in a table based on particular characteristics.

Someone who agreed with me, and who I was very fortunate to be introduced to early in my project, is Birgitta Cappelen who is dedicated to enabling children with special needs to express themselves. She has written:

"traditionally within health research, we divide health into two main areas, the biomedical and humanistic. The biomedical health perspective focuses on the patient's diagnosis and disease. The humanist health perspective focuses on the person's resources, not his weaknesses, and on strengthening these resources. Here it is important to look at the entire context around the person and create the basis for positive mastering experiences ..." (4)

Positive mastering experiences would become a key element in my thesis. However, to design these experiences it was still important that I understand the biomedical symptoms of autism such as tactile defensiveness, sensory overload and communication difficulties. I approached these from the perspective of Dr A. Jean Ayres' theory that human behaviour is an expression of the brain (5). Through my design process I came to understand how:

1. what we design can trigger these autistic symptoms/sensitivities,
2. what we design can actually take advantage of these sensitivities to design positive self-regulatory experiences.

During my research phase I became uncomfortable with the language used to describe some autistic characteristics as a *weakness* or a *disability*. This did not correlate with the individual autists I met. There is a perception of *sensitive* people as weak, but what I learned through my process is that design has the power to disable or enable a person's strengths. At the forefront of my project was my determination to enable these strengths by involving, and learning from, autists and their experiences throughout my design process.

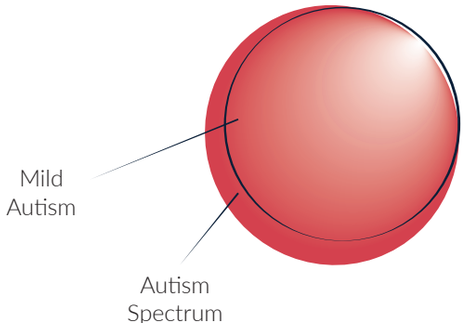



*Figure 11:*
*I chose not to work with users with severe autism, which I have represented graphically above as the group that fall outside the black circle. However, in reality there is no clear black line. The diagnosis and definition of autism is in such flux that it is difficult to tell when a normal human variance becomes severe enough (3). The evolving diagnostic process also means that exact numbers are not possible.*

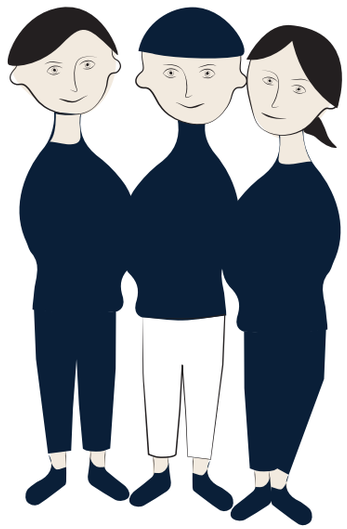


*Figure 12:*
*We interact with people with mild autism every day; our classmates, colleagues, co-habitants, partners, friends.*



# (re)defining my user group
## part 1

Narrowing down my user group within the autism spectrum was an essential step quite early. I recognised that there is a lot of great work already being done designing textiles for autists with severe learning difficulties. I specifically looked at the work of Katie Gaudion, a researcher at the Helen Hamlyn Centre for Design at the RCA in London, who uses textiles as sensory props to "explore and test the boundaries of their sensory sensitivities" (6). I also spoke with the leaders of the RHYME project here in Norway; Birgitta Cappelen and Anders-Petter Andersson, who collaborate on tangible media for children with multifunctional and severe disabilities. I realised that my short 20 week project could not compare with the projects these designers have dedicated their careers to developing, or contribute in a way that users with severe autism deserved. It is also important to note that although my observations and discoveries are still relevant to children with autism, many children have additional challenges that I do not cover in this project.

However, I was becoming increasingly inspired by the autists that I had met, and continue to meet, who described themselves as having *mild* autism. It is difficult to define *mild* autism as each person I met experienced the world in their own unique way and had challenges that were vastly different from each other. In very simplistic terms they all had a high IQ, often higher than average. They all had found social interaction and communication difficult but worked extremely hard to overcome these ongoing challenges. I came to understand that over-stimulation by sensory experiences was prevalent amongst this user group, which severely affects concentration and focus. These sensitivities were specific to the individual, which I have documented later in this chapter.

But the most important and over-arching description of people with *mild* autism is that they interact with us every day. They are our classmates, colleagues, co-habitants, partners, friends. They fight so hard to be functional team members, communicate effectively with us, contribute to our well-being and produce work of the highest level in a world designed for neurotypicals. They do this while simultaneously struggling to filter and process the overwhelming information that surrounds us and making sure we do not notice and they do not inconvenience us. They are a forgotten user group because they are so successful in hiding their struggles that their needs become invisible. I felt compelled to highlight and understand these needs.

# ‘ making sense of the world ’

Our brain's main function is to make sense of our world, both external and internal.  Living with autism was described to me as the brain working at full speed all the time.  An autistic brain has the ability pick up on details that neurotypicals might ignore.  This ability allows autists to see the world in a different way that can be extremely useful in solving complex maths problems, honing the most skilled handicrafts, composing beautiful pieces of music (3).

But working at full speed all the time brings its challenges.  The same ability to pick up on details, that others can filter out, can become overwhelming. Acute awareness of the tick of someone's watch, a clothing tag rubbing the back of your neck, bright sunlight in your eyes, can become all consuming. Therefore the ability to 'make sense' becomes inhibited.

During my first week I met with the mother of teenager with autism through Autismeforeningen, a Norwegian organisation offering support and advice for autists, parents of autists and others interested in learning more about autism.  Her son has mild autism and she has spent the last 10 years trying to understand how he experiences the world so she can assist him in enabling his strengths.  To help me gain empathy she spoke at length about how the inhibition of the 'making sense' function can affect communication.

She explained to me that every one of us has to find a way to make sense of, and communicate, our feelings.  She used love and anger as an example.  She asked me to consider how difficult it is for a neurotypical person to express love and anger and comprehend another’s love and anger.  Then imagine an autist whose brain is working at full speed all the time.  Imagine the frustration in trying to make sense of their own feelings, filter them, communicate them and simultaneously interpret the same in others.  Whilst a neurotypical can have some empathy for this state of overwhelm, it is almost impossible to fully empathise with the extent of this avalanche of emotions.

An outdated assumption is that autists lack feeling, in fact I found it to be quite the opposite.  Perhaps autists feel even more deeply than neurotypicals. Rather, it is the processing of those emotions (and later I would learn about the processing of sensations) that is lacking.  The accumulation of these processing challenges, both physical and emotional, causes overwhelm, disabling the function of these brilliant minds.



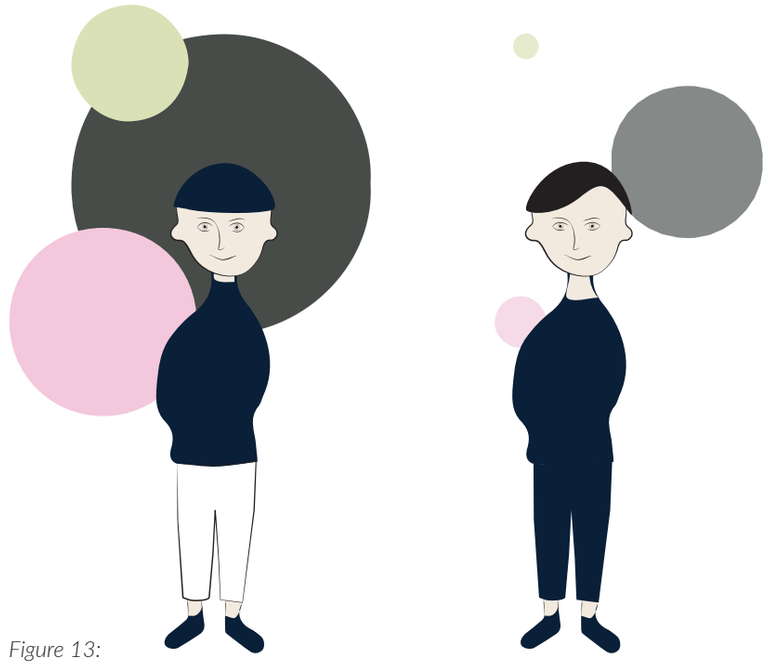


*Figure 13:*
*A person with mild autism experiences a more intense sensory world than neurotypicals, which brings with it both superpowers and challenges.*

'To feel' is multi-layered.  If you search for a definition of the word 'feeling' you are presented with four different definitions:

1. an idea or belief, especially a vague or irrational one,
2. an emotional state or reaction,
3. the sensation of touching or being touched by a particular thing,
4. a sensitivity to or intuitive understanding.

I had a feeling that definitions two and three were inextricably linked.  What sensations our body feels can affect how we feel emotionally.  This is by no means a new concept, but this entanglement is more heightened with autism.  What I needed to develop was a sensitivity to the feelings of autists, in every sense of the word.  To do so I needed to get reacquainted with my own sensory experience of the world and make sense of how I use those experiences as a designer.  My first step was to go back to basics and make sense of the fundamentals of 'the sensation of touching or being touched by a particular thing', and let the autists guide me in their experience.

“ Ours senses are in constant dialogue with our surroundings. The colour of a wall, the texture of a chair cover, the intensity of lighting, build-up of odours, and breeze from an open window are examples of sensations that we can experience all at the same time. Typically our brains process this kind of sensory information automatically and formulate a response.

The abilities of people with autism to interpret, perceive or regulate sensory information can be impaired; leading to them being overwhelmed or under-stimulated by what they sense. Living in an environment that does not take into account their sensory sensitivities can cause anxiety, which in turn can bring about unusual behaviours and diminish motivation and confidence. Therefore it is essential to provide environments, in which the visual, acoustic, odour and tactile qualities can be modulated to suit a person’s preferences and eliminate their sensory dislikes. (6) ”

*Katie Gaudion, textile designer & senior research associate at the Helen Hamlyn Centre for Design at the Royal College of Art, specialising in celebrating neurodiversity.*



# ‘ making sense of our senses ’

We have five primary senses: sound, vision, smell, taste and touch. The other two senses that have most significance to this project and autism itself, are the vestibular and proprioceptive sensory systems, which will be explained later.

This project works predominately with the tactile sense, touch. I chose to work with the tactile sense because my starting point was 3D digital knitted textiles and my background is in the design of things that touch our skin. But all senses deserve equal consideration, the tactile sense is simply where I think both I personally, and the medium of digital knitting, can have the most impact.

We use a combination of senses to help us navigate the world. They do not act in isolation. For example, “the concept of an orange is learned by sight, touch, taste, and smell, later the sensation from only one of these sources can activate the engram for an orange and the other associated stimuli.” (5)

Therefore it is important to consider how the visual aesthetics of a material could draw or repel someone, how the sound the material makes when touched influences the tactile experience, and how pleasant or unpleasant odours from the material can colour the user’s experience. We also know that when it is not possible to utilise one sense, for example if the material is used in the dark, then the other senses are heightened.

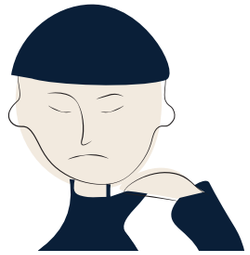
Most of us are familiar with these senses but perhaps have given little thought to how we experience them, we just do. I was constantly amazed at the self-awareness of autists whom I spoke with. They were so clear in their sensory aversions, which environments inhibited them and those in which they thrived. As a young boy with autism, Neil, said in his online video "it is important that we get to know our own bodies and understand our senses" (7). After my experience with this project I would recommend this for everyone.

Given the autists' impressive awareness of their own bodies, I think they are best equipped to explain our senses, and their unique experience of them. In the following pages I have transcribed Neil's experiences from his video (7). It is important to remember that each autist is unique in their sensory experience but the experiences I selected were commonalities that I mapped throughout my research, particularly with children and teenagers.

# autists' sensory experiences

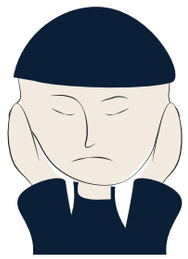
## TOUCH

"Some people don't like to be touched and I don't like my hands to be messy because they feel bad.  Touch is the tactile sense and if you are not used to having things touching your skin it can make you feel uncomfortable sometimes.  Certain clothes and tags can really feel not right ... most people get used to the uncomfortable clothes but for me I just can't think of anything else apart from the tag that is bothering me.  I will tug at it and want to take it off the whole time I am wearing it."



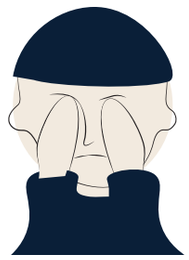
## SOUND

"We get the sense of sound through our ears.  When the sound is too loud I can't concentrate on anything except stopping the loud noise.  I have a really hard time with vacuum cleaners ... Classical music makes me feel relaxed."



## VISION

"Our eyes are how we use our sense of vision.  Some people like bright lights and lots of things to look at.  But I get too distracted if there are lots of things to look at.  I like things to be in soft colours and organised.  When I walk outside the sun is always so bright it hurts my eyes and I can't look up."

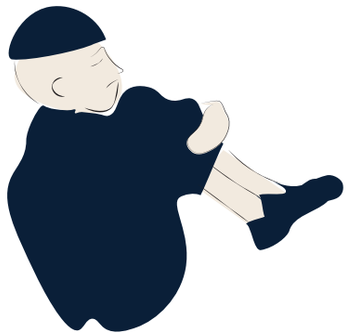


## PROPRIOCEPTION

"You get proprioceptive input every time you get input through your muscles and joints.  It sends a message to your brain that this is where I am and this is what I'm doing.  You need proprioceptive input to help your body do everything it wants to do like riding a bike, carrying something heavy and even getting dressed.  By doing more with your body you can get more proprioceptive input.  This helps me feel better, when I feel like my body is out of control I like to jump or get wrapped up tight in a blanket.  Proprioceptive input helps me to calm down and organise my body."

## VESTIBULAR

"We all have something in our inner ear that tells the brain whether we are balanced and whether we are moving.  It tells my brain whether I am right side up, upside down, moving forward or moving backwards.  It is what tells us that we are dizzy and better stop spinning.
If our brain is under-responsive to vestibular input then our body wants to constantly move and spin and we never get dizzy.  If your brain is too responsive to vestibular input then you feel off balance.  It makes it scary to do activities where you have to tilt your head back or your feet are not flat on the ground."



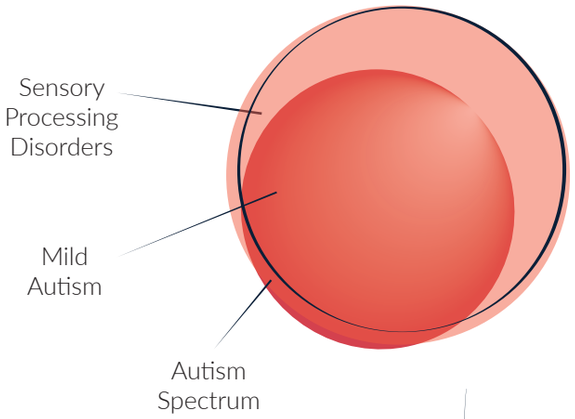



*Figure 14:*
*A graphical representation of how sensory processing disorder affects most people with autism, but not everyone with a sensory processing disorder is diagnosed with having autism. Exact numbers again are difficult to define.*

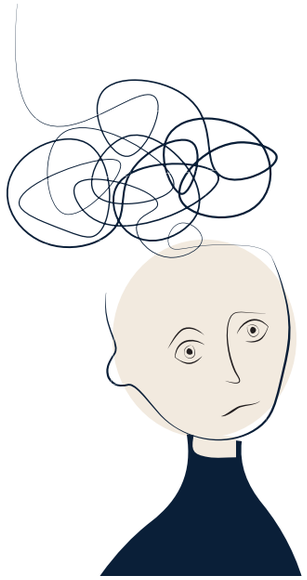


*Figure 15:*
*A disorder of the senses can mean the messages that your brain gets from sensations are not organised.*



# Disorder of the Senses

The process of responding to, organising and interpreting information from our senses is called sensory processing. How we use this information is called sensory integration. Autism is often decribed as a *disorder of the senses* because how the information is processed can lead to difficulties integrating it (16). A neurodiverse person's reaction to stimuli can often be considered *problematic* because they have processed the stimuli as something different than what is processed by a neurotypical person. For example, a loud noise or scratchy surface is processed as dangerous, resulting in a defensive action.

This is put forward as a hypothesis as to why autists have high arousal or anxiety levels (16). As the body's nervous system becomes overwhelmed by the build up of these negative reactions to the threat of danger, the body's response can be observed in motor, language or behavioural difficulties, such as poor concentration and meltdowns (3).

I learned that *sensory processing disorders (SPD)* are not limited to persons with a diagnosis of autism. This means that the body's negative reaction to certain stimuli affects a much greater percentage of the population than autism alone. My user group was expanding, as depicted in the diagram opposite.

A disorder is defined as a disruption to the systematic functioning of something; a state of confusion. Confusion suggests the brain's 'making sense' function is disabled. This is best described by young autist Neil:

"SPD is when the messages that your brain gets from your senses are not organised, so you don't respond to things like most people. This makes it hard to do every day life stuff, like getting ready for the day, going to school, eating and playing (...) Some times of days are good and some are too much for me. I don't like loud or busy places. I cover my ears and I want to run away and tell everyone to be quiet. I need less noise to feel in control of my body. I like to always be moving I have a hard time holding still. I don't like people to touch my skin sometimes. But everyone is different. (7)"

# sensory processing challenges

Sensory processing is the conversion of a sensory stimulus from one form to another, i.e. a physical stimulus is converted into an action potential. In other words, a sensation can affect a person's behaviour. In very basic terms this involves three steps:

1. sensory receptors detect the stimuli,
2. sensory stimuli are transduced into electrical impulses that travel to the brain along neural pathways,
3. the brain processes and decodes the impulses into useful information.

Perception is about making sense of the stimuli. It is this perception that determines the reaction of the human. In Neil's case he perceives loud noises as something dangerous so his natural reaction is to run away. His sensory perception resulted in a defensive action. With others a scratchy surface can be perceived as something to fear so they physically pushed it away and withdraw from it. This tactile perception results in a tactile defensive action.

I spoke with staff at the neuro department at St. Olav's hospital where I learned that if you perceive a situation as dangerous then your sympathetic nervous system is activated, i.e. your body is in fight or flight mode. This makes you feel anxious and irritable, and can affect your sleep, ability to concentrate and digestive system. If you are surrounded by an array of unpleasant sensory inputs then the signals in your body get confused and you become stuck in this fight or flight mode, causing an anxiety attack.

Kate Gaudion goes further to explain that for autists “everyday sensations can be experienced an unbearable levels ... compromising their abilities to interact with the environment effectively and participate in daily activities” (6).

# opportunities for design

Once I understood the process of converting sensory stimulation into a reaction, albeit in rather simplistic terms, I identified opportunities where design has the opportunity to alter the tactile experience of the user.  Transduction and processing are firmly in the field of neurology, and I am very unqualified in this area to surmise about opportunities there.  Collection and reaction are human actions where the autist develops their own coping mechanisms, by avoiding the sensory stimuli and/or working with an occupational therapist to normalise the sensation of the stimuli and learn how to control their reactionary behaviour through the use of sensory props.  The compression vests and weighted chairs, that were my starting point, fall into this category.

However, there were another two opportunities that were emerging as more interesting to explore:

1. at the end of the process, design has an opportunity to promote self-regulatory practices that calm, comfort & refocus to relieve anxiety,

2. the root cause of the anxiety is the sensory stimuli that is put out into the world therefore as designers we have a responsibility to be more considerate during the selection and/or design of this stimuli.

# the value of universality

I would like to briefly introduce the value in universality that emerged in this project, firstly in terms of design but also in terms of building a network of experts and like-minded people who could support and inspire me.

Dr. A. Jean Ayres, famous for her work on sensory integrative therapy said "... any given person's thinking reflects the reasoning and factual contribution of other investigators. Without such interaction, the rate of growth of knowledge would be painfully slow. If I have been productive it is partly because I have had the advantage of contact with those with the courage as well as the ability to think independently and along unorthodox lines" (5).

I had successfully gathered a team of knitting experts in Norway and tried to do the same with autism experts and designers. I found that medical professionals would refer me to knitting products that already existed. They struggled to grasp the open ended nature of my research topic, i.e. I didn't know what the end product I wanted to design yet, rather I wanted to understand the root cause of sensory processing disorders. So I sought out other designers that had identified similar design opportunities and had experience working with textiles for autists. Rather than output something that was another version of the same thing I needed to build on their research, experiences and knowledge.

This was extremely beneficial in October when I was struggling to recruit autists for participatory workshops. The next few pages analysis the insights from other designers and experts that influenced my project. Whilst this was very helpful it is still was no substitute to spending time with autists, testing and getting to know them and their unique experiences.



# *desktop research*
# Katie Gaudion

1. November 2019

Katie Gaudion is a Senior Research Associate at the Helen Hamlyn Centre for Design at the Royal College of Art, specialising in design for neurodiversity. For her MPhil, Gaudion designed a range of non-age or gender-specific textile toys to stimulate the primary senses and encourage movement and play for adults and children with sensory processing dysfunctions. She strongly believes that as designers we need to take advantage of our sensory training to help others.

For her PhD, Gaudion worked with autistic adults with additional learning disabilities to understand how they use and experience their living environment, in particular sensory stimulation that causes anxiety and where sensory stimulation can give pleasure and comfort. Her user group had severe communication difficulties, and although this was not my user group, her work inspired me to develop collaborative design tools that would facilitate the user in guiding me in the design process.

*Figure 16: Katie Gaudion's stimulatory textiles from her MPhil at the RCA*

# *interview*
# Ellie Turner

29. October 2019

I came across Turner's work through an internet search for textiles and autism, and reached out to learn more.  Turner became a great support throughout my project, even advising on sourcing padding materials towards the end.  Turner also introduced me to the influential work of Katie Gaudion, discussed later.

For her bachelors project in screen printing, at Gray's School of Art in 2016, Turner designed, a range of interactive textiles for users with severe and profound learning disabilities, guided by her brother who has autism.  Turner screen printed on elasticated knitted fabrics to create interesting textures and stretch properties.  The key pieces of advice Turner imparted were:

- textiles should promote whole body interaction, not only touch,
- textiles should stretch to encourage a dialogue between two people,
- let the user guide me in what textures they like, never assume,
- there should be no wrong way to use whatever I develop,
- they should be adaptable for everyone.

Figure 17: Ellie Turner's screen printed interactive textiles



# *interview*
# Madeleine Oakley

25. October 2019

Oakley is a masters student at Derby University specialising in developing technical knitwear motivated by personal experiences with pressure vests and a desire to make them more sensuous for the individuals that benefit from them.  I came across her work on Instagram and reached out to learn more.  I was delighted that we could support each other during our respective masters.

With 3D knitting Oakley was able to create subtle pockets in soft wool into which the weights slotted, creating a beautiful textured pattern, hiding the weighted function from observers.  The key things I learned from Oakley were:

- sensory consideration within textiles is beneficial far beyond autism,
- there is nothing on the market for autists that is fashion conscious,  which greatly impacts their confidence,
- adaptive fashion is not possible within our current fast fashion culture, digital knitting offers a cost-effective means of counteracting this by allowing for rapid prototyping and customisation.

Figure 18: Madeline Oakley's 3D knitted weighted vest



# *site visit*
# Melhus Sansesenter

4. November 2019

I visited the Sansesenter (Sense Centre) in Melhus, which is a beautiful space consisting of a collection of rooms offering different sensory props and experiences which I got to try out. They adapt and customise the rooms for local children, and some adults, who have very individual behavioural problems. Their initial purpose was to treat autists' with sensory processing disorders, but they explained that they no longer require a diagnosis to use the facilities. They welcome anyone who sees a significant change in behaviour as a result of working with the sensory tools at the centre.

Inflatable and weighted vests, and some chairs, were available to borrow here but staff explained that they were unpopular. Whilst the pressure did provide comfort in one way, the vest caused discomfort in a multitude of other ways. For example the vests are difficult to move in, pressure across the breast area is not good for women, the material is very synthetic and sweaty, the aesthetics scream “look at me ... I have something wrong with me!”.

Their most popular item was a simple rectangular bean bag that could be sat on in many different ways, and could be placed over the body, or pulled around the body, much like a weighted blanket. Staff said they had now gotten these for their own homes! Their social worker and occupational therapist had the following advise for my design development:

- sensory therapy is for everyone,
- we all should get to know our sensory preferences and how to calm our own bodies and minds,
- everyone needs a hug, but not everyone likes to be hugged, hence the application of deep pressure stimulation (discussed further in chapter 4),
- the user needs to explore by themselves,
- the user may need to hide from sensory stimulation and must be in control of how they re-emerge and access it,
- it should not be a defined garment or a chair, but rather furniture that you wear or clothing that supports the user,
- it must be easily adaptable for different users.

*Figure 19: copyright of Melhus Sansesenter*

# *interviews*
# Birgitta Cappelen

31. October 2019, 21 & 22. January 2020

Birgitta Cappelen is an associate professor in interaction design and design for diversity at the Oslo School of Architecture and Design (AHO). She was initially introduced to me by the fashion and textiles staff at the Oslo Academy of Arts (KHIO) when I had a workshop with them on conductive knitting.

Cappelen co-created RHYME with Anders-Petter Andersson (NTNU), a project with the goal to improve the health and life quality for persons with disabilities, through co-creative tangibles. I called Cappelen for advice on developing interactive textiles and co-creation with autists, however her experience fed my project on a much deeper level than I anticipated.

During our call Cappelen raised three very interesting points that became the cornerstone for my project:

1. everyone has the right to positive mastering experiences, i.e. equal participation or controlling of an environment,
2. we are all uniquely sensitive, and should be encouraged to be so,
3. as creative designers we are trained to be highly sensitive and we should use this to gain empathy for inclusive sensory design.

Cappelen also referred me to the work of Kate Gaudion, as Turner had done. Whilst Cappelen and Gaudion disagree about the benefits of integrating technology into textiles, both agree that “a designer’s deep understanding of the sensory qualities of materials, skills in making and spatial/visual thinking has the potential to develop new modes of non-verbal communication, dialogue and understanding around an autistic person’s everyday experiences in a way that is separate to, but equally valid as, the medical approach” (4).

Cappelen also introduced me to Dr A. Jean Ayres’ *Theory of Sensory Integration* (which I discuss in chapters 2 and 4) and was a strong advocate for it to be used as the basis for universal design. Cappelen's greatest words of wisdom were that "health is something we own. We control what our healthy looks and feels like and we have the right to the resources to maintain this health despite any limitations we might have." She encouraged me to explore this through whole body interactions in an embodied design process.

# design requirements

**I had already defined my overall design requirement as the consideration of everyone's unique sensory preferences; understanding what causes anxiety and what gives pleasure.**

**However, through collating the experience and advice of the experts I consulted with, there were several other red threads emerging which formed the following requirements:**

1. **the product should promote self-regulation and positive mastering experiences,**
2. **the product should enable the user to hide from sensory stimulation and control of how they re-emerge,**
3. **the product should consider the whole body interaction and the embodied experience,**
4. **the movement in the product should create a dialogue between the material and the user; a push and pull, a to and fro,**
5. **the product should not be one defined object, it should be adaptable, the perfect match for that particular user for that particular moment,**
6. **the product should encourage the user to explore,**
7. **there should be no wrong way to use the product, it should be “consciously designed to be ambiguous, to afford different interpretations and actions” (4).**
8. **the product should be universal in its intended use, addressing symptoms of anxiety not diagnoses.**

# *symptoms, not diagnosis*

Through my research I was already beginning to see that we all have our own unique sensory issues. We often develop coping mechanisms to tolerate the design around us rather than design being the mechanism that enhances our experience of the world. By breaking down the process of sensing I was able to step back from focusing on the diagnosis of autism, or sensory processing disorders, but rather shift the focus to the symptoms I wanted to address:

> *" anxiety caused by overwhelming sensory stimuli and/or unpleasant tactile sensory stimuli "*

This reframing of the project was beneficial in several ways:

1. Recruiting workshop participants

   The recruitment process for my participatory workshops could have been a thesis in itself, which I discuss in chapter 5. For example one person asked me, rather bluntly,

   "What do you mean by autism? I don't have full blown bicycle helmet autism but I'm on the spectrum. I'm pretty sensitive, can I get involved?" Therefore explaining the symptoms I wanted to explore became crucial.

2. Removing the stigma of the label 'autistic'

   The majority of autists that I spoke with were under 21 and quite proud of their diagnosis. They were very comfortable talking about autism and their specific needs with their friends, and found it helpful that more autists were now represented in the media and public eye. However, I found that older generations were more difficult to reach perhaps because of a hungover stigma from when there was less understanding of autism. For example I received this message:



> "I know someone who would probably be fitting but she doesn't talk to anyone about her diagnosis and wouldn't be comfortable being singled out as an autist for a workshop, I guess because she hasn't accepted it herself. I don't know enough about autism but maybe it would be easier to find volunteers if you take a step back from the term 'autism' and address the symptoms more than the diagnosis."

3. Gaining empathy for sensory sensitivities

   One of the purposes of these workshops was to gain empathy through observation. In our 2018 'design for society' class at NTNU we learned that empathy has two components; the affective component, an immediate emotional response, and the cognitive component. With the latter the empathiser sees or hears about the situation of the empathee and imagines the situation from his own perspective. I had read about the challenges of developing cognitive empathy for the experience of living with autism, however I found that concentrating on specific sensory experiences was an effective approach.

   Chatting among friends and colleagues about my project, it became clear that many were aware of the social and communication challenges associated with autism, but most were unfamiliar with the sensory issues. To explain these I would tell an anecdote that I had read or heard from an autist about their sensory sensitivities. I became increasingly surprised how others could then draw empathy by relating to their own sensory sensitivities. Whilst they could not possibly fully relate to the experiences of living with autism, there were little snippets, maybe one shared experience, that they sympathised with.

   Much like the spectrum of autism, sensory information is experienced at different intensities by the individual. This is not limited to the neurodiverse. We all take in and use sensory information differently. For example, some of us enjoy sitting on a train watching other people, listening to the sounds, and reading a magazine whilst other people are more relaxed when they can block out some of the sensory inputs and close their eyes while listening to music with headphones on. Some experiences shared by neurotypical people I spoke with were:

"Loud noises aren't even really the problem.  I have to leave the room or wear headphones when the volume level is so I can't pick out a distinct conversation, feels like someone is constantly whispering in my ear, ... I'm getting worked up just thinking about it!

"Every morning I walked into my office and the bright fluorescent lights overhead automatically turned on.  Who decided that's what I needed!  I was getting headaches, I couldn't do my job.  I've put a sticker over the sensor now, bought my own desk lamps that I turn on as I need them."

"I can't be in the same room as people wearing strong smelling cosmetics, or have washed their clothes in that artificial flowery detergent.  Its all I can think about.  Its even worse when its on my own body as there's no escape!  I can't concentrate on anything except getting rid  of the smell."

"My mother-in-law keeps knitting me mittens for Christmas.  My hands feel like they are on fire when I put them inside, but I have to wear them because she made them.  She stands there talking, I can't even hear what she's saying as all I can think about are getting the mittens off!"

Whilst these are less extreme than the autists' sensory experiences, that I discussed earlier, negative reactions to sensory stimuli clearly extends beyond the autism spectrum and sensory processing disorders.  Although, the threshold for tolerance of the sensory stimuli seems to be higher and defensive actions are restrained, suggesting the anxiety experienced is not as intense as someone on the autism spectrum.  However, focus and concentration is still greatly affected.  The importance of adaptability and personalisation of sensory experiences was also being highlighted.  I felt that their experience was equally valid and diverged my user group to include, what I have called, *sensitive* people.



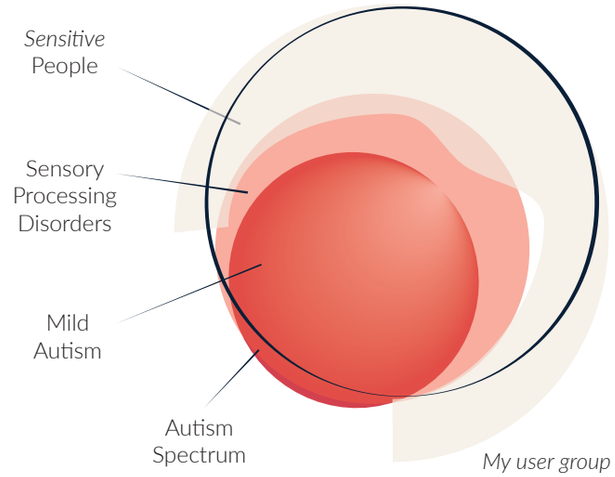


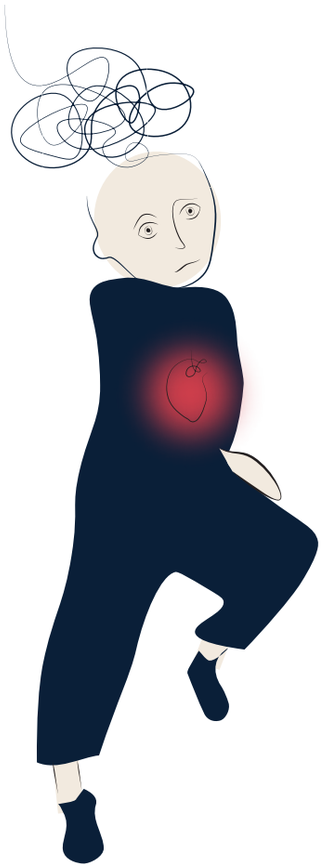

*Figure 20:*
*My user group diverged to include sensitivities that affect focus and concentration*

4. **Gaining empathy for anxiety**

Many of us have suffered from anxiety at some point in our lives and can sympathise with this experience. However, the idea of becoming stuck in this state of fight or flight is unfathomable for most.

A friend who has been learning to overcome her anxiety attacks, explained the similarities with her own experiences, except instead of negative sensory input she is triggered by negative thoughts. She was described by her doctor as having "an over active alarm system which is constantly activated, so all she can concentrate on is turning it off. Anne in crisis is not Anne. She cannot stay present as her normal functions are disabled."

The purpose of these empathy building exercises was not to diminish the experience of living with autism. Neurotypicals can never fully know what its like to experience the world with the intensity it is experienced by people with autism. Even users on one part of the spectrum can never fully grasp the experience of someone on another part of the spectrum. But each of us can take the time to try to understand their experiences by finding even a little snippet of their experience that we can relate to, after all "the world needs different types of minds to work together" (3).

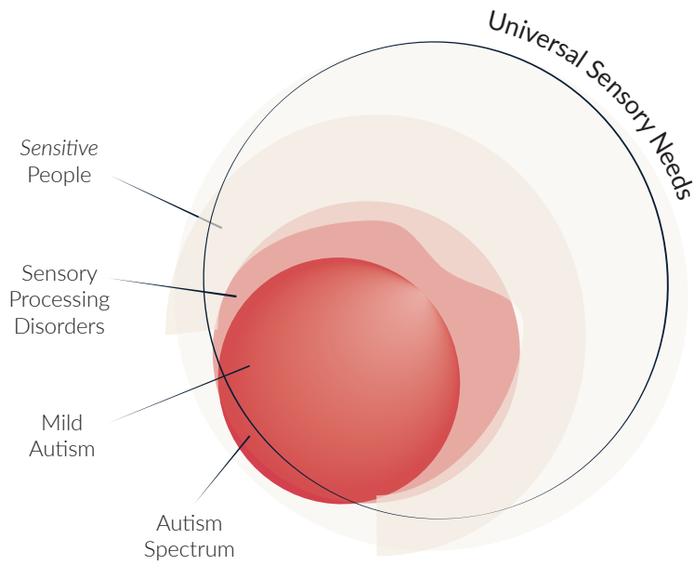




# (re)defining my user group
## part 2

Autists* would remain at the core of my user group but my hypothesis was that by designing for their extreme sensory needs, we design a better world for everyone because:

1. by designing out sensory stimuli, that cause autists to have a negative reaction we can improve everyone's sensory experience,
2. by considering the sensory preferences of autists we can promote a positive self-regulatory experience for everyone,
3. if we work and live with autists, then by eliminating defensive stimuli and surrounding them with comforting stimuli, we enable them to preform at their optimum which benefits everyone.




*Here I am still referring to users on the spectrum with mild autism, however, I would like to consider their experiences in the future.

# my principles of universal tactile design

The term 'universal design' means that an environment or product should be designed so that it can be accessed, understood and used to the greatest extent possible by all people regardless of their abilities or disabilities. In 1997, a committee of 10, under the leadership of architect Ron Mace, wrote the seven principles of universal design, listed in table 1, overleaf (9)

Driven by legislation, their purpose is to ensure potential users are not excluded. However, I believe that to *not* exclude is not the same as to actively include. The concept of *not* creating an unpleasant experience is not the same as actively creating a positive experience. It is not enough to say that the product should *not* provoke a strong negative reaction in the user. A neutral reaction is not a successful design either. In terms of designing for a tactile experience, I would argue that a design is not successful simply because the user does not withdraw from it. To be successful the user must want to immerse themselves in it because it feels so pleasurable and empowering.

Birgitta Cappelen, who I introduced earlier works with, Anders-Petter Andersson, a professor at NTNU Gjøvik. They have written extensively about how "designing for health-promotion represents a much more ambitious and complex design challenge than the 7 Principles of Universal Design represent." (4) Cappelen and Andersson are passionate about designing for, what they call, health-promotion. Health-promotion includes self-mastery, which in the context of this project is an autists' ability to work to their full potential in their environment and self-regulation during sensory overload and overwhelm.

During our second meeting Cappelen advised me to define what environment I want to promote and what action I want to understand and develop. Although my exact definition evolved the more I researched, prototyped and tested over the course of the project, it has been centered on the following:



**I want to promote self-mastery by providing the tools to facilitate all users in creating their own pleasurable tactile experience, by developing:**

- **a knitted surface texture that does not evoke tactile defensiveness but evokes pleasure,**
- **a stimulatory knitted texture that calms and refocuses,**
- **form that affords the user adaptation of their environment to self-regulate.**

With this definition in mind, I formulated my own set of design principles to develop this product, listed in table 1. Guided by the 7 principles of universal design I considered their correlation with my own findings. Inspired by Cappelen I also considered how I can actively design for diverse users in a way that allows them to express themselves and create meaning over time.

I realised that the principles of universal design should also extend to my design process. I recognised that to design an inclusive product I needed to invite users to, not only use their voices to tell me about their experiences, but to use their bodies to show me their experiences and guide me in enhancing these experiences. Two design methods emerged:

1. iterative testing of the tactile experience of materials
2. embodied design workshops.

These methods and design principles form the basis for the rest of the project.

| UNIVERSAL DESIGN PRINCIPLE | DEFINITION (9) | | MY RELEVANT FINDINGS | MY DESIGN PRINCIPLE |
|---|---|---|---|---|
| **1. EQUITABLE USE** | The design is useful and marketable to people with diverse abilities. | | Users with tactile sensory processing issues are prevented from participating in experiences because of tactile defensiveness. | The design should not provoke tactile defensiveness but invite an interaction that promotes a positive tactile experience. |
| **2. FLEXIBLE IN USE** | The design accommodates a wide range of individual preferences and abilities. | | Everyone's pattern of sensory experiences and needs are unique to the individual and equally valid. | The design should be easily adaptable and promote playfulness to explore and understand their sensory limits and needs. |
| **3. SIMPLE & INTUITIVE USE** | Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level. | | When users experience sensory overwhelm their ability to understand complex instructions or scenarios is inhibited. | The design should promote calmness by avoiding unnecessary complexities that could enhance a state of overwhelm. |
| **4. PERCEPTIBLE INFORMATION** | The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities. | | My design should consider that the user may have difficulties processing visual information because they are in a state of overwhelm. | Affordances in the product should not need to be heard or seen, they should be felt, promoting intuitive use. |
| **5. TOLERANCE FOR ERROR** | The design minimizes hazards and the adverse consequences of accidental or unintended actions. | | A feeling of calmness cannot be promoted if the use of the design requires vigilance or invokes fear. | There should be no wrong way to use the design, promoting trust between the user and the design. |
| **6. LOW PHYSICAL EFFORT** | The design can be used efficiently and comfortably with a minimum of fatigue. | | Sensory overload causes anxiety so we need to reduce energy levels to calm and refocus. | The dimensions, weight and malleability of the design should not require high energy movements or strength, promoting an uninhibited feeling of limitless possible interactions. |
| **7. SIZE & SPACE FOR APPROACH & USE** | Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility. | | Easy use and adaptability of the design should be possible for all. | |

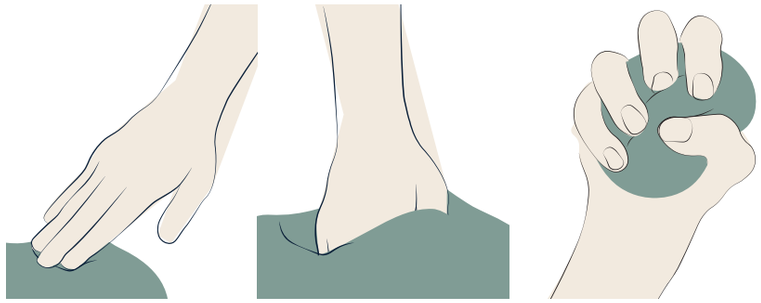
# Prelude
## *to chapters 2 & 3*

In Chapter 1 I identified that through understanding the tactile experience of users with autism I can design, not only a better tactile sensory experience universally, but real sensory pleasure. The physical making and testing part of this project became about exploring this sensory pleasure through the medium of 3D digital knitting. The goal was to create some type of 3D knitted form that comforted, calmed and refocused the user. The knitting process could create both the material and the 3D shape simultaneously.

I started prototyping early, which helped me learn about the possibilities and limitations of 3D knitting. In parallel findings were gradually emerging, through my research into autism, that informed the qualities that should be embedded in the form. However, materials consist of a multitude of properties and an array of elements make up a shape. The combination of particular material properties with certain shape elements give form. Changing any of these properties and elements give a completely different form. About half way through the project it became very clear that it was necessary to break this form-giving into smaller separate pieces.

# Kanz's touch

The tactile sense is not only what we feel under hand but also what we feel against our skin and around our skin. The skin is the body's largest organ and arguably its most sensitive. Experimental psychologist David Katz argued that touch was the most prominent sense in his 1925 book *The World of Touch* (32). This book is revered for its theories on tactile perception, but I found it too intellectual for a project where I wanted to observe lived experiences and create tangible surfaces and structures. However, I did find his text helpful in explaining what he calls the three modes of touch:



1. surface 2. immersion 3. volume

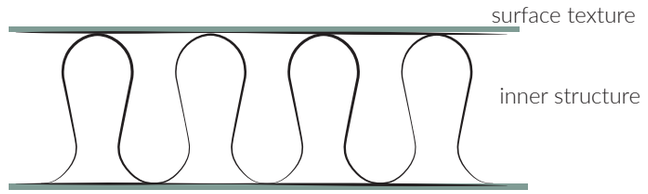
All three of Kanz's modes of touch are considered in the development process in this project. The user touches the surface of the textile and immerses their body in the textile. A starting volume is provided to the user but they are free to adapt the volume as they desire using both surface and immersive touch. But it became necessary to break this down further.



# Albers' tactility

Bauhaus weaver Anni Albers breaks down what it is in the material, in particular textiles, that our touch responds to: the combination of the surface quality and the inner structure (1). In reality it is not so simple to separate these; the yarn that creates the surface texture affects the overall structure, changing the stitch that creates the structure affects the hand feel of the same yarn. But I needed to simplify this to enable my user to make decisions.

Albers explains that normally the surface quality is the responsibility of the designer and the inner structure is the responsibility of the engineer. It is how these work together that create the tactile aesthetics (1). Fortunately with 3D digital knitting I was responsible for both the surface and the structure, with technicians on hand to help me understand their relationship.

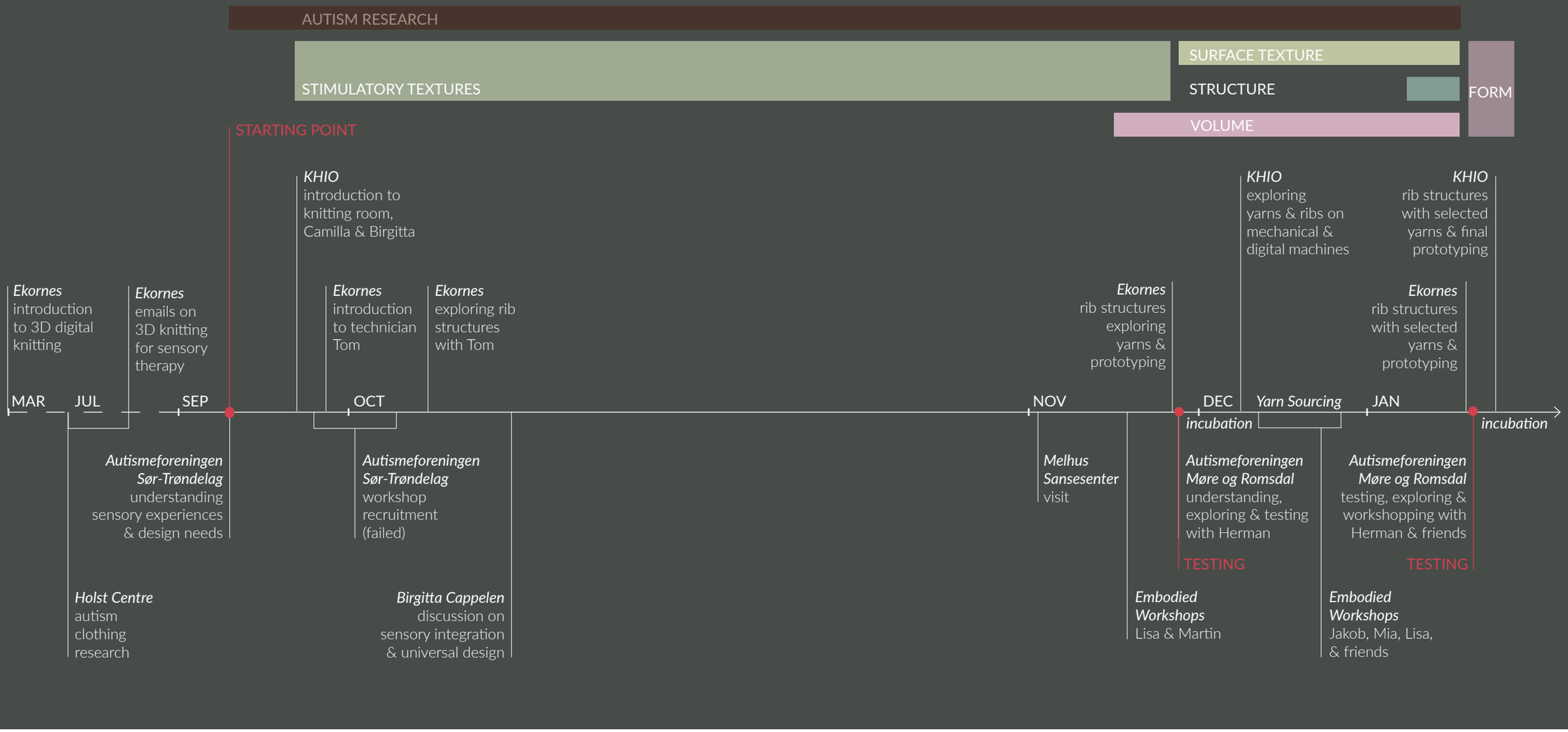



Marieke Sonneveld explains that tactile aesthetics influence the tactile perception and the tactile experience of the user. Tactile perception is determined through active touch of the physical aspects of a product, for example, texture, weight, balance, dynamics and material properties like elasticity and plasticity. The tactile experience is the response of the user to the physical aspects of the product, through touch (8). The physical aspects of the material therefore directly influence the response of the user.

I began prototyping by trying to develop both the surface texture and structure movement in unison but when user testing I realised that to determine what was working and what was not working I needed to separate their development and then bring them back together, as illustrated in the timeline overleaf. Although they were developed in parallel, the following chapters are broken down, as follows, to make it easier to explain my findings:

- Chapter 2 - texture development
- Chapter 3 - volume development

# *product development*



# 2

# Tactile Sensibility

In Chapter 1 I identified that through understanding the tactile experience of users with autism, I hope to design a better tactile sensory experience for everyone.  Chapter 2 is about understanding the tactile experience of one particular autist, Herman.  With his guidance and lots of iterative knitting, both manually and digitally I explore:

1. tactile defensiveness,
2. tactile pleasure,
3. transferring tactile memory,
4. the limitations of digital machines tactile,
5. my own tactile experience as a maker and designer.

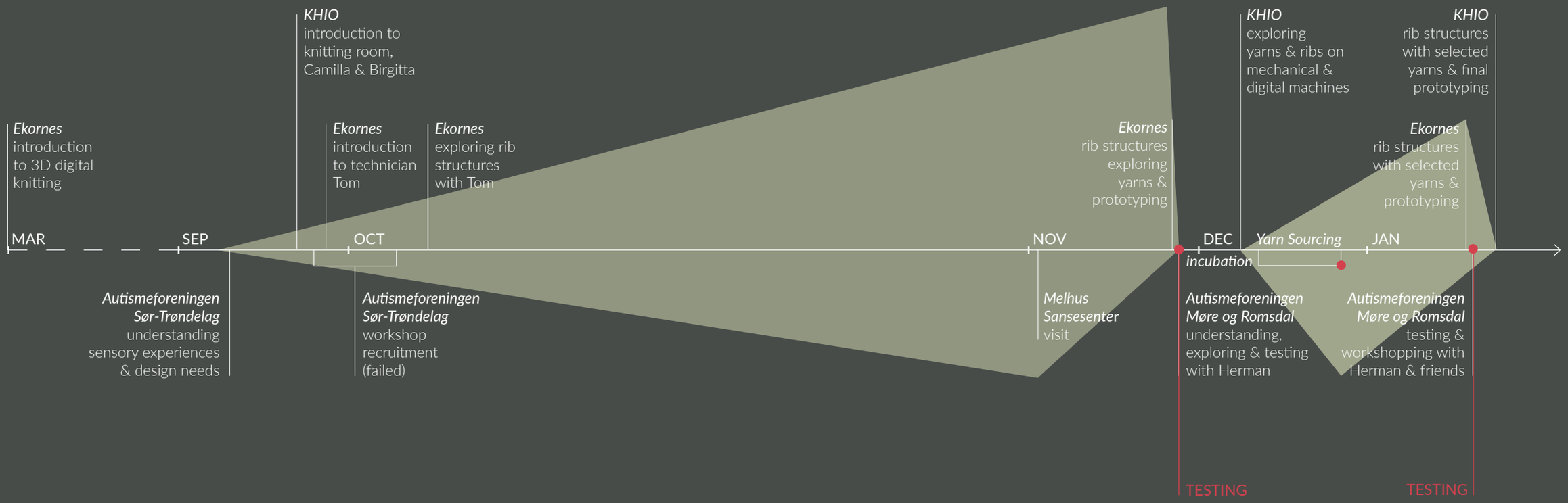
# *texture development*

TESTING WITH AUTISTS

SURFACE TEXTURE

STIMULATORY TEXTURES

STRUCTURE



# Herman
# & his Tactile Sense

By November I had spoken with a few people with mild autism, parents of children with autism, and professionals who work with people with autism. But I had struggled to find autists in Trondheim who were willing to guide me in my design process, although I reflect in chapter 4 how I could have approached this differently. As I was travelling to Møre og Romsdal, to use the knitting machines in Sykkylven, I reached out to their local autismeforeningen and connected with a teenager, "Herman" who has mild autism, and his mother. Building this relationship was a major turning point in my project.

Herman is 13, super cool, super stylish and a keen swimmer. He has a very high IQ and attends a local school. Herman is extremely sensitive to textures, particularly food and textiles. He has never liked human touch.

Herman is very engaging and exceptionally reflective for his age. I was quite taken by his self-awareness. He was immensely helpful in giving me an insight into what it is like to live, and thrive, with extreme sensitivities and how he manages sensory overload. For example, he has his own room in school where he can go to take time out to self-regulate if a situation becomes too stressful.

His mother has her own medical condition, so he has very much been raised with the attitude that we are all different, we all have challenges. These should not disable us but rather we have to be resourceful in finding ways to overcome these and use our own experience to be mindful of others facing obstacles in a world designed for the "typical" person. Herman and his mother became an inspiration for my design process and life in general!

Herman knows exactly what works and doesn't work for him. He was quite certain of his likes and dislikes, but he was also adamant that his preferences are individual and he is not representing everyone with autism.

Autism does not define Herman but is simply part of his everyday life. Both he and his mother are very open about his diagnosis. His mother is a speaker on autism and Herman is very keen to educate his friends on life with autism. Both were very happy to be identified in my thesis but I chose not to because of GDPR. I let him choose the pseudonym "Herman". The experiences I describe with this persona are predominately his, peppered with a few similar experiences that I noted in other autists I met around the same age.



There are many things that we choose to touch with our bodies, but often we have limited choices, for example the upholstered seats on a train, the towels in a public bathroom. I learned that many autists did not wear clothing as babies as it caused them so much discomfort, but societal convention dictates that as we grow up we should be clothed in public. But time and time again the discomfort of clothing came up as a major issue with autists. When I spoke with autists about 3D knitting the first thing they would ask was if I could eliminate clothing seams and labels. This is quite straightforward in 3D knitting; the clothing is knitted in a 3D shape so there is no need to join panels with seams, and compulsory label information can be knitted in as a pattern inside rather than an additional piece of material that rubs the neck.

Every time I met Herman he was wearing very very soft clothing like cotton jersey sweatpants and a jersey hoody. He told me that "I choose clothing based on how it feels not how it looks. It sucks that sometimes that means I stand out from my classmates."

The most prevalent feeling across those I met with mild autism, especially teenagers, was the desire to have the same choices as their peers. Whilst they are proud of their differences they still want to fit in with their friends.

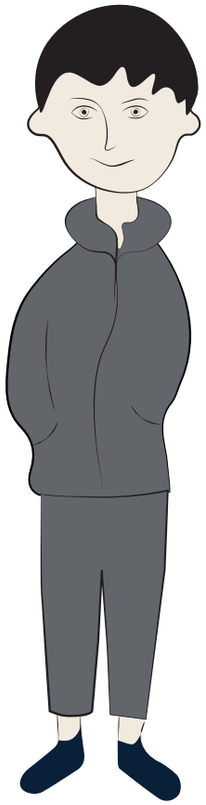


*Figure 21: Herman can only wear soft cotton clothing because of his sensitivities*

Common issues were:

"I can't wear tight elasticated socks they have to be loose and super soft. Otherwise I feel so trapped at my ankles."

"I want to wear jeans. I want to wear the same things as my friends but they are just too stiff, I can't relax and be myself. I only ever wear soft jogging bottoms. I found a pair of jogging bottoms that look like they are made of denim, so sometimes I cheat!  My mum bought me a pair of jeans recently so I've started trying to wear them to school one day a week.  I know when I'm older and want to look more professional I will have to learn to be comfortable in them.

Clothing also protects us from the elements, especially in Norway!  Herman described waterproof clothing as "the worst, its not so much the texture in this case its a combination of things and when they all merge together.... eewwhh. I mean firstly its so stiff to move in and its not breathable so I get really sweaty.  And the squeaking noise the fabric makes when I move ... aahh. Of course I'm wearing it because its raining and then I have to listen to the rain splashing on the fabric and then the more I move and the more it rains the squeaking noise turns into a squelching noise which I can't stand anyway but everything combined is just too much!"

*Figure 22: Herman is very sensitive to waterproof clothing, jeans and tight socks*



# Herman
# & my first prototypes

26. Nov 2019

*Figure 23: One of the first prototypes I knit with Ekornes using their softest yarn*

After hearing about Herman's sensitivities to textiles against his skin, I was worried that knitting was entirely the wrong medium for me to be exploring.

I had already had two knitting sessions with Ekornes where we developed stimulatory textiles that I will discuss later.  Ekornes' brand is centred on longevity, wear and tear, as exemplified in their leather upholstery.  Their furniture is marketed as investment pieces, so it is vital for them that the yarns they are knitting with endure the same wear tests as the leather and woven textiles they currently use.  As a result their yarns are very hard.  The softest yarn that I could find in their collection, to prototype in, is pictured above.

I presented this prototype to Herman and his physical repulsion was immediate. He jumped back as he touched it and quickly pushed it over to his mother. The displeasure it caused was etched across his face.  There was no way he was putting it around his body.  This was quite a blow for my development and designer ego, but a very necessary one.  I had read about tactile defensiveness but to witness it first hand was a crucial experience for me as a designer.

# Herman's Tactile Defensiveness

Sensory integration was defined by Dr A. Jean Ayres in 1972 as “the organisation of sensations for use. Our senses give us information about the physical conditions of our body and the environment around us ... the brain must organise all our sensations if a person is to move and learn and behave in a productive manner.” (5)

Ayres was an occupational therapist interested in “human behaviour as an expression of the brain” (5). She worked with children who exhibited behavioural problems and were considered to be troublesome, but she recognised that they had “hidden disabilities” related to the “dysfunction in sensory integrative processes”, a syndrome "closely and directly associated with emotions" (5).

Ayres first wrote about observations she had on tactile defensiveness in children in 1963, "characterised by deficit in tactile perception, by hyperactive, distractable behaviour, and by a defensive response to certain types of tactile stimuli" (5).

Ayres believed that the tactile stimuli was sending a message " warning the organism of danger and to prepare to flee or fight. This type of interpretation of tactile stimuli leads to the over-alertness of distractability, the flight-like behaviour of hyperactivity, and a tendency toward negative affect (fight)." (5)

*Figure 24: Certain textures can cause Herman to have a defensive reaction that affects focus and stress levels*



## Meltdowns

Herman's reactions are no longer considered troublesome behaviour. Our understanding of autism has evolved since the 1960s. But it can be very stressful on the autist and others around them especially family members. I spoke at length to Herman's mother and her neighbour who also has a child with autism. They told me about autistic *meltdowns*, when the body becomes so stressed and overwhelmed that the autist cannot focus on anything and must be left alone to clam down. They explained that unpleasant sensory stimuli, in users with mild autism, was unlikely to solely cause a meltdown but that it might be the tipping point in an already stressful situation.

The most distressing part for a parent is watching their child in a state of meltdown as they are unable to help in any way. I asked how they coped with their own stress and both mentioned hiking, being in nature, creating their own space, where they are in control, away from everyone else. They concurred that this is what autists need during their meltdowns; to create their own space, where they are in control, preferably with natural elements, away from others. Self-regulation is internal and can only be done by the autist.

When neurotypicals are in a state of stress it is possible to hug or hold them to help calm them down. But human touch can exasperate an autistic meltdown. In such a situation an object that can facilitate the autist in hugging themselves or the provision of tools that the autist can use to comfort themselves are very useful. In these circumstances pleasurable tactile stimuli can actually enhance the process of self-regulation.

*Figure 25: Certain textures can calm Herman*



# Herman
# & the cashmere genser

I met Herman in his own home, which was more important than I first thought. Of course it was a space in which he is comfortable and familiar but it also meant that he was able to show me his life and natural reactions more clearly than had we met in another space.  It also allowed him to take control and show me his belongings, rather than me simply show him what I had made.

After I had given Herman my first prototype to test he left the room.  I was worried that I had upset him with the hard knitted sample but he returned, upbeat, and presented me with his mother's cashmere sweater and told me "I want it to feel like this".  He waited for me to take the sweater in my hands and feel how fine and soft it was.  It was beautiful to touch, so soothing.  I was embarrassed by the hardness of my first prototype in comparison.

Herman's reaction to holding the cashmere could not have been more different than when he touched my prototype.  Rather than pushing it away and screwing up his face, he lit up as he pressed it against the side of his head.

It is difficult for us all to express what we like or dislike, and even more difficult to articulate why we like or dislike something.  I thought this would prove even more difficult with autists but in fact Herman's aversion to many textures and the pleasure he got from just a few textures made my job easier.  The direction was crystal clear,  albeit it was apparent he had expensive taste!

The first half of my meeting with Herman had been focused on all the textures he didn't like.  I sat there making lists of all the things that I should design out of the product.  I had forgotten about the pleasure I had the power to create. Herman didn't want to dwell on what he found problematic, his mood elevated when he began showing me the textures that he loved.  He showed me how he would lie on his sheepskin rug when he needed comforted, shown in figure?. On my second visit he introduced me to his friend's dog that he was looking after, shown in figure? He sat and stroked the dog as he spoke with me.  You could see the calmness and joy wash over him.

It was still important for me to consider tactile defensiveness but I was now focused on how design can elicit a pleasurable tactile experience for Herman.

*Figure 26: One of the first prototypes I knit with Ekornes using their softest yarn*

*Figure 27: Herman's friend's dog that he loves to stroke*

*Figure 28: Herman's sheepskin rug that he lies on to find comfort*



# designing for Herman's pleasure

The Oxford English Dictionary defines pleasure as "the condition of consciousness or sensation induced by the enjoyment or anticipation of what is felt or viewed as good or desirable; enjoyment, delight, gratification. The opposite of pain." Herman had guided me in what was painful but also what he delighted in, what he desired and what brought him joy.

In his book *Designing Pleasurable Products*, Patrick W. Jordan discusses pleasure in terms of practical, emotional and hedonic benefits. All three are important in my design. I will discuss practical and emotional later, but in terms of the surface texture of the material, the hedonic benefits were my main focus. Jordan describes these as "those pertaining to the sensory aesthetic pleasures". He categorises these as representing phsyio-pleasure; "to do with the body and with the pleasures derived from the sensory organs" (10).

If pleasure is what is "felt or viewed as good or desirable" then it has to be subjective. I had already discovered that it is subjective to a person's sensitivities but it also subjective to individual taste. Whilst I would have liked more input from others with autism this was proving challenging. Therefore, I was now designing specifically for one extreme user and concentrating on customising the tactile experience for his specific desires, in the hope that my learnings could then be adapted for other's individual pleasure.

I can never fully understand what it is like to experience the world as Herman experiences it. The way he perceives textures is different to how I perceive them, but in some ways that is not important. I need to be aware of this difference in perception but it is the experience that I am most concerned with. By Herman allowing me to touch the textures that brought him pleasure, I was creating my own experience on which to draw, a sort of tactile memory. I understood the tactile perception that I had from Herman's pleasurable tactile experience, so this is what I had to draw on as a designer.

I was also beginning to realise the limitations of a digital process in me transferring my tactile perception into the knitted textile. I decided that:

1. I needed to change my prototyping method,
2. I needed to source cashmere and other soft yarns for Herman to test.


# the tactile sensibility of the maker

Bauhaus weaver Anni Albers wrote that as we make progress in industrial manufacturing technology we grow “increasingly insensitive in our perception by touch, the tactile sense”.  Firstly, she was concerned that consumers no longer understand or appreciate the qualities of materials and the joy and comfort they can bring to an experience.  Secondly, she questions how designers can design such a tactile experience, for the user, when we no longer touch, listen to or understand the materials ourselves (11).

Touching Herman's objects that bring him sensory pleasure was such an important experience for me.  Whilst I did not have the adverse reaction he did to the prototypes I had made at Ekornes, deep down I knew they were not pleasurable, they could not provide true comfort in a stressful situation.

My early training was in tailoring where I touched the fabrics as I made the garments.  I got to understand the nuances embedded in each fabric and how they responded to my manipulation.  I was beginning to suspect that I had lost my touch by shifting to a digital way of making.

At Ekornes I relied on Tom Daykin, the technician, to program the machines. We threaded the yarn and then waited as the yarn was knitted inside a box before emerging from underneath, much like any typical office paper printer. If I replaced the yarn, I never knew what to expect on the other side.  If the knitted sample didn't quite feel like I wanted, I didn't know how to tweak the program or the yarn to interchange to create the tactile experience I wanted.

Daykin was used to working with designers who gave him a yarn and a specification with finished dimensions of a garment.  It was Daykin's job to develop a program that used that yarn and output the desired dimensions reliably for mass production.  There was very little collaboration with him and the designer to tweak the hand feel of the textures of the garment.  So I struggled to understand how I could recreate the feeling of the touch of Herman's objects if I could not feel the material as we were creating it.

I knew I needed to step away from the digital knitting process if I was to develop something truly pleasurable for Herman.  He had guided me towards cashmere yarn but I also needed to understand the different ways I could knit cashmere and explore other types of yarn.

*Figure 29: Stepping away from digital knitting to mechanical knitting I could feel*

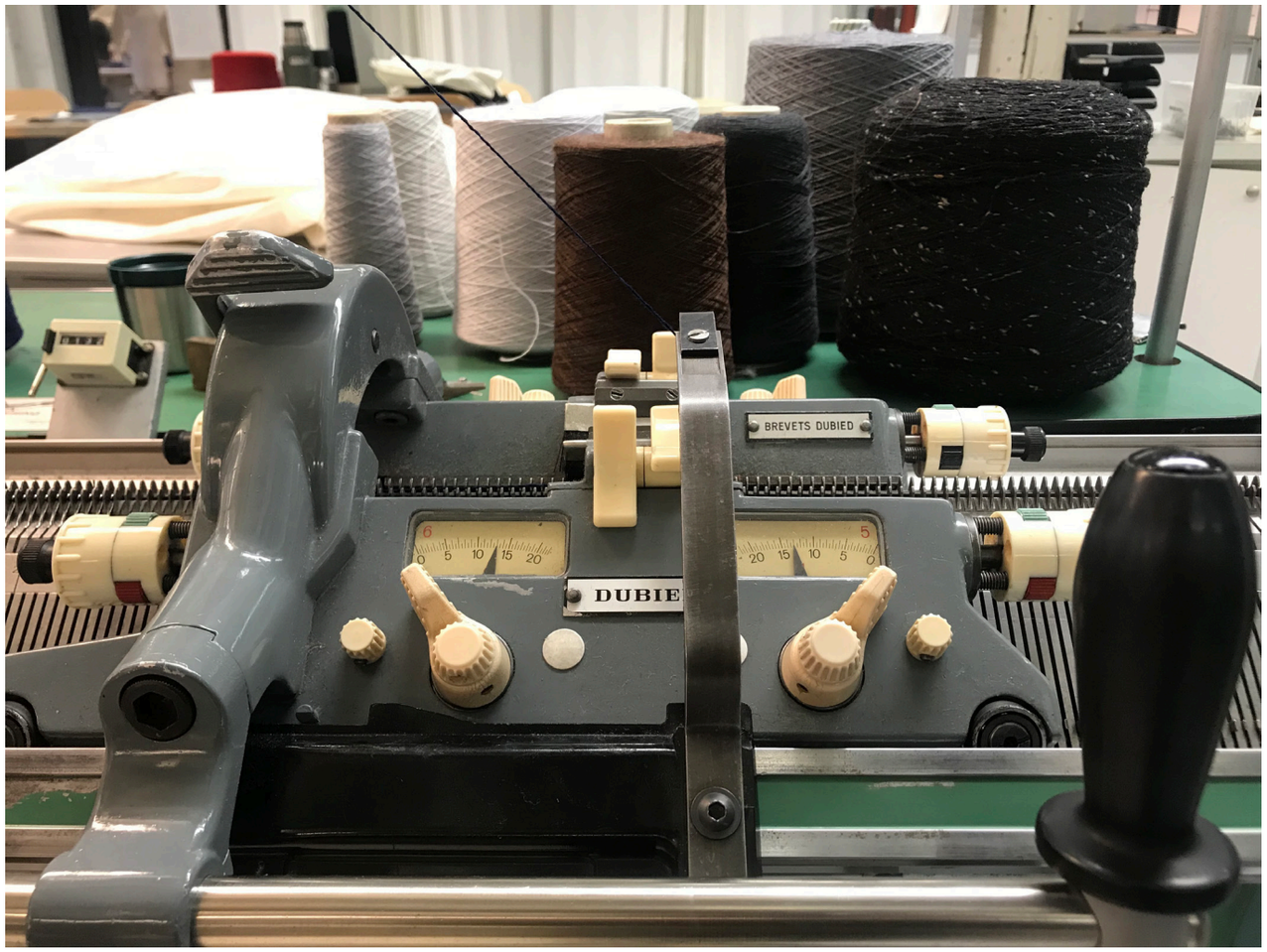



*Figure 30: The mechanical knitting machines I used at KHIO to test all the yarns*



5 - 6. Dec 2019

I contacted Camilla Bruerberg at KHIO and explained my findings. She confided that she often found the same within her own PhD projects. She would work through design developments on mechanical knitting machines, sometimes even by hand, before considering programming a digital machine.

Bruerberg kindly offered me the use of the manual mechanical machines at KHIO. She also very generously gave me access to her yarn cupboard. I travelled to Oslo and spent 48 hours, almost straight, working my way through samples of all the yarn on the mechanical machines.

It was so good to feel the yarn as it was being pulled through the knitting machine, sensing the tension and deciding right there and then if it needed to be loser or tighter to create the texture I imagined. Although the digital machines are fast, I was never really sure what exactly I needed to change or tweak. It was a little bit like Chinese whispers. Herman had shown me what he wanted. I had interpreted this, asked the technician to program the machine and then the machine did its thing. When the machine was finished I would touch it, perceive and asses it but I was never really sure how to tweak it. With the mechanical machine I was in full control and I could touch the output immediately and iterate within the one sample until I got it just right.

Bruerberg also introduced me to the work of ceramist Camilla Groth and her PhD, *Making sense through hands: Design and craft practice analysed as embodied cognition*. Groth's PhD was inspired by her daughter's observation that "my hands are making the biscuits and my eyes are just following what my hands are doing", exploring the importance of felt experiences as we make, moving between digital and handicraft techniques to develop forms in ceramics. Groth writes that "materials have an important role in conveying felt experiences that affects the emotion of the user. Further, materials have general connotations as we share concepts and understandings about their nature, images and values. Tactile aspects are important in the evaluation of which materials to use, as well as in evaluating the final product. During material explorations the student has a possibility to iterate his concepts based on the physical interaction with the material, and while doing so he makes important decisions for the continuation of the project." (12)



# developing the *feeler* in me at KHIO

Concurring with Groth, Sonneveld writes that "augmenting awareness for the tactile aesthetic aspects of products is mainly a matter of development of the sensitivity of the students themselves, through their own tactile experiences. To illustrate this thought, the analogy with a chef cook is presented. To be able to cook delicious food, s/he has to develop the 'taster' in him/her, has to learn by cooking, and above all, by tasting while cooking. Similarly, the designer has to develop the 'feeler' in him, and use this sensitively when designing." (13)

This is exactly what I needed to develop to relate to how Herman feels the world. I could not do this with something I was creating digitally inside a box. I needed to feel the yarn input into the machine, treat my hands and arms as an extension of the manual machine and feel the knitting as it was happening. I could immediately touch the output in order to perceive how close the experience was to what Herman had let me touch and feel. I also needed to allow room for chance discoveries rather than predefine the program.

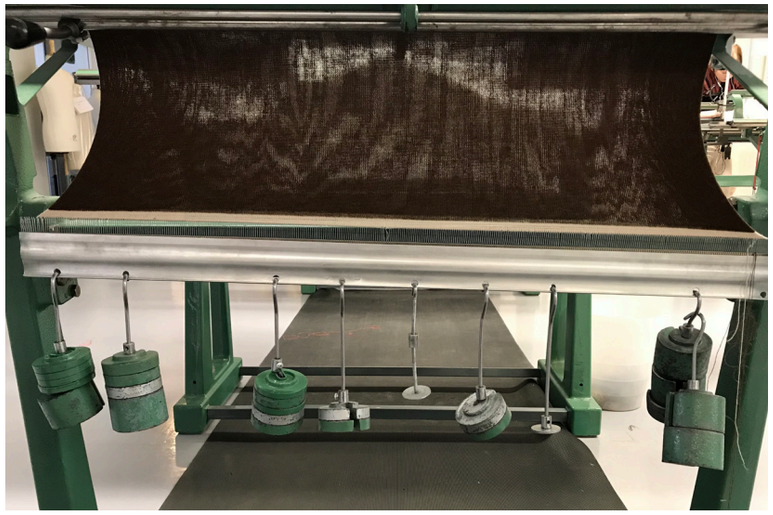


*Figure 31 & 32: Feeling the yarn inputs and outputs immediately by hand at KHIO*


Through the manual knitting process I discovered many nuances that affect both the surface texture and the inner structure of a knitted material; the yarn thickness, the carriage tension, the feeder tension. I have chosen not to write about such details in this thesis, although they were obviously practical considerations in my making and selection process. I will specifically write about my experiences with yarn choice and the stitch type.

The choice of yarn has the greatest influence on the surface texture of the material. For example the greater the percentage of cashmere in the yarn the softer the surface is perceived. (Again there are more nuances such as spun etc. that I have chosen not to discuss). But the choice of yarn also influences the inner structure. For example wool inherently has more springiness than cotton yarn, therefore the inner structure will inherently have more springiness.

The stitch type has greatest influence on the materials inner structure. For example a 1x1 rib creates the greatest elasticity in comparison to both a single bed knit or a 2x2 rib (Again there are more nuances such as front and back bed tucks that I have chosen not to discuss).

I worked my way through KHIO's yarn cupboard, as well as feeling other students work and asking them where they bought their yarn. I then touched all the samples I had knitted and made a decision on which yarns I should order. I was more confident in my intuition having felt Herman's pleasurable textures. As he was not on hand in that moment I make my own educated guesses based on my tactile memory.

*Figure 33: Varying yarns manually knitted at KHIO*


# rapid digital prototyping at Ekornes

16 - 17. Jan 2020

It was a difficult, lengthy and costly process to order the yarns. There are no digital knitting machine yarns available in Norway so everything has to be imported. I had to source and import Herman's request for fine cashmere from Italy which delayed the making and testing process over the Christmas holidays. I also sourced some inherently soft lambswool, angora and merino wool.

The yarns were deliberately in a muted colour palette as I did not want the visual aesthetics to have too much influence over the tactile aesthetics, although with the sheen of different yarns this is not fully avoidable.

I was keenly aware that my educated guesses on yarns needed to be tested by Herman. I needed to be sure that my interpretation of the tactile aesthetics that gave him pleasure were correct. I also felt that I should not assume what would evoke a defensive reaction as I may have missed some nuances. I arranged another meeting with Herman so he could do some testing with me. My objective was to have as many possibilities for him to feel.

When I had all my yarn in stock I travelled back to Ekornes. Here the ability to prototype and iterate rapidly on the digital machines was ideal. I worked with Tom Daykin to test each yarn in the Shima Seiki machine, he digitally tweaked the tensions until I was happy with the output. Once happy we could:

1. change out the yarn to see how the same program knitted in different yarns
2. reprogram the stitch type to see how a different stitch structure affected the surface texture of the same yarn

With the digital process we could easily make multiples of each sample, so I could wash and steam variations to see how soft I could make them.

*Figure 34: A selection of swatches made on the digital machine at Ekornes, by switching out the yarn and/or changing the knitting program, for user testing*



# testing with Herman
## *"... oohhh ... så myk!"*

18. Jan 2020

I visited Herman's home with my suitcase full of samples for him to test. We had arranged for others to join us through autismeforeningen but for various reasons the testing was solely done by Herman (although I hope that after seeing the testing process the others were reassured and will join in the future).

With out any prompting, Herman jumped straight in to testing the samples. I observed that he would:

- touch them lightly under his finger tips, figure?,
- if it was OK he would pick it up and squeeze it in his hand,
- if it was still OK he might rub it over the back of his hand, figure ?,
- if he really liked it would rub it along his cheek, figure ?,
- he then might pick up another sample in the other hand and compare them by rubbing his thumb over the surface of each, figure ?
- if still curious, he would stretch and fold the sample to analyse it and try to explain to me what it was that he liked or didn't like about the sample.

The latter was not always straightforward as there were so many nuances to consider. For example Herman loved a brown cashmere sample but not so much a green sample with exactly the same yarn content. They felt exactly the same to me, but he insisted they were different. I later discovered that I had forgotten to wash the brown sample which meant the tiny hairy fibers were not sticking out like the green sample, which I suspect is what Herman's sensitivity picked up on. I had some thicker, chunkier lambswool samples that I personally found very indulgent but the fluffiness was not pleasant for Herman.

My initial plan was to present a scientific table of results, marking Herman's tolerances, aversions and pleasures. Then compare this with other autists responses and perhaps formulate a guide for knitting for autists. But there are just so many yarns possibilities and stitch types out there. Personal preferences play such a key role that I decided my table would be void. It is impossible to fully articulate or understand the exact science behind why we like or dislike a particular material, but the key as a designer is iteration and testing, and letting the emotional response of the user guide you.

*Figure 35: Herman testing my digitally knitted samples in different yarns*



# *(very limited)* **universal testing**

Anni Albers concurs that the emotional experience of a material should not be intellectualised, "the surface aesthetics of a material, that can be experienced by touch, cannot be experienced intellectually. They must be approached nonanalytically, receptively. (It) asks to be enjoyed and valued for no other reason than intriguing performance of a play of surfaces. But it takes sensibility to respond to the touch of materials, an acute sensitivity to tactile articulation, and a receptive mind, to discover the meaning, thus the task today is to regain a faculty that was once so naturally ours." (11) Therefore this thesis is accompanied by a presentation of materials and I encourage you to touch and feel for yourself, rather than attempt to describe or picture the materials.

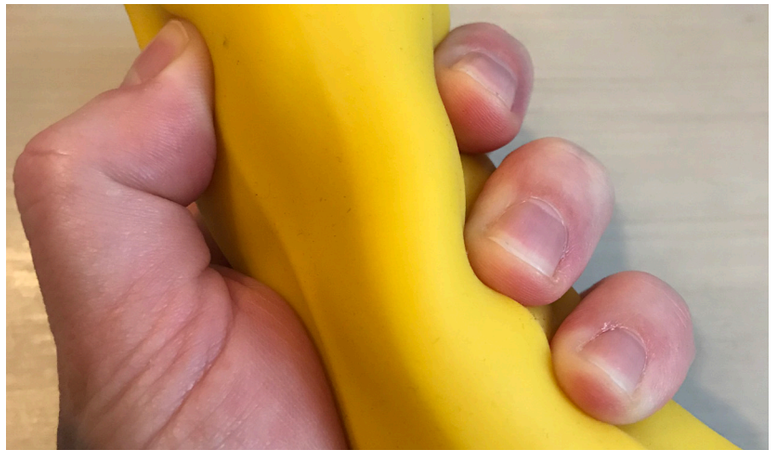
I also encourage this because of the interesting patterns I started to see when I would give friends, colleagues, classmates and professors the same materials that I had given Herman. These users were not on the autism spectrum or at least they did not divulge this information to me. This was not set-up as a controlled test but rather observations that I noted in the table below. More testing would need to be done to substantiate my claims that neurotypicals simply tolerate the textures that autists find intolerable. They do not find any pleasure in them. Whilst most of us do not find it necessary to seek out more pleasurable textures with the same vigour and intensity, when presented by what is selected by autists they understand why it is more pleasurable.

| | **Herman's response** | **Neurotypical response** |
|---|---|---|
| **Ekornes hard wool rejected by Herman** | *" Noooo!! "* | *" Hmmm, ok. It's fine. "* |
| **Cashmere yarn selected by Herman** | *" Yes! "* | *" Wow ... that's so lovely! "* |

*Figure 36: my friend testing my digitally knitted samples in the same manner that Herman had tested them*

*Figure 37: Herman's 'trappetroll'*

*Figure 38: Herman's squishy silicone banana*





# Herman & his stimulatory materials

Autists often form repetitive self-stimulatory behaviours (stims) in order to cope with their sensory chaos, for example hand flapping. These stims are not exclusively used by autists, for example many of us can relate to fidgeting when we are nervous or doodling to regain focus. But they are perhaps more extreme in their function for people of the autism spectrum. It has been suggested that stimming is a non-verbal communication to express emotional states however this is not conclusive. They are more common in a state of overwhelm.

Often these stims are aided by transformable materials, which I defined as materials that have some mechanical resistance but can be satisfyingly adapted by the users hand and then return to their original form. Some examples are squeezing a stress ball or stretching an elastic band between your fingers.

Many treatment plans exist to detect and eliminate stimming. This primarily because neurotypicals that autists' interact with might find these behaviours annoying or strange. Personally I don't think is a good reason as these behaviours have their purpose. Almost everyone I have spoken to with autism considers stimming as an essential behaviour to calm and refocus. Whether we understand the behaviour or not, we know that they are calming and help the autist refocus. Rather than eliminating stims I wished to embrace them in this project and provide an outlet for this repetitive movement. I wanted to understand the properties of these materials that made them so calming, satisfing and facilitated refocusing.

Herman showed me the products he used for stimming, pictured opposite. I played with them and immediately understood why they worked. The material can speak, but only when spoken to. The user's input creates a dialogue between them and the material , the more you use it the more you understand the possibilities and can predict the response of the material. The common material properties I identified were:

1. softness,
2. flowing movement,
3. elastic behaviour (transformable but some resistance),
4. adaptable volume.

*Figure 39: Knitted stimulatory tucks at Ekornes in very hard yarn*

*Figure 40: Knitted elasticated structures at Ekornes in very hard yarn*



A plethora of these products already exist on the market, but know can 3D knitting help?  As pictured in figures ? and ? these existing objects are extremely child-like in their form.  My user group are people with mild autism who otherwise lead very normal lives in school or work environments.  It is embarrassing for them to be seen to have to use 'toys'.

Developing a stimulatory structure through knitting can be more subtle, integrated into textiles that already surround us, our clothes, chairs, curtains. A knitted material is inherently elastic, this can be increased by knitting across 2 machine beds and/or adding a lycra yarn.

I began developing these first with Tom Daykin at Ekornes as shown in my project timeline. We developed some interesting structures as shown opposite. I tested these with Herman on our first meeting and whilst he enjoyed the springiness of them they were much too hard for his sensitivities.  I put development of these on hold until I found the yarns that Herman liked and then developed softer versions with Camilla Bruerberg at KHIO.

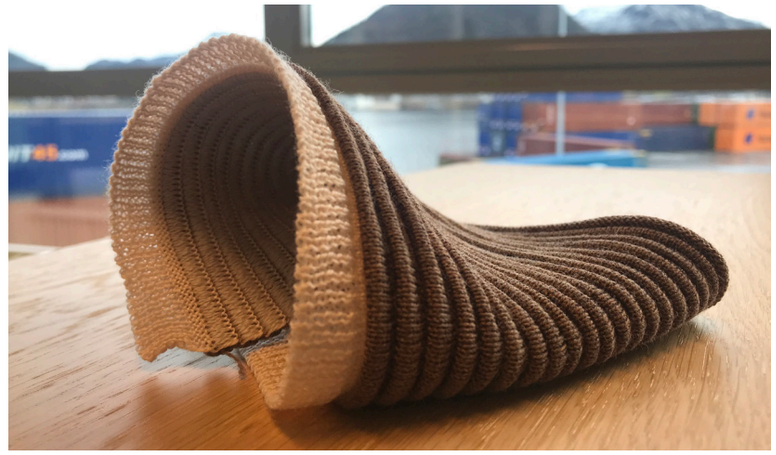


*Figure 41: Soft versions of the 3D stimulatory textures developed at Ekornes &*

# testing with Herman

*observing his natural inclination to stroke*

*Figure 42: As we chatted Herman repeatedly stroked the soft ribbed structure*

18. Jan 2020

Herman was very excited by the softer stimulatory textures. He was fascinated by their movement. Some samples stretched a little further than others to reveal a different colour on the inside. The satisfaction he got from them was immensely evident. Some time later, as we were chatting about something else, Herman's father nudged me and pointed to how Herman had continued to stroke the samples even though the testing period was over. Herman suddenly became a little self-consioius that he was doing this but relaxed when he saw how delighted I was that he enjoyed them so much.

Speaking with me in my poor Norwegian I am sure was a stressful and frustrating situation for Herman. Although he fully embraced the testing, being constantly observed and questioned and asked to preform is not the most relaxing of set-ups and I was so pleased to see the calming affect that these textures had on Herman.



# forming with Herman

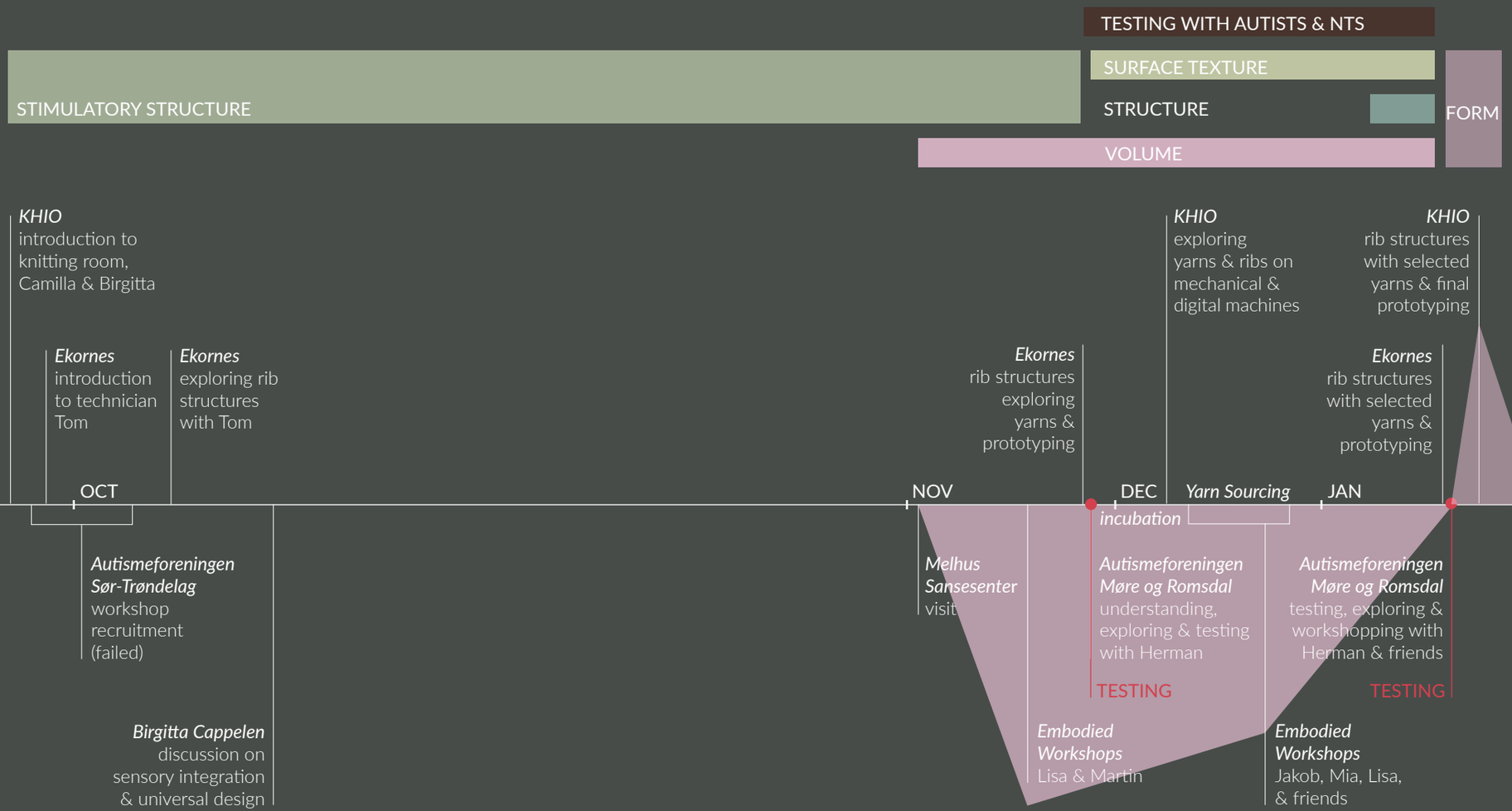
*"I want this here & there & this in between"*

*Figure 43: Herman guiding me in which textures he wants where*

Without being prompted, Herman started to select and arrange the swatches, both the plain yarn textures and the stimulatory textures. He showed me how he wanted the tucked stimulatory structure that revealed a little colour but lined with his favourite cashmere. He showed me that there should maybe be another layer in between to give more depth and malleability to the form.

In a very natural and organic process, Herman was guiding me in forming an object for his personal tactile sensory preferences. In the prelude I introduced Albers' break down of the surface and inner structure of the material. Herman was choosing both of these. He was doing this through Kanz's definition of touch, considering both surface and immersion. Kanz's final method of touch, through volume, is documented next in chapter 3. I developed the volume, through participatory co-design, in parallel with the surface texture, as shown in the timeline overleaf. Herman tested the volume on the same day as he selected the textures so he formed the product in its entirety. I will present this formed product in chapter 4 and reflect on customisation of products.

# *form development*



3

# Embodied Experience

Chapter 3 is about the development of the volume of my product and how it might be used by autists and beyond.  In an ideal world this would have happened after the surface texture devleopment, as was my original plan shown in figure 8.  However, due to timing, I began these workshops in parellel with participants not necessaily on the autism spectrum.  This helped build my confidence in facilitaing such workshops.

I held 6 workshops with particpants who did not identify with being on the autism spectrum, and two workshops with Herman.  Whilst each workshop participant's contribution was unique, I was pleasantly surprised by the patterns that I observed across everyone that confirmed that this product could be used universally.

This chapter will take you through how the findings from each workshop contributed to the final form of my product.  I have also documented the common and individual ways the users wanted to use the product, ensuring that the necessary affordances were embedded in my final product to facilitate these.

# Embodied Design
## *tactility as a whole body interaction*

As explained earlier, the concept for this project started during my summer job at the Holst Centre. The idea was to redesign a chair or a vest that provides compression to the body to calm and refocus. My supervisor at my summer job was Pauline van Dongen, a fashion designer who is famous for her embodied approach to designing wearable technology. We had many lunch conversations about my forth coming masters project and she encouraged me to adopt an embodied approach and forgo any preconceived notions of what the product should be.

Van Dongen defines embodied design as to design with the body as the primary context through which everything is experienced and perceived. It stems from Merleau-Ponty's phenomenology, specifically that:

1. what is worn is located spatially and temporarily
2. anything worn is an appendage of the body
3. to wear is a lived experience.

When designing objects that interact with the body, the experience cannot be simulated, it must be lived. I was determined that whatever I design would not be developed on a computer, it should be developed with the user in context. Ideation on the body is a common training in fashion design, although not so widely practiced in industry. I was very fortunate to learn this as part of my tailoring apprenticeship where ideation on the body allowed me to combine functionality, think through movement capabilities, user interactions and the perceptions of aesthetics. It naturally encouraged co-design, with the body and the wearer presenting instant feedback. By designing directly on the body, I was guided by the emotional response from the user.

During my first week of this project I attended a talk by Cheryl Akner-Koler at the WONDER seminar at NTNU. She reiterated the value in pursuing an embodied approach to design, emphasising the nuances that we miss by simply sketching or rendering our designs rather than living the experience with our whole bodies and understanding our relationship to our environment. Akner-Koler advocates for an embodied design process in her teachings at Kontsfack. I contacted her before beginning my embodied workshop series and she kindly shared her PhD thesis *form and formlessness* which questions "the formgiving process aimed to create tangible artifacts" (14), which I drew on during my process of giving form (or lack of form) to my product.



This was reiterated by the experiences of Ellie Turner and Birgitta Cappelen, whose work and advice I touched on in chapter 1. Cappelen teaches an embodied design process at AHO and also encouraged me to approach this project in terms of whole body interaction, not simply touch under hand or against the skin, but through movement.

In the prelude I introduced Kanz's three methods of touch. Chapter 2 primarily dealt with touch under hand, but through the embodied workshops I could explore immersion more deeply and most importantly volume. I could observe unique preferences and experiences, the whole body interaction and the dialogue between the user and the material.

The prompt I gave each participant was to use the materials to hide from sensory stimulation and control how they re-emerge and access it. I asked them to show me how they might use it for self-regulation and positive mastering experiences, how they would do the action naturally rather than a predefined form imposing a specific interaction.

If I was to let the users participants guide me then I had to redefine what I have typically thought of my role as a designer. My designer ego was still thinking it I should create a recognisable “thing” and then present it to the user. But I had to take a step back and swallow my pride, redefine my role as:

- to inspire,
- to provide the tools so that (the user) is free to imagine, explore ideas and invent new things,
- to be a good listener, listening to the users and the material,
- to be the expounder of interplay between the user and the materials.

**"Your job is to invite the user and then inspire the user." (Birgitta Cappelen)**

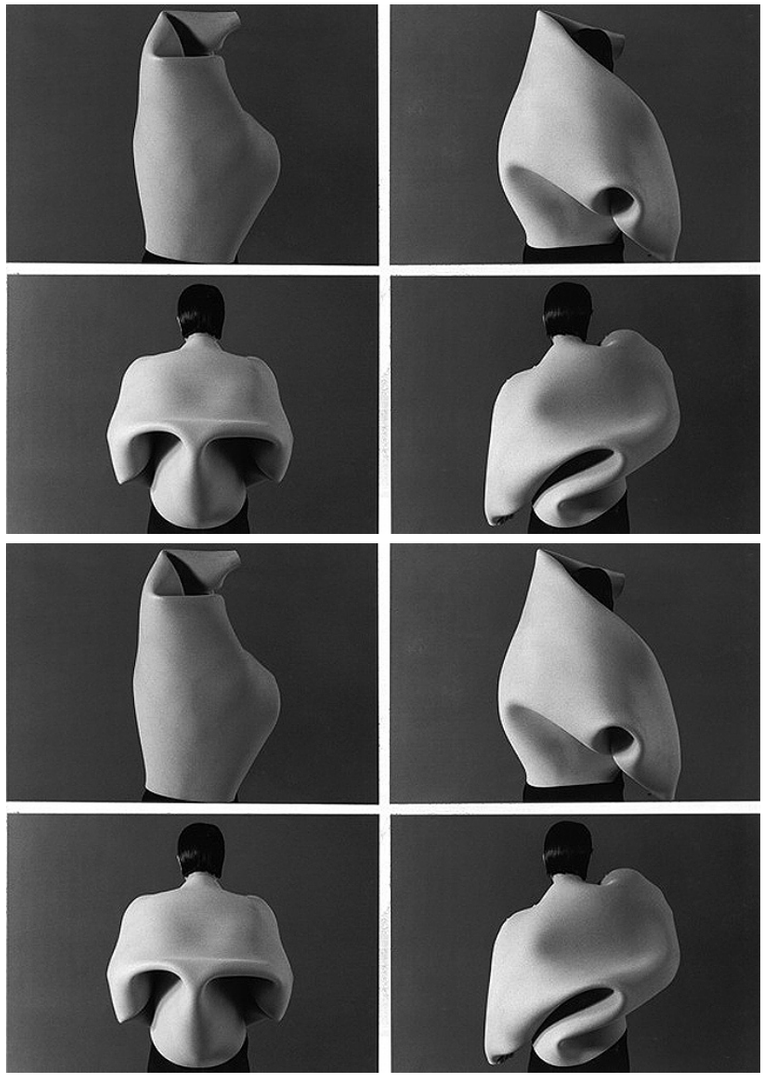


*Figure 44: copyright of Maria Blaisse*



# Emergence of Form
## *providing tools for co-design*

Pauline van Dongen gifted me Maria Blaisse's book *The Emergence of Form* to inspire how I might provide the tools for participatory design and facilitate effective co-design in my embodied workshops. Blaisse's work, in very simplistic terms, stems from an obsession with a material. Although she is an artist, not a scientist, she appreciates its physics. Rather than design a form and then find a suitable material, she allows the form to emerge from the material. Most often, this is done through whole body interaction, sometimes with performers. She then beautifully captures how one form emerges from another as depicted opposite (15).

My plan was to have selected the knitted textures with the participants in previous workshops. Then in this workshop series I was to provide them with large knitted samples to discover what forms were embedded in the material and explore how the participants would like to use them to create an environment that is comforting and promotes self-regulation.

However, as these workshops were carried out in parallel with developing the knitted textures it was necessary for me to provide alternative materials to be used. I kept in mind that it should be possible to knit the properties of the chosen materials but they were also selected based on the following criteria that I learned from observing Blaisse's work:

- the emergence of form should be organic,
- it should allow for humour,
- the tactile sensation of the material is felt through the whole body,
- the design should transform freely,
- a sense of lightness should inspire a playful feeling (15).

I selected a range of malleable materials, traditionally used in both garments and furniture, for example, knitted jerseys from Stoff og Stil, and foams and elasticated straps used in upholstery. The latter were kindly provided by *Prima Møbelomtrekking*, an organisation in Trondheim that trains adults, who wish to return to the workforce, in furniture repair.

*Figure 45: copyright of Shani Ha: 'Embody'*



# Tactile Aesthetics:
## *the 'Perfect Match'*

In the prelude I introduced Sonneveld's definition of the tactile experience as "the affective response of the user to the physical aspects of the product, through touch." (13) She goes to explain that one such response, is to assess the way the object fits us. "We enjoy the feeling that something can be perfectly right. Shoes, tools, chairs or clothes can feel as if they are made for us. This feeling of a perfect match can be obtained through shape, size adaptability, absorption properties, etc." (13)

This 'perfect match' is something for which I wanted to explore in these workshops. As my research has shown that the object should not be predefined, i.e. not a chair or clothing, I was determined that it should have the potential to become the perfect fit, adapting to meet the needs and body of the particular user at a particular moment.

This is in perfect keeping with my design requirements that I defined in chapter 1. As the object is transformed by the user's body it becomes unique. It becomes theirs, at least in that moment. The feel of the fabric against their skin becomes familiar and their imprint becomes as familiar to the fabric, creating an ongoing dialogue through which understanding and trust can be built. It is not only about the active surface contact but the follow through, how the user's movement causes the object to move, resist and respond. There is a balance of power between the user and the material to control this transformation, creating a dialogue between the material and the user: a push and pull, a to and fro.

This dialogue is something I wanted to explore, using Shani Ha's 'Embody' performances, pictured opposite, as my starting inspiration. In an interview she explained that "I'm interested in the way each person invests (in) these sculptures. One can just sit on them with someone and hang out for a moment, while performers can be completely immersed and literally disappear to animate the form and become mysterious living sculptures."

# *volume development*

Over 2 months I held a series of participatory embodied workshops where the users explored how they use materials to comfort. Through whole body interactions we developed the volume, shape and proportions of the knitted form. Each workshop tested something from the last workshop. Each participant brought a unique insight. And so the design evolved.

This was more successful than I ever imagined, the proof being testing with Herman and seeing he pleasure from using something that had been developed through the bodies of others, but somehow still managed to perfectly fit his body.

22. NOV
- ***Lisa & Martin***
  Exploring volumes through rectangular sheets of material without constraints & body storming

26. NOV
- ***Herman***
  User shows padded adaptable form that he hugs

9. DEC
- ***Jakob***
  Giving constraints with tube development

16. DEC
- ***Mia***
  Affordances, inspiration & weight
- ***Lisa***
  Affordance of rolling to make adapt the volume

17. DEC
- ***Sampsa***
  Methodical approach & opening up
- ***Pouya***
  Extension of body for dynamic movement

18. JAN
- ***Herman***
  Confirmation by user that the volume is a success

# *workshop 1*
# Lisa & Martin

IPD
22. Nov 2019

**Workshop description**
As I had discovered that building trust with potential participants was a large obstacle, not only between myself and the participants but also between other participants that might have different sensory needs.

Although embodied design informs a large part of my fashion background, this type of participatory co-design through materials was new experience for me. Normally I would be manipulating and experimenting with the materials around the body of the wearer and asking for audible feedback. However, the purpose of this workshop was to allow the user to manipulate the materials.

I was both curious and nervous to see what would emerge without any real structure to the workshop. So for my first workshop I invited just two participants, Martin & Lisa. They were friends of mine so they already trusted me. They are both in creative professions so they respected and trusted the design process. They are a couple, so they fully trust each other. They both are involved in amateur dance and professional Parkour, so are comfortable with improvisation and understanding their body's movements in relation to each other and the environment.

The only specific goals I set for the workshop were:
1. To learn how to improve an embodied workshop for my next session
2. To determine if knitted volumes were indeed comforting
3. If so, what dimensions of knitted textile are best

Establishing dimensions was pertinent at this stage of the project, to allow for an efficient and effective iterative prototyping with Tom at Ekornes. We needed to import yarn and program the knitting machines so we needed to know what volumes we were working with.

*Figure 46: Lisa & martin warming up*



My only plan was to provide the participants with the space, tools and creative freedom to explore how they could manipulate materials and volumes, with their bodies, to provide sensory relief.  This sensory relief could, and should, change as the workshop progressed.  With this, I expected the material manipulation and volumes would also change.

I collected sheets of foam and a variety of soft stretch knitted jerseys which I stitched into tubes.  I also collected a variety of soft padding which could be inserted within the tubes to create volume and support if desired.

The workshop took place at 5pm on a Friday evening.  It was evident that both Lisa & Martin were tired after a long week at work.  I had not taken the timing into consideration when scheduling the workshop but their weariness actually proved to be perfect for a workshop that was to explore the idea of using textiles to escape from sensory overload and overwhelm.  It was very interesting to observe the change in energy levels throughout the two hour workshop, which I have mapped in figure .

I began by introducing Lisa & Martin to Temple Gradin's 'Hugging Machine' and the idea of giving the body a hug.  I showed them images of Maria Blaisse's foam to inspire manipulation of materials through the body.  I demonstrated how the rectangular sheets of foam could be folded around the body and secured with safety pins to create interesting shapes.  I then showed them Shani Ha's 'Embody' (figure ?) to inspire the exploration of stretch fabrics and padding to hide the body and then emerge.

The room had very harsh lighting and distracting colours.  As a warm-up task I challenged them to use the foam to hide from the brightness.  They began by individually crawling under their sheet of foam and then rolling themselves up in it.  I left the room to find some music to add to the sensory experience and when I returned they had naturally gravitated towards each other and were trying to hide each other in the same piece of foam.

Allowing them to work together in the beginning was a very effective way of warming up.  I watched them explore together, inspired by each others manipulation of the material, building on the other's previous move and influencing each others body position.  The energy levels rose.

*Figure 48: Martin finding comfort with padding between his legs*

*"It feels like a safe space but you still need perspective,  to know what you need.  It depends if you are overwhelmed by the outside world or by your own head.  What are you trying to block out?  You don't want to go further into your own thoughts.  You must be able to emerge quickly if you need to."*

*Figure 47: Martin getting too comfortable*

## “the opposite of getting out of my head”

With energy levels up, creativity was increasing but we needed to calm the body and material interaction.  I used the word “vulnerable” as a prompt.

Lisa transitioned from covering her body in the foam to rolling the foam and covering it with her body.  This created a more dense structure that she could squeeze her body around to induce a light comforting pressure on her body. Martin discovered the same comfort by wrapping his foam around his legs and then sitting back to apply the pressure and a bouncing sensation.

Lisa discovered that it did not feel good to cover her whole head, causing her to feel all consumed and overwhelmed.  She described it as “the opposite of getting out of my head, I couldn’t be anymore in my head”.  Martin had a similar feeling.  He needed to find a happy medium between shutting out the environment without feeling claustrophobic, so he created the perfect sweeping head rest.  He said he felt “like a turtle” with the ability to go in and out as he pleased.  The adaptability of the material meant he was in control.

*Figure 49 & 50: Lisa exploring the foam*

## “materials that fight back”

After sitting in figure ? for some time, Martin felt almost too relaxed.  He explained that the softness of the foam was lovely but his body sank into it with very little resistance causing him to fall asleep.  If the goal is to calm and refocus, then this isn’t effective.  He needed a more dynamic material, with a greater elastic energy, that focused the user by engaging them in the play of balance between their body and the material’s movement.

As Lisa continued to explore with her foam, Martin observed by relaxing on a padded cube.  His body sank down into the material, pushing the volume to the sides which came up to hug him from the bottom.  I had left some elastic straps lying around and he began to fidget and play with these, in the same way one might stim with an elastic band between his fingers.

Through playing, Martin found a comfortable position with the strap across his shoulders and under his feet as shown in figure ?  He was very fond of the support that this gave his back, keeping him in an upright position.  The tension around his shoulders created a hugging sensation.  He said that he would like to stay in this position for a long time but he also liked that it was possible to move back and forth like in a rocking chair.  Like a rocking chair, it is the shift of his body weight that caused him to move backwards.  Martin trusted the elastic energy in the strap to push him back when finding its point of equilibrium, similar to the rocking chair mechanism.

Although the spandex hammock in the sansenter did not facilitate the same rocking motion, the elastic material did help me understand how my body weight can affect how the material stretches around my body and then contracts to apply a pressurised support to my body.  Martin described a similar dynamic with the elastic strap.

This achieves both the ‘perfect match’ and the dialogue that I had hoped for.

There were many great discoveries in this workshop, but post workshop analysis revealed that the rectangles were too open.  We needed to impose some type of restraint.  Lisa and Martin suggested a tubular shape so the person could move inside without having to hold it.

*Figure 51: Lisa exploring the foam*



# *workshop 2*
# Herman & his pillow

Herman's house
26. Nov 2019

**Design status before workshop**
I knew that there had to be some resistance and malleability in the materials but there was no form.

**Workshop description**
I'm not sure if I can technically describe this as a workshop.  This was a little bit of a short impromptu moment in my first meeting with Herman, but a very valuable one.

I showed Herman pictures from workshop 1.  He told me they looked a little impractical to move around in!  He was disappointed when he realised that I wasn't designing clothes (although I promised to do this is the future).  I explained that, for now, I didn't want to make something predefined but rather see what emerged through my process.

When he understood the concept he left the room and his mum's pregnancy pillow and showed me how he had re-purposed it to calm himself down and provide comfort.  He loved that there were many different ways and positions in which he could use it, sitting on the sofa or lying on the floor.  Again it was such a rich experience for Herman to show and guide me with his sensory pleasures as he had done with the cashmere sweater in chapter 2.

**Workshop outcome**
I was reassured that I was on the right track, but now had some valuable design constraints from the intended user:

- material should be padded to create volume and increase softness
- it should provide weight on his shoulders
- allow him to hug it with his arms
- it should shelter his face at the sides
- he should be in control of how much visual sensory information is visible
- shape must be even more adaptable than what Herman already owns.

*Figure 52: Andreas showing me how he uses his pillow.*

# *workshop 3*
# Jakob & the tube

Rom 347 IPD
16. Dec 2019

**Design status before workshop**
Fabric was pinned into a tube but could be adapted  and a selection of padding was provided.

Jakob and I worked together in Design and Wood, defining proportions and dimensions of our stool through iterative 1:1 prototyping.  This worked very well so I asked him to join in me in testing how Lisa and Martin's proposal of a tube volume would work.  It was also inspired by Herman's pillow that was heavily padded.

As you can see from the pictures we decided that the tube worked very well.

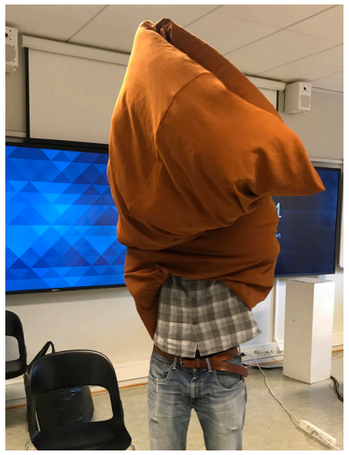


Figure 53 (opposite): Jakob exploring the tube
Figure 54 (above): Jakob checking out the dimensions

Figure 55 (opposite): Jakob folding up the tube
Figure 56 (above): Jakob finding places in the tube to tuck things

Figure 57 (opposite): Jakob hiding and getting refocused
Figure 58 (above): Jakob moving to the floor

# *dimensions & Romlab*

I had learned in my previous workshops that context was very important. The bright lights and busy surroundings of the classrooms at IPD did not represent a typical space in which we find solace.  So I booked Romlab, an interchangable space in the architecture department at NTNU.  I set up Romlab with some plain white walls, low lighting.  Based on findings in workshops 2 and 3, I also placed a chair and a pillow to the side should the participant wish to use them.

The gaol was to confirm that the proportions, weight and dimensions I developed with Jakob were suitable for everyone.

Figure 59 (opposite): The object as set-up before the participant entered

# *workshop 4*
# Mia & affordances

Romlab
16. Dec 2019

**Design status before workshop**
I had stitched up the tubular shape developed with Jakob in workshop 2 but had left the bottom open to allow us to remove and replace the filling inside should it seem necessary.

**Workshop description**
Mia was a classmate who had seen me preparing for a previous workshop and expressed interest in it trying out.  I didn't know her well personally but I knew her work to be thoughtful and creative so I was excited to see how she explored the volume.

When Mia entered the room the object was positioned as shown in figure 59 I asked her to explore how she might use it to comfort herself.

Figure 60 (opposite): Mia climbing inside
Figure 61 (above): Mia inside the object  & quickly getting out

She got inside.  She found it a little difficult as the padding was too warm and heavy.  I changed it to a lighter padding and experience was much better.

Mia said she felt very exposed in the middle of the floor and moved to the corner.  She explained that she always did this.  If she was in a cafe she liked to have her back against a wall or it could become too overwhelming.

Masked if she had to be inside the tube.  I told her no and asked why she felt that should.  She explained that it had been the way that the object had been set up when she entered the room, as shown in figure ?.  She suggested that I should leave it as shown in figure 59
 as this provided her with more affordances.  She then proceeded to experiment with wrapping the object around her in different ways or lying on top of it.

At a certain point Mia also asked for some prompts.  I showed her pictures from

Figure 62 (opposite): Mia mimicking Herman
Figure 63 (above): Mia exploring around the tube

**Workshop outcome**

- We selected a padded lining was selected that provided a comforting weight but was not too warm or too heavy as to limit movement or the adaptability of the product.
- The product should be easily used in a different context, i.e. from exposed setting to sheltered corner, to sitting on a chair.
- I learned that I needed to consider how I presented the product to the participants and how this influences their intuition and what they think they *should* do.
- Prompts in the form of images from how other users used the object could be inspiring.

Figure 64 (opposite): Mia's suggestion on how the object should be set-up
Figure 65 (above): Mia finding comfort on top of the object

# *workshop 5*
# Lisa & the donut

Romlab
16. Dec 2019

**Design status before workshop**
The tube was as we had left it after Mia's workshop; the lighter lining was inside but the bottom was left open to allow us to remove and replace the filling inside should Lisa require it.

**Workshop description**
Lisa got inside the tube immediately. She said it was a little cumbersome to get inside because of the length. She suggested shortening the length but once inside she quite like that she could completely immerse herself, so suggested the length is somehow adjustable for getting in and out. Trying to find a way to do this she discovered that the tube could easily be rolled down to adjust the length. She continued going until she had transformed the volume into a donut shape that she could move up and down her body.

Figure 66 (opposite): Lisa hugging her donut
Figure 67 (above): the process of getting to the donut

This new volume afforded so many new possibilities to provide comfort and hide from sensory overload.  I have included just a few of Lisa's discoveries for uses for the donut.  This was an exciting revelation that the volume could be easily transformed.  It also brought at more playful nature to the product.  It encouraged more engagement with the user, an different kind of relationship with the materials.  There was a sense of mastery and satisfaction in making something new.

**Workshop outcome**

- The length and proportions seemed to much to get into, but once inside they felt good.  We discovered the length was adjustable by rolling the material.
- Rolling the material allowed the formation of new volumes and afforded the user to become the maker.

Figure 68 (opposite): Lisa with her inside the donut for support
Figure 69 (above): Lisa exploring the donut volume

# *getting involved*

Inspired by the creation of Lisa's new volume I jumped in.  I was curious to see how the donut felt.  It was amazing!  The material was compressed.  When the body was inside this applied a compression much like the vests that I had started this project with.  The volume was much sturdier than the tube so it also provided support.  It was lovely for a head rest.

When I took off the donut and sat it on the floor it hand a different affordance than the original tube.  I wanted to put by body inside and then have it emerge on the other side.  This inspired me to try and recreate some of the comforting poses Lisa and Martin had come up with in workshop 1.  For example, putting a material between the thighs and calves and pressing down, pictured below.  This felt so good!  I loved this new dimension to the object.

Figure 70 (opposite): Me trying Lisa's donut
Figure 71 (above): new affordances in the donut

# *workshop 6*
# Sampsa & logic

Romlab
17. Dec 2019

**Design status before workshop**
The tube was as we had left it after Lisa's workshop; the lighter lining was inside but the bottom was left open to allow us to remove and replace the filling inside should Sampsa require it.

**Workshop description**
Sampsa is an engineer.  Most of the other participants were from creative professions who perhaps were more experienced with open-ended design workshops.  So I was anxious how my methods could accommodate.

ampsa's exploration was very methodical in his approach.  I observed how others would immediately get inside to explore but Sampsa walked around it, looking inside, picking it up, feeling its weight.  As I stated in my design

Figure 72 (opposite): Sampsa analysing the object
Figure 73 (above): Sampsa exploring from the outside rather than the inside

requirements in chapter 1 there should be no wrong way to use it.

As the workshop progressed Sampsa started to relax.  Once inside the object I felt like he started to open up, telling about his ideas for improvements, other ways he might use it.  He said that the tube felt like a safe space for him to express himself, which I was delighted by.

Figure 74 (opposite): Sampsa inside
Figure 75 (above): Sampsa finding ways to roll and support

# *workshop 7*
# Pouya & the worm

Romlab
17. Dec 2019

**Design status before workshop**
Fabric was stitched into a tube the padded lining was secured inside.

**Workshop description**
Pouya and I share an office.  Although he didn't know much about my project he had seen this lump of material, sitting in the corner of our room, disappear and reappear in new volumes and forms.  He was disappointed that he hadn't been asked for is input and jumped straight in when the opportunity arose. Although this wasn't an officially scheduled workshop, Pouya's interpretation brought a new dimension.

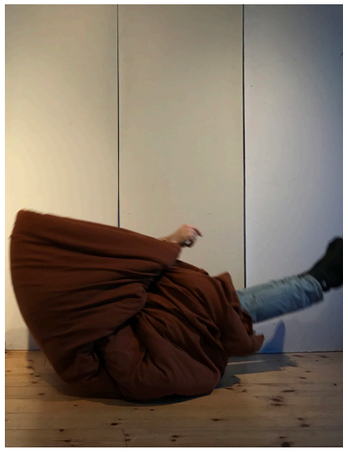


Figure 76 (opposite): Pouya putting on a performance
Figure 77 (above): Pouya's dynamic movement

For Pouya the volume seemed like an extension of his body.  It inspired a dynamic movement.  At times it wasn't apparent where the material ended and Pouya's body started.

There was also a distinct change in energy in the workshop.  In the beginning it was all about movement, and high energy exploration.  But then as both the movement was exhausted and Pouya became exhausted physically the object transformed into something to relax and find comfort in.  The multi-function of this was interesting.

Figure 78 (opposite): Pouya moving inside the object
Figure 79 (above): Energy levels beginning to drop

Figure 80 (opposite): Pouya calming down
Figure 81 (above): Pouya very relaxed

# *workshop 8*
# Herman & his object

Herman's home
18. Jan 2019

**Design status before workshop**
The design remained how it was at Pouya's workshop

**Workshop description**
I took the prototype to Herman's house to test.  I was quite nervous, as so far it had only been tested by neurotypicals and I was afraid that I had missed something completely.  I was also worried that he might find it childish and be offended by its simplicity.  There were also a lot of adults in the room and I was concerned he might feel self-conscious.

Herman didn't need any prompts, he jumped right in, moving exactly as Pouya had done, using the tube as an extension of his body for a dynamic movement.

Figure 82 (opposite): Herman jumping immediately inside
Figure 83 (above): Herman inside on the floor

Figure 84 (opposite): Herman testing in standing position
Figure 85 (above): Herman testing on floor

I didn't record how long Herman spent inside the prototype, but he didn't want to get out.  He wanted to explore more and more.  He took a break got up an walked about, got a drink as Jakob had suggested and rolled it up just as Lisa had done.  I was very surprised by the similarities in his use of the product, compared with the other participants.  It is was lovely to see how their development had resulted in such a pleasurable experience for Herman.

Herman exclaimed that is was so much fun!  I was so delighted by this result. His parents were also pleasantly surprised by Herman's engagement, and how his energy levels rose and dropped through exploring.

Figure 86 (opposite): Herman walking around in the prototype

*"kan jeg prøve igjen?"*

Figure 87 (opposite):High energy start
Figure 88 (above): Energy level dropping, taking a break

After Herman's first exploration I showed him some pictures from the other workshops.  You could see he was inspired and asked could he try again.
He started with a dynamic movement but slowed down and became more thoughtful.  He started to use the tube to hide from what was going on in the room and re-emerge to join in the conversations when he felt like it.

This interaction and control of the environment was exactly what I had set in my design requirements in chapter 1.  Herman wanted to place an order!

Figure 89 (opposite): Herman hiding from the room
Figure 90 (above): Herman rejoining the conversations

# 4

# Making Sense

Chapter 4 is about bringing together all the elements that Herman selected to form his own custom product.  The object affords his personal tactile sensory pleasure.  However, also embedded in the object are the preferences of everyone who participated in the workshops documented in chapter 3.  The object also affords for others to be inspired and find meaning in Herman's sensory experience of the world.

The chapter then attempts to make sense of everything I have learned throughout the process: reflections, discussions, lessons, considerations, recommendations, and finding a way forward through 3D digital knitting.

# forming the form

KHIO, 16. Dec 2019

The final step in this project, before reflecting and dissecting everything I have learned, was to take all the elements that Herman loved and specially selected and form them together in an object.  To do this I travelled back to KHIO with the cashmere yarn for the lining, samples of the outside stimulatory material to program and the dimensions of the volume, assisted by Camilla Bruerberg.

As is typical of most projects, the best laid plans run into a few problems:

1. the cashmere yarn kept breaking in the digital machine, so I had to knit the cashmere lining manually.  Figure ? shows my tests with the machine. Although time consuming it was really very nice to engage my tactile sensibility in the making process one last time.
2. the cashmere yarn knit too tight to create the stimulatory textile, so I opted for a merino wool which I knew Herman liked but not as much as the cashmere.  I could only source the merino wool in blue and grey in the short space of time, so colour is untested with Herman
3. the machine at KHIO can either knit a 3D texture or 3D shape, not both together.  So I had to knit the stimulatory outer textile in 2 parts and sew together.  But 3D shape and 3D texture can be formed on the machine at Ekornes.
4. It was not possible to knit in a yarn padding on the machine at KHIO so I have sewn in a synthetic padded lining for now.  A 3D knitted process that includes pusher to insert the padding is possible at Ekornes.

Another iteration is definitely needed to refine the manufacturing process. Ekornes have invited me back to present my findings to their team so I hope that I will have the opportunity to make one final version of the product, fully 3D knitted, and talk through cost and manufacturing process with them and how they might facilitate a custom order and production system.

*Opposite:*
*Figure 91 : final assembled product*
*Next spread:*
*Figure 92 : trials and tribulations of knitting with cashmere yarn*
*Figure 93 : digitally knitting the stimulatory outside in panels*

10 GAUGE

Tension 11
too loose

Tension 10
ok but little
transparent

Tension 9
10
11
cast-on
good

Tension 9
good body
but cast-on
problematic

Tension 8
cast-on at
11 but moving
every 2 rows
down to 8
got too tight

# reflection on form

My initial goal had been to create a tangible product, perhaps one ready to be put on the market.  Before my final testing with Herman, I was not convinced that I had achieved this.  After witnessing Herman's pleasure I was convinced. It will not necessarily be ready for market in its current form, but some version of this form, customised for the individual's needs.

My final design is more simple than I had ever imagined, but perhaps that is the key.  Less is definitely more in the world of an autist, the less unnecessary information they need to process the better.

After assembling the final product back in Trondheim I took it to Lisa's house. I began this embodied design process with Lisa and had a workshop with her about half way through.  I was curious to see what she thought of how far we had come and what she thought of Herman's choices.  She loved the cosiness of the cashmere lining, the movement of the piece as a whole and the calming satisfaction of the stimulatory outer layer.

We began trying to recreate all the positions I have documented in chapter 3, to check that the product afforded all the positions and movements that the workshop participants had desired.  We ticked every box but in addition, inspired by Herman's selected elements, Lisa began finding new positions. The weight of the product was different than the previous prototype and the ribbed outer layer had a new kind of rhythm.  Just as Herman had been inspired by pictures of Lisa's explorations, Lisa was equally inspired by Herman's customisation.

I realised that within my final object, was embedded every participants unique sensory experiences, the universality I had been aiming for.  This was the advantage on the embodied design process that Pauline van Dongen had encouraged me to embrace.  "The material artefacts that are the outcome of the design process embody theoretical knowledge that is transferable to other researchers through their prototypes or annotated lessons learned etc. which is what I wish to do in this chapter." (16)  Van Dongen refers to this as Research *through* Design (RtD).

# **Research** *through* **Design**

Although simple, I hope that my object might be used as an instrument to facilitate discussions on the tactile sensory experience of autist's, universal sensory design and affording tactile sensory pleasure.

I do not wish to propose that this tube of fabric is the greatest object ever designed.  Rather, I would like to present it as a source of inspiration to consider the sensory needs of others that we interact with, and an example of the value in taking the time to understand what causes others anxiety and brings them pleasure, and how we might benefit from this understanding.  I believe this is equally as valuable if not more valuable that one singular defined object.  My initial goal had been for my research to be embodied in an artefact but I do not wish for my artefact to be presented as something finished.  There are so many more possible evolutions.  Rather, its an example of an insight into the possibility of future artefacts.

I had earlier defined my role as a designer as to inspire and facilitate my users in guiding me in the design process.  This method of working was new to me and I tried to understand its place in the world of design.  Christopher Frayling discusses three different types of research in art and design.  Firstly there is research into art and design.  This is research in the traditional sense, researching things that already exist.  Secondly there is research for art and design; "research where the end product is an artefact - where the thinking is, so to speak, embodied in the artefact, where the goal is not primarily communicable knowledge in the sense of verbal communication, but in the sense of visual or iconic or imagistic communication."(17)

The latter type of research is typical in product design, where the designer presents a final product that embodies all their experiments and research, but the learnings from the process remain stored in the body of the maker, the nuances are left to be discovered and interpreted by the user.  What I wish to present in this thesis are my experiences, my lessons learned, considerations that have emerged from my reflections that I hope are helpful to the design community.  Frayling defines this as research through art and design which he breaks down further into three sub-categories as materials research, technology development and action research where a diary communicates the findings from practical experiments (17), which I think I have achieved in my project and documented in this thesis.



# *making* as sensory integration therapy

“There is, of course, a most legitimate urge in everyone to use their hands, and this takes us back again to the earliest periods.  For when man learned to go upright, his hands were freed for the making of things, his most human trait, and his mind developed with it.  The process from the vague impulse to make something to the final condensation is not served best by limitless freedom but by limitation, by the compelling rules of matter or by self-imposed rules." (11)

Albers assertion is shared by Dr A. Jean Ayres who developed sensory integration therapy for children with autism.  She writes that "accurate grasp of the body scheme is necessary before the body can be expected to deal with space (...) Knowledge of how different segments are related to each other in position and movement is acquired through participation in gross motor activities (...) Crafts such as woodworking, which involve the more gross motions are especially appropriate for body scheme training." (5)  This is both the tactile and proprioceptive senses working together, as I described in chapter 1.  I would liked to have analysed the proprioceptive sense more in the embodied workshops.  Perhaps another time.

In chapter 3 I wrote about revisiting my own tactile sensibility as a maker by reverting to a manual making process at certain points in my design process. I was finding it difficult to articulate what I had observed but I think that Groth perfectly sums this up:  “the act of making something with one’s hands in a material is a way of participating in the world.  It is the conversation, interaction and negotiation between the person and her environment.  By manipulating material, we affect the world and are simultaneously affected.  What we make either stays or vanishes, but the experience has changed us, maybe in little ways, maybe in great ways.  Our hands are the ultimate contact point between our self and the world, the physical and the material.  Through our sense of touch, we feel the material and its properties, its potential and its agency.”(12)

In this project I believe that this is true for both the maker and the user.  In some ways the user became the maker, I simply provided the tools.  Herman became the maker by choosing the materials, I had the knowledge and the opportunity to make it happen.  The workshop participants became the makers, I simply invited and inspired.  This is true ownership and empowerment.  The object is transformed to fit their body and their tactile preferences perfectly.



# Somaesthetics

"Tactile stimulation is primal, and therein may lie some of its significance. Man's phyletic heritage involves tactile information as a major source of information about environmental conditions ... All human perception and action goes through the soma" (5).

The use of the body in making sense, as described by Ayres, fascinates me. I believe this is similar to the theory of somaesthetics, which might be the main overarching theory of my project. Although I knew that I discovered many valuable and interesting findings in each part of my project, I was struggling to pull them together in a cohesive manner. The writings of Richard Shusterman helped pull the elements together.

Shusterman believes that somaesthetics is a tool for designing life (18). The living body is the site of sensory appreciation (aesthesis). Somaesthetics aims to "improve the meaning, understanding, efficacy, and beauty of our movements and of the environments to which our actions contribute and which they also derive their energies and significance" (18).

This perfectly sums up my project. I used my body as a maker to feel through the mechanical machines; to feel the yarn, how tight it wants to be, loosen it, adjust, add in another yarn, touch and immerse my senses in the output. With each iteration I improved my own tactile sense. Then I used the senses of the autist to guide me and found that by utilising their heightened sensory experience I can design a better tactile sensory experience for everyone. Every time someone stepped inside the next evolution of the object in my participatory workshops, they stepped inside someone else sensory preferences, allowing them to inform and inspire how they seek pleasure.

Somaesthetics is about better mastery of our own bodies which gives us control. The knitted object is a means to absorbing our attention, engaging our emotions, regaining focus and control of our own body. We have to improve our own sensibilities as makers and designers in order to help others, almost like putting on your own life jacket and oxygen mask on an airplane first. "Not only art's creation and appreciation would be enhanced through this heightening of consciousness, but also the attractive shaping of our lives as an art of living could be enriched by greater perceptual awareness of aesthetic meanings, feelings, and potentials in our everyday conduct of life."(18)

# Process Reflections

I am a firm believer that a good design process should not be linear, but to begin with I had made a very sensible linear plan, shown on figure ?, with some room for moments of discovery and pivots.  My more chaotic actual process is shown on page 2.  I didn't expect my process to go exactly to plan but this was definitely the least linear process I have ever had! There were several reasons for this including access to knitting machines, importing different yarn qualities and recruiting autists for participatory design workshops. In hindsight it was probably quite ambitious to try and combine these in a 20 week project.

Firstly Ekornes and I agreed that I would not write my thesis for them but in partnership so that I could have creative control over the topic, which I was passionate should be about designing for an autistic sensory experience.  This meant that I only had access to machines for two days approximately every 6 weeks.  To take advantage of this access I began knitting before finishing my research which was probably not the best utilisation of our time, although I did learn a lot about the capabilities and limitations of 3D knitting which informed my design work later.  Deadlines for Ekornes' own projects meant that the machines were occupied when my research dictated I should be prototyping.

Not having digital knitting machines in Trondheim was a big disadvantage but I am extremely fortunate to have been offered use of the knitting room in the Oslo National Academy of the Arts (KHIO).  However, economics and travel time restricted my visits.  I was also very fortunate to have access to their yarn room where I could experiment with different yarns before placing my orders. As digital knitting is relatively new to Norway all yarn for these machines has to be imported, which involved extra cost and long delivery times which hampered progress in prototyping, testing and iterating.

My dream of having a design process that was fully participatory with people living with autism was not always possible, especially in the beginning. This was due to some trepidation in being labelled autistic and my quite exploratory design brief, or lack of brief for that matter.  I found the more work I did, and had to show, the more trust was built and interest in partaking grew.

Whilst I have mentioned the disadvantages of such a topsy-turvy process, it was not without its advantages.  There were many beautiful moments that I would not have discovered had I dictated the flow:



1. I knitted my first prototype in an available yarn the morning before a meeting with a teenager with autism.  He refused to even test my prototype because the texture was so unpleasant.  But this just proved the importance of tactile considerations, it allowed me to see first hand the extreme experiences of living with sensory issues and let him guide me to create something truly pleasurable in a way that might not have happened had I first presented him with something he found tolerable.

2. I started exploring the form through embodied workshops with store bought materials rather than those I was knitting.  Although I would like to repeat these workshops with the materials I have knitted, the absence of these to begin with allowed for commentary on details that might have gotten lost if texture had taken centre stage, for example the textile's movement, weight, padding and how it could be constructed.

3. I started exploring the form through embodied workshops with participants that did not have an autistic diagnosis but were skilled in improvised movement.  This allowed me to experiment and hone my workshop facilitating skills but I was also surprised how the autists were later inspired by the images I showed them from my first workshops and identified correlations with their own self-regulatory practices.

4. As designers we use our intuition.  In this process sometimes I got things right and sometimes I completely missed the mark.  User testing with physical examples proved vital even if they were the *wrong* physical samples.  By getting things wrong, Herman and the workshop participants could use the physical samples to show me how they feel rather than having to verbally express it.  I could observe their body language, the discomfort and pleasure, right in front of me.

# designing a pleasurable tactile experience

As a designer, our role is also to make sense of information, to 'order' our findings in a helpful way. Below is my sense of order, a recommendation for a continuous loop of prototyping, testing and iterating. I would encourage its use even more often than I did it in this project and with many more participants and diversity of users.

## tactile experience of the user

Herman presented / selected the textures that elicit a pleasurable tactile experience.

## maker perceives tactile aesthetics

I touched Herman's textures to form my own tactile perception from the tactile aesthetics. (This may be different than the users perception but I must use it to form my own tactile memory of his pleasurable tactile experience.)

## mechanical making by designer

I touched the textiles as I was knitting them, immediately understanding if I had a similar perception to touching Herman's textures. If not, I could easily experiment with changing or tweaking the yarn, stitch or tension to change the tactile aesthetics.

## digital making by designer

The tactile aesthetics I developed were programmed in the digital machine, with the help of a digital knitting technician, and rapid prototyped many variations.

# building trust

Aspects like weight and finish inform us of the quality of an object which tells us if we can trust something, whether it is valuable.  However, emotion also plays an important role in tactile perception.  Akner Kohler argues that an embodied experience is a combination of sensed stimuli, cognition and emotions which give meaning to a product (14). I am extremely interested to observe how this meaning changes over time.

There were two problems I was trying to solve.  Firstly the provision of pleasurable sensory input.  I think I succeeded with this.  The second was to provide comfort when the autist was in fight or flight mode.  My solution remains untested in this context., even though I have observed that it has a calming affect.  I am interested to learn if it has the same affect in the context of a meltdown.  Are the affordances, semantics and relationship still the same when in a state of distress? To answer this I would need to leave the product with my user for an extended period of time.

I am also very interested in seeing how the affordances, semantics and relationship between the user and the object will evolve over time. "When we become familiar with a material, we have grown in understanding it and its possibilities in relation to our skills and our intentions.  We may recall the tactual feel of a material even when not in contact with it, through our tactile memory and imagination.  We have embodied the material and the way it behaves or the tools used to handle it." (12)

I struggled with trust throughout this project, mainly trust in the process.  This made it difficult to recruit participants.  It is difficult to convince others to join when you don't trust yourself.  But now I do.  I believe I have a strong example of work that I can use to build trust within the autistic community and let them guide me in the next step of this project, wherever it may lead.

We touch things to assure ourselves of reality.
We touch the objects of our love.
We touch the things we form.
Our tactile experiences are elemental.

If we reduce their range, as we do when we reduce the necessity to form things ourselves, we grow lopsided. We are apt today to overcharge our gray matter with words and pictures, that is, with material already transposed into a certain key, preformulated material, and to fall short in providing for a stimulus that may touch off our creative impulse such as unformed material, material in the rough.

*Anni Albers, Bauhaus Weaver*
*excerpt taken from her essay*
*'Tactile Sensibility' (1965)*

# Conclusion

At the beginning of this thesis I described the challenges that autistic sensitivities bring; the tactile defensiveness, the distractability, the anxiety, the meltdowns. But through my design process I discovered many wonderful things about living with autistic sensitivities, in particular the self-awareness, the thoughtfulness, the attention to detail and the pleasure that well designed sensory stimuli can bring. I hope that I relayed these more joyous discoveries, although my intention is not to diminish the challenges of living with autism and sensory processing disorders. I cannot design the perfect world in which these sensitivities and challenges are completely removed, but I can contribute in some small way by inspiring other designers to be more considerate in their creation of sensory output and the affordance of adaptability that empowers everyone. 3D digital knitting is just one opportunity for customising sensory experiences and others should be explored.

Autism is a normal human difference. Diversity is beautiful and important; "the world needs different minds to work together." (?) Our unique experience of the world is something we own. We control what our normal looks and feels like and each of us have the right to the resources to adapt our environment, that considers any limitations we might have, to create an experience that empowers us and allows us to make our unique contribution to the world. This should be the norm. As designers we have the power to redefine what is considered normal.

The embodied design process was crucial to my design development. It was by no means perfect and was a steep learning curve for me, but its importance was the collaboration between the user and I, the user and the material, and the material and I to create an individual pleasurable experience for the user. Embodied design is extensively written about and used in the context of computer interaction design, however many of its theories have been inherently used in fashion design for centuries. I find both interaction design and fashion design practices to be focused on finding patterns within individual responses to develop a one size (or perhaps a few sizes) fits all solution. They are about designing an input and predicted output, leaving little room for an expression of individuality.

I was disappointed that I did not have more participation from autists in both developing and testing textures and volumes. But Herman serendipitously



turned out to be the perfect user to develop my design process with. This experience has given me the confidence to continue iterating on this process. I now have a strong example of work produced using this method. I can use this portfolio to build trust and interest within the autistic community, and investors, which I am passionate to build on.

In some ways the deficit in participants became of less significance because of the possibilities for customisation with 3D digital knitting. Simply understanding this potential and making it available to others is such a game changer in how we design and mass-produce. The "affording" in my title refers not only to the facilitation of the user intuitively understanding the possibilities for interaction, but also the efficiency of prototyping, testing, iterating, and producing all in the same room as part of product development, and in turn offering the user an affordable personal product that is the perfect fit for them.

This digital process is wonderful but my project also served as a reminder that the world is rapidly disengaging with our tactile sensibility both as makers and consumers. So often designers sit alone simulating a predicted experience on a screen, emailing manufacturers in another time zone. But absolutely everything, design, manufacturing and user interactions, should be in the moment, a lived and collaborative experience. What we create together touches us at every moment of every day. This project may have started with autism, but the universality of touch became strikingly apparent.

I defined my role, as a designer, as one that invites and inspires the user. I believe my product outcome succeeds in this. The pleasant comforting and stimulatory textures invite the user to interact and the volume inspires them to explore, adapt and indulge. My goal was to invite the autists into my world, and inspire them with my tools, creativity and skill set. In the end it was the autists who invited me into their experience of the world to share their sensory preferences, inspiring me with their tactile sensibility and self-awareness. I wish for this to become a continuous loop of shared experiences, understandings and inspiration. I would encourage this process for every designer.

By harnessing the heightened sensory experiences and self-awareness of autists I believe we have the opportunity to design a more pleasurable sensory experience for each and every one of us, to create a world in which we thrive.

# *project overview*

**1.**
**understanding the sensory experience of autists, focusing on touch**

**2.**
**developing knitted textiles that eliminate tactile sensory inputs that causes anxiety**

**3.**
**developing knitted textiles that evoke a pleasant tactile experience, inviting the user in**

**4.**
**developing 3D knitted volumes that inspire and empower the user to customise their tactile environment**

**5.**
**developing my tactile sensibility and self-awareness as a designer**

**6.**
**customising tactile preferences for the user through 3D digital knitting**

*harnessing the heightened sensory experiences and self-awareness of autists; as much as they experience unpleasant textures more intensely they also experience pleasant textures at a greater intensity than most*

*embracing normal human differences, personal preferences and unique sensory experiences to customise the surface, immersion and volume of tactile interactions*

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