University of South-Eastern Norway
Faculty of humanities, Sports, and Educational Science

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Master's Thesis
Study programme: 60MASTRP
Spring/Autumn 2022

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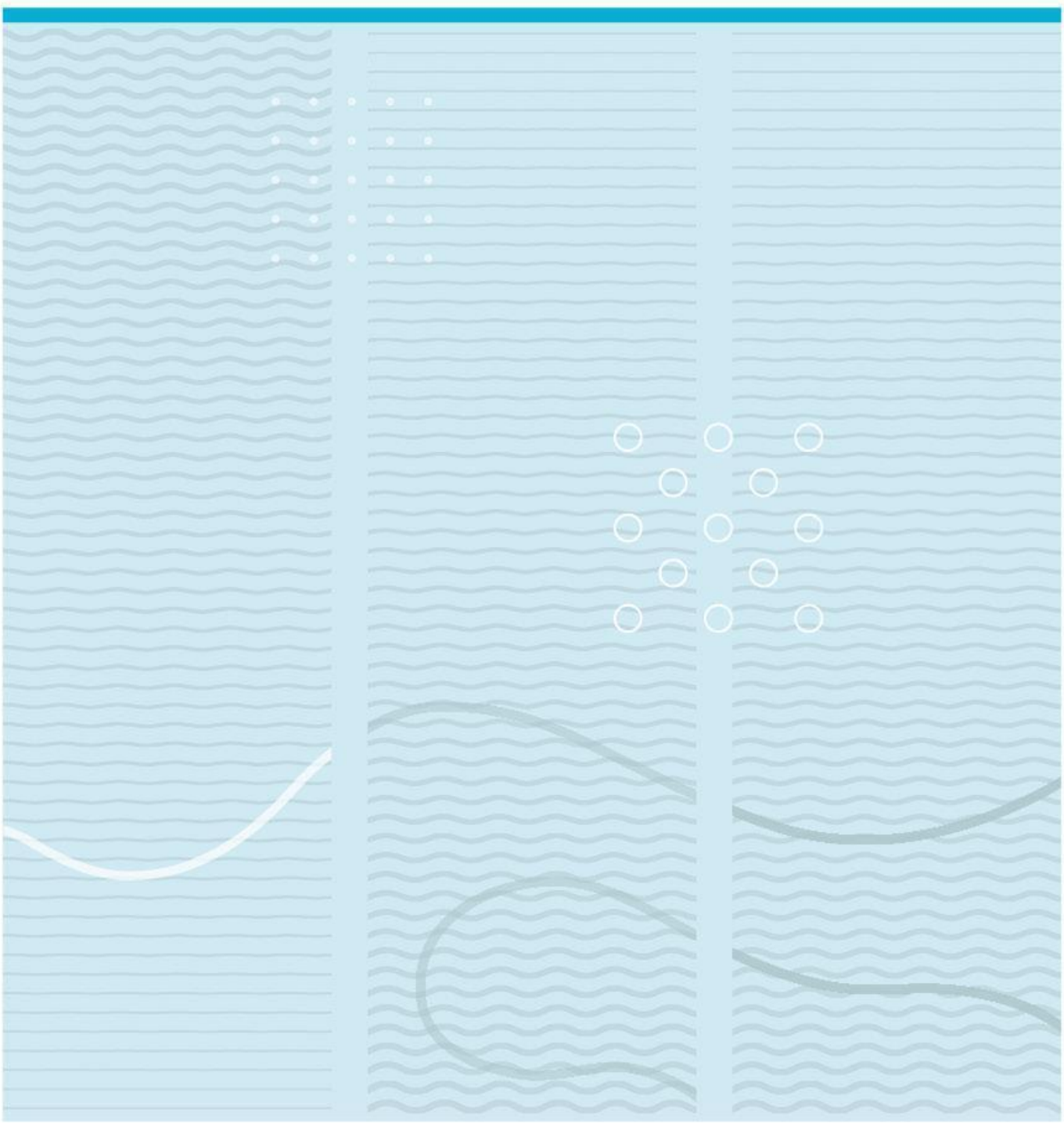
Meeting the material halfway

Exploring material affordances in Norwegian Old Spæl Sheep spring wool using felting as technique



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This thesis is worth 60 study points

Summary

Sustainability and resource usage are presented to us in phrases and terms that we hear about almost every day. In Norway, wool can almost be said to be part of our cultural identity. Despite this cultural importance, a lot of the wool from old and historical sheep breeds are not made use of. One way to honour this wool is to engage with it during felting, a craft that can get one as close to nature as possible when working and creating with wool. Felt requires few resources or processing, and is easily degradable and recycled, in other words, environmentally friendly. Felting wool is therefore sustainable, in the modern sense where environment and natural resources are focused. In this research, I have chosen to work with a method that involves practice as research and emphasises an understanding of new knowledge creation that happens *during* the practical work, and not only by analysing the samples afterwards – the PaR method. The practice and its outcome are placed within a framework of new materialism as a philosophical lens and affordance as theory, in addition to the historical context of sheep, wool and felt.

By making use of spring wool from Norwegian spæl sheep, we can realise a potential from the past. Our Nordic history shows highly appreciated products made from double-coated, pigmented wool like the one Norwegian Old Spæl Sheep has today. The results show that a potential from the Nordic past can be realised when using tog and/or thel into products that have their features based on the natural properties of the wool. To maximise the potential, I suggest both types of fibres should be used in the future, and that it is key not to lose contact with the natural ecological value of the wool. My results state that spring wool felts fast and well, and the wet felted textiles show a great variety of future usage The coarser tog has proven to play an important role in durability aspects, but so has the way the wool is prepared before felting. For future developments, collaboration between interdisciplinary fields is recommended to enhance finding material possibilities. Findings also stress engineering innovation, to create small scale felting machines to build new industries upon.

Contents

Foreword

The desire for this research has come from my love for wool as a natural material and questions I had on how value is created. How can a specific type of wool suddenly become low-value, or worthless and not be made use of? With my professional background in both the textile industry and teaching, and a huge interest in understanding the world, I never seem to be able to let questions like these go without doing my best in understanding them. I, therefore, dug into value creation and if there were ways to make use of this wool material and at the same time re-actualize its value.

This thesis was written for my master's degree in Traditional Arts at the University of South-East Norway, campus Rauland. The subject is related to perspectives of sustainability regarding wool, material knowledge and felting as a craft technique. The topic is very exciting because when looked upon through a new materialistic lens, it creates a holistic approach where past, present and future ways of life can lay a foundation for future developments that resonate with long-term healthy ecosystems.

Several annexes are appended to this thesis. In these documents questions asked in the survey, industrial manipulation and names of the wool samples, manual felting method, and shrinkage test A are included. In addition to these annexes, there is a catalogue/booklet where all the practical data from material analyses are gathered.

I want to extend an enormous thank you to all the supportive and kind women that have believed in my research and stood by me during doubting hours of despair; Lori, Birgit, Erika, Ingrid, Ronja, Sara, and Elise. A huge praise to Selbu Spinneri, and Oslo Mikrospinneri for inviting me into your production. Thank you to the Gammelnorsk spælsau farmers that answered my survey and for keeping such wonderful sheep. To their chairwoman of the board, Anne Lise, you have been wonderful. And to you, Norwegian Old Spæl Sheep, I adore you for supplying this research with wool!

<Rauland / 09.05.2022>
<Nina Alsborn>

1 Introduction

This thesis takes a closer look at the Norwegian Old Spæl Sheep spring wool, and the diverse usage possibilities that this material offers. As of today, there is little research that goes into depth on the felting properties of Norwegian wool. I wanted to explore what wet felted woollen textiles that consist of both coarser hair and finer down can achieve. What affordances, or possibilities for action does this wool offer, what aesthetic, technical or functional properties can such textiles have, and how are they perceived visually and tactilely? To explore the wool in this way, I have decided to use available industry tools and their ways of manipulating the wool. After the manipulation, I move into wet felting, without having a specific end product in mind. The reason for not having a product in mind, was to be more open minded in the exploration process. I use both hands-on felting and machines to simplify further work in further development or research.

I work from a definition of sustainability that not only sheds light on a future for human needs, but also how to counteract the general loss of resources. I want to emphasise how using material knowledge from the past and one of the oldest textile techniques we humans have can be implemented into the development of a sustainable future. In such a context, looking at pigmented, double-coated wool and felting will be important - they are two important factors in our Nordic textile history and cultural heritage. The Norwegian Old Spæl Sheep has a wool type that has been with us in the Nordic countries for more than 5000 years and has been described as indispensable. Wet felting is a textile technique that is considered one of the oldest and has been used by humans for over 8000 years. The aim of my research is to contribute with new knowledge about textile materials that can be part of long-term and healthy ecosystems in our future and re-actualize the value of wool from the Norwegian Old Spæl Sheep. The practice and its outcome are placed within a framework of new materialism as a philosophical lens and affordance as theory.

Keywords – pigmented, double-coated wool, value, affordance, new materialism, materiality, resource usage

2 Background

2.1 Contemporary debate and external motivation

Sustainability and resource usage are presented to us in phrases and terms that we hear about almost every day. When it comes to materials, wool is both versatile and sustainable. In Norway, wool can almost be said to be part of our cultural identity. For as long these lands have been inhabited, the sheep has been a partner in cultivating the landscape and providing us Nordic folk with both clothing and nutrition to survive (Blix, 2018). Despite this cultural importance, a lot of the wool from these old and historical sheep breeds are not used. During the last few years, several different articles and projects have stated this fact (Hilton, 2021; I. G. Klepp et al., 2019; McKinnon et al., 2019). This tendency caught my attention and made me reflect upon the reasons for this underuse of a wonderful resource? I started looking for ways to address this problem by turning attention to the initial stage of producing wool: the sheep farmers. More specifically, I conducted a survey of Norwegian spæl sheep farmers.

The survey[1] was presented to them during my pre-project and 50 % answered that they throw away or burn wool that could have been used for something else. One factor that contributed to this development is that this wool is not considered socially beneficial. In the 2016 the National Agricultural Budget Agreement, the subsidies for Norwegian wool were changed and new categories for distributing the funding were created. This means that from 2016, "beneficial" wool is promoted due to their "important" classification. The total amount of the subsidies hasn't changed, however, they are redistributed to these "beneficial" and "important" wool types, such as the C1 where we find crossbred breeds such as, Norwegian white sheep (NKS). C1 wool received increased support per kg, while Old Norse Sheep and Norwegian Old Spæl Sheep (spring wool) lost all its subsidy (Norwegian Directorate of Agriculture, 2015). The latter wool types also lost its own category and therefore ends up in a collection category called CS2. When you sort and choose the finest wool, the result is that the rest will become of lower average quality (Hebrok et al., 2012). In the survey, the farmers respond that after the loss of governmental subsidies, 48 % report that

[1] The survey was conducted in 2021 and was answered by 141 participants all members of the Gammelnorsk spælsau lag. This gives it an answering rate of 28 %.

working with these sheep is not financially justifiable, and 79 % are very displeased with the overall financials in this line of agricultural work. All questions asked, can be found in annex 1.

2.2 Inner motivation

During my work in the textile industry, I experienced how much of the wool from Norwegian Spæl sheep was discarded. In terms of production, wool from this breed is a technically challenging process for production due to a fleece consisting of two types of fibre that needs to be separated to accommodate the mill machinery– the soft down hairs and coarser guard hairs. In addition to having different softness properties, they also have different thicknesses and lengths, which can make them demanding in yarn production. The wool is pigmented, which gives it fewer options in dying. At the mill, where I worked, many guard hairs were separated and sorted out of yarn production and later thrown away. Fleece with longer hairs, not suitable for yarn production, could be made into rug yarn. Still, I encountered too much waste of wool with excellent properties - strength, water repellence, shine, and colour. An indication that yarn milling may not be the best processing craft technique to fully utilise the Spæl wool properties. During felting I experienced that some of these problematic areas were not so visible. Could felting be a way of utilising wool not suitable for e.g., yarn production? In addition to the fact that there is a potential for further utilising the wool as a material and resource, there is also a philosophically ethical aspect of regarding *all* this material as important, useful. In the background, I always have a strong connection to the work that the Norwegian Old Spæl Sheep farmers in Norway do without sufficient payment.

2.3 Previous publications on the subject

Information about the significance of the Norwegian Old sheep breeds for our Norwegian identity and cultural heritage has been written down by, among others, Drabløs (1997), Lightfoot (2008) and the Krus project (I. G. Klepp et al., 2019). They refer to important aspects of the properties of wool, but also to the areas of use and importance in our Nordic historical textile heritage. In the field of resource utilisation and of wool, there are several different research projects, both in Norway and abroad. Woolume in Poland (storbyuniversitetet, n.d.-b) and Hiwool in Portugal, work with increasing the value and finding uses for worthless wool. Amazing grazing (storbyuniversitetet, n.d.-a) at Oslo met / SIFO and NIBIO in Norway work in a similar fashion with sustainable utilisation of meat and wool from sheep grazing in Norway. In addition, work is being done via NIBIO and VerdifULL (*VerdifULL*, n.d.) to contribute to increased value creation for downgraded wool, as well

as increase the proportion of 1st class wool. In 2017, the first pilot project characterising Norwegian wool was carried out. It is not published yet, but it states that felting must be investigated further (Espelien, u.publisert). Presented projects show that the topic today is important and that my research can be a contribution to the field.

I have found no research so far that investigates the propensity for felting, or felted textiles made from Norwegian wool. In Norway, the performative approach to felting as a technique has been written about by Jamouchi (2019). Internationally, there are several articles about craft dynamics in felting wool, design development and the interaction between performer and the material (Aktaş, 2018; Aktaş et al., 2020; Aktaş & Mäkelä, 2017). My dissertation differs from previous studies when I go deeper into spring wool from Norwegian Old Spæl Sheep and explore what material affordances exist. In addition, I have an industrial background, which gives me a broader perspective of opportunities in industrial production today. I suggest a broad group of target audiences that could benefit from knowing more about these woollen felted textiles, including industrial producers, designers and practising art and craft persons.

Felting wool as a craft gets me as close to nature as I can in terms of creating. It requires few resources or processing, is easily degradable and recycled, in other words, environmentally friendly. Felting wool is therefore sustainable, in the modern sense where environment and natural resources are focused. Today many definitions look to the future when discussing how to move forward more in balance, based on three basic pillars – economy, environmental, and social/cultural. But I would like to take a historical approach to the term sustainability through my work. I intend to think of the field of conservation – a prevention of wasteful use of resources – when I define sustainability. In conservation, a sustainable way forward can be to *preserve the future as a realisation of the potential of the past* (Rawles & Holland, 1994). I interpret this definition in my thesis to highlight the importance of remembering and actualizing the potential that wool from Norwegian Spæl sheep and felting as textile craft has had in human past, by bringing this knowledge with me into the future.

2.4 Research question

The purpose of my research is to try to re-actualize the value of wool from Old Norwegian Spæl Sheep and increase the understanding of felted textile materials made from spring wool. My role as a researcher is also a role of a technician, supplying the industry, artists, and artisans with practical information of the material and technique. The lens of new materialistic philosophy and the conceptual framework of affordance theory and practice-based methodology, are actualized through the following research question:

How can felted textiles made from Norwegian Old Spæl Sheep spring wool be part of future development, which views sustainability as a realisation of the potential of the past?

To answer this inquiry, I must ask three questions:

1. What does our Nordic textile history tell us about usage of wool from double-coated sheep breeds and felting as technique?
2. How can felting and exploring this material for affordances, give me insight into woollen felted textiles and their characteristics?
3. How can these findings be incorporated into future development that resonates with long-term healthy ecosystems?

2.5 Glossary

Batt: The preparation stage for feltmaking. Webs of fibres are peeled off by hand or with drum carders and then layered to form a batt several layers deep. A batt is formed as a stage in the commercial preparation of wool for spinning, as done at Selbu Spinneri and Oslo Mikrospinneri, but can also be done with a table carder.

Breeds: A generic term used in the classification of sheep in commercial and industrial processing of wool

Felt: Felting is a form of tangling produced by the persistent rootward migration of the individual fibres, which is caused by the directional frictional effect (…) of fibres (Liu & Wang, 2007). Wet felting requires moisture, friction, and heat.

Fibres: Individual hairs which are grown collectively, in this case as fleece on a sheep.

Fulling: The final stage in feltmaking when the fibres shrink and lock together, compacting the felt and increasing strength, density, and durability.

Hardening: The process where it goes from pre-felt and continue to the point where it is ready for fulling

Material: Untransformed matter with its own natural characteristics. Materials can later be formed and shaped by human hands giving it either new features or enhancing characteristics from before.

Materiality: A quality or character of being material or composed of matter (Oxford languages)

Potential: Possible as opposed to actual. Having or showing the capacity to develop into something in the future; latent or prospective (Oxford languages)

Perception: Used in a broad term, perception is seen as a sort of awareness through the senses. In this research it involves especially the senses looking and touching.

Pre-felt: Wool fibres which have been cross layered and wet felted just enough to form a cohesive sheet.

Preserve: The standard definition, for example from the Oxford dictionary, is maintaining something in its original state, while I define it as *taking care of* or *looking after*.

Sustainability: A way of realising a potential from the past to preserve the future (Rawles & Holland, 1994).

Tradition: Understood as a transmission of customs or beliefs from generation to generation (Oxford languages). In customs and beliefs, I include techniques, methods, and material knowledge necessary in the craft and art of feltmaking. The term is used in a wide sense, independent of a discussion about or classification as a 'living' tradition or not.

Textile: A textile is a type of cloth, unfinished or in need of applications, and felt is a non-woven cloth. Since my felted samples will or can need further work, I have decided to call them textiles in my thesis. Felt is therefore mentioned as a felted textile.

Fig. 1 - Livredderen Norwegian Old Spæl Sheep © N.O Mevatne

3 Historical context of wool and felt

To answer the first questions of this research, chapter 3 will present the history of sheep, and cultural and material importance, using sources like Brueneck (1949)*, Drabløs* (1997)*, and Blix* (2018)*. To understand more about felting and the technique, knowledge from Sjöberg* (2009) *and Damgaard* (1994) *is chosen. They have a vast understanding about wool as a material, the history of felt, and technical aspects of the craft.*

3.1 The sheep

As a domestic animal the sheep have coexisted with humans for over 10 000 years. According to research done by the Italian wool association in "The world of animal fibres" (Robbatino et al., n.d.) the domestication started in the Mesolithic time which ranges between 10 – 8000 BC. The fleece of the sheep was brown, black, or grey/beige, or white fleeces due to its camouflaging effects, with double layers to provide protection. Today there are approximately 1 billion domesticated sheep in the world, and raising sheep is one of the oldest organised industries in the world (Aaron & Ely, n.d.).

Signe Brueneck (1949) explains, that in the Nordic countries the *Stuttrove* or *spælsau* differs from many other known sheep breeds. She continues that in Norwegian the name points directly to one of the most prominent features of this type of sheep: the short tail. "Spel" or "stutt" means short – hence short tail. The characteristic of its wool is a significant feature that differentiates this type of Nordic sheep from all other refined[2] sheep. The prehistoric sheep - also called a primitive breed - had a double layered fleece. The wool from the spæl sheep is much like the prehistoric wild sheep. With its two layers of wool, one consisting of merely coarse cover hairs – also called *tog* - and one underlying type of fibres that are soft and very fine – called *thel*[3].

The spæl sheep is (Fig.1), apart from its very specific type of wool, also known for its great perseverance and frugality. These qualities make it especially well-suited to survive in the Nordic

[2] Refined describes the breeding away from the prehistoric primitive breeds of double coated fleece, and into a modern sheep consisting of one type of white wool fibre. It is likely that this genetic selection of white fleeces started around 3000 BC in Mesopotamia (Robbatino et al., n.d.).

[3] The *tog* and *thel* are Icelandic terms for these types of wool fibres. There are no better terms today, and I will continue using them throughout my research.

cold, weather-beaten landscape and serve humans here. The Nordic spæl sheep is a result of thousands of years of environmental influence and genetic evolution as well as breeding.

The breed that is the closest descendant from the prehistoric ancestor, is the Norwegian feral sheep called "utegangersau" or "villsaue"[4]. The breed is called "Gammelnorsk sau" – Old Norse Sheep. It has been assessed that the Old Norse Sheep was quite dominant here from the Viking area until the 18th and 19th century. The Norwegian Old Spæl Sheep is a direct descendent of the Old Norse Sheep. In 1912 there were only a few sheep flocks left in Norway that could be considered a pure breed of Old Norse Sheep and Norwegian Old Spæl Sheep. With national funding, two breed locations were created, and through that work purity of these sheep breeds were maintained (Drabløs, 1997).

3.1.1 Cultural and material importance of sheep and wool

Sheep's wool has always been of great importance to humans, and especially in colder or northern latitudes, where in prehistoric times, it was a necessity for survival. An old saying on the Faroe Islands is: "Seyða ull, er Färoya gull" which translates into the "ewe's wool, is Faroe gold" (my translation) (Drabløs, 1997). If not for wool, clothing would be much more difficult to obtain in the weather-beaten countries. Food on the other hand, could be found on both land and in the sea. According to Blix (2018), domesticated sheep have been with us for about 5000 years in Norway. The sheep helped the first settling farmers with grazing the fields and thereby clearing areas for agriculture. Manure was spread on the fields, which gave much more nutrition than formerly used seaweed and leaves. More nutrition in the soil gave better crops. The wool was used for clothing, and meat was easily accessible without hunting.

In our textile history, double-coated, pigmented[5] wool has played a significant role. This double coated wool gave a great variety of usage. The two different fibres – *tog* and *thel*– could either be combined or used separately. Separating the *tog* from the *thel* was a circumstantial process, but

[4] *Uteganger* or *villsau* are not breed terms. There are several sheep throughout the world that are both wild and lives mostly outdoors.

[5] They come in a variety of colours-shades; black, grey, grey-blue, brown, light brown, off white. There are also combinations like mixed badgerface and mouflon, The *tog* can be of darker shades, while the *thel* can be lighter or display similar colours as *tog*.

crucial for products like Viking sails. Only the coarser guard hairs were resilient enough for the warp in the loom, while the softer and finer fibres were used in the weft[6], keeping the sails dense. Also, products like water resilient mittens for fishermen (Lightfoot, 2008), or boat carpets were produced with a high content of the stronger and water-resistant *tog* (Kjellmo,1996). Also worth mentioning, is the well preserved Baldishol tapestry, which is over 1000 years old, made from double coated wool (Klepp et al., 2016). These products all display important, symbolic value. Monetary values were as well given these products. Woven woollen fabrics, that were afterwards felted, became highly sought after during the Viking area (Smith, 2018). Smith (2018) explains that this type of fabric – in Norwegian named "vadmel" – was used as a means of payment. While silver during that time had an unstable alloy and therefore an unstable value, "vadmel" could easily be spotted to have good quality or not and therefore were seen as more stable and reliable than silver, giving it high monetary value. In one of the oldest books of law in the Nordic countries, *Gulatingsloven* which was governing the 12th century, *vadmel* was considered a lawful payment (Brueneck, 1949).

We can also find a semantic thread, regarding spring wool and potential. In the Norwegian word for carpet, *rya*, there is a connection to the usage of spring wool. Kjellmo (1996) explains that these highly appreciated carpets are woven, curly carpets. The semantic thread Kjellmo (ibid) lays out has to do with the word rya, which can have its origin in *ru* or *ruv*. In her dialect *ru* means *spring wool from sheep*, a semantic meaning that she states is confirmed by research done by Hveding where *ru* is described as *wool sheared in the spring*, *winter wool*. These semantic explanations show that spring wool could have been important in production of these carpets, but that it did not have to do with felting as a technique – although the carpets did felt afterwards due to the characteristic of the wool and was a south after feature keeping the carpets strong and resilient on the boats.

3.2 The understanding of wool and felt

3.2.1 Wool as a fibre – characteristics

Wool is made from the protein *keratin*, which is the same protein that human hair and nails are made of. It is the most absorbent fibre of all, being able to absorb up to 35 % of its own weight (Thompson & Thompson, 2014). Wool is also *hygroscopic*. This means that it keeps the warmth even when wet (Humphries, 2008). The outside of the wool fibre has three layers of scales that

[6] Warp is the lengthwise direction in the loom ↕, while the weft is the crosswise direction ↔ (Humphries, 2008).

overlap. Edges on the scales protrude, giving the fibre a rougher touch from tip to root than from root to tip. When moved about, the fibres travel, but only one direction – from tip and inwards. This property makes felting possible (Humphries, 2008). A good scientific explanation on the technical transformation that the natural wool fibre goes through during felting is found in Lui and Wang: *Felting is a form of tangling produced by the persistent rootward migration of the individual fibres, which is caused by the directional frictional effect (…) of fibres* (Liu & Wang, 2007, p. 957)

Lui and Wangs definition contributes with scientific information about how the felting and entanglement happens. It is the rootward migration that starts to move due to a specific (directional) action of rubbing or moving on the surface (friction) with hands or another object, which in turn gives certain consequences (effect). In the modern yarn and textile industry, this ability to felt is not a wanted feature due to fibre breakage and undesirable shrinkage in wool in scouring[7] or finished textiles. But in a longer historical perspective, felt and felting has had an important cultural position in our textile history.

3.2.2 Cultural importance

When addressing the field of felt and felting as a technique, previous work done by Damgaard (1994) and Sjöberg (2009), two prominent felt artists in Denmark and Sweden, will be presented. Both Damgaard and Sjögren display vast and broad knowledge on historical aspects of felting and felting as a craft, in addition to wool fibre characteristics.

According to Sjöberg (2009) legends tell tales about sheep, travelling with Noah and all the other animals, shedding their fleeces during the long trip. The fleece, landing on the floor of the boat, was both urinated on and stamped on during the trip, thus leaving a fully felted mat of wool on the floor when all animals left the boat. The legends and stories come in many different varieties, and it is not likely one will ever find one answer to the real origin of felt. But they present the factors that contribute to making a felted textile: the loose wool, the pressure, heat and added liquids.

[7] The washing procedure of wool where grease and impurities are removed.

3.2.3 Historical context of felt

This story does not evolve Nordic history, but it is still important to tell when creating a backdrop for felting as craft. Felt has a historical timeline dating more than 8000 years[8]. Before, several scholars have presented the probability and finding that felt might be the earliest form of textile (Burkett, 1979; Damgaard, 1994; Laufer, 1930; Sjöberg, 2009). The history of felt shows a thriving culture by the nomadic Asians early in time and the felting knowledge then spread to both China, India, and Greece (Burkett, 1979; Laufer, 1930). The most important finding that indicates knowledge of felt as a technique, are in Catal Hüyük in Turkey, a settlement with pre-eminent importance for the Neolithic Age in the last period of the stone age, dated back to early 6500 B.C. The two major archaeological findings of felt made are in Pazyryk, Siberia and Noin-Ula in Mongolia, which shows felted items displaying a rich and valuable crafting technique (Burkett, 1979).

3.2.4 Felt findings in Nordic countries

A good overview over felt history in the Nordic countries is presented by Damgaard (1994). The oldest findings of felt fragments in Scandinavia, are from Hordaland, Norway in the 6th century A.D. The most important finding was from an excavation of a Viking ship in Hedeby, Denmark. Damgaard (ibid) explains that when finding only a few felt fragments in Nordic history it can be because felt is a natural and easily perishable material, that also could easily have been overlooked by archaeologists resembling mud or old wood. The reason the felt findings in Hordaland and Hedeby has survived, is due to their usage as caulking[9] material therefore covered in tar. Scientific studies and analysis that have been made of the two different findings show that the felt materials are different in quality. It states shorter fibre in thick loose felt, felt made of two-coloured layers, and felt made from scratched up woollen web (ibid).

3.2.5 Traditional felting craft

According to Ågren (1976), felting in Norway was mostly done by women. She continues that it was often boots and socks that were made. In Namdalen, felting was very common which resulted in industry coming to life in Mo i Rana during the 1950`s. Another industry near Haus outside of Bergen, were later established. In Sweden, the tradition of felting did not spread further south than

[8] In this research it is wet felting that is mentioned. Needle felting is another technique, introduced by industrial tools much later in history.

[9] Caulking is a material used to seal joints or seams against leakage in various structures, today silicon is mostly used.

Hälsingland and Jämtland. This due to central heating in the south and introduction of modern materials. Traditional felting in the Nordic countries did, like mentioned above, refer to more simple utensils like socks and boots or mittens (Ågren et al., 1976). Ågren (1976) says that these products were well needed in a cold and sparse climate where the economy was harsh. The shoes, more fulled than the socks, could often be reinforced with *vadmel* or leather. The craft of felting could vary from local women and families performing it, to travelling masters that traded the skills for payment. Making hats became more and more common amongst craft makers. During early 1900 felted socks had a higher price that knitted garments, even though the felting took less time than knitting. For Ågren (ibid) this shows the importance and value of the material. Felting required more material than knitting did. No industrial development of felt grew in Sweden. In the Nordic countries, opinions about which wool material that was best suited for felting varies. Sjögren (2009) writes that while some wanted the longer fall wool blended with finer and softer wool, others preferred the shorter spring wool. The longer wool from the rya sheep were seen as strong and durable and therefore used for socks.

Different rules apply when working with felting characteristics of wool. Factors that are vital are choice of wool material, the number of layers and their thickness, temperature of water, pH in detergent or soap, and amount of time working with the wool during the felting process (Sjögren, 2009). Since the wool fibre only travels one direction, it is helpful during felting to place layers of wool in crosswise directions. If not, the felted textile might shrink more vertically than horizontally.

In addition to these factors, a few golden rules apply (Damgaard, 1994; Sjöberg, 2009):

- The thicker the layers, the softer the felt can become
- The thinner layers, the more firm felt
- Fewer layers create a thinner felt
- More layers create a thicker felt
- When using a rolling technique, the felt will shrink in the direction of the rolling. Therefore, it is important to turn the felt in all directions to achieve a similar result on all sides.
- The fineness of the wool affects the propensity for felting, fine fibres felt and shrink faster.
- Long, whole year wool can require more pressure and time to felt, but in return creates a strong felted textile. Shorter wool sheared twice a year, is easier to work with.

- When felting wool from the primitive sheep one can separate the *tog* from the *thel*. The finer *tog* with many cuticle scales felt rapidly, the tog with coarse hairs has a lower feltability.
- The pigmented wool consists of such a rich variety that many aesthetical and functional needs can be accommodated.

This contextual backdrop of how wool and felt have been used shows the importance the material and the technique have had in our history. It has been used to survive in cold, sparse climates by keeping us warm, making use of the wool characteristics. Felt did also generated industrial developments – especially in Norway.

4 Theory

4.1.1 Choosing a philosophical lens

Karen Barads (2007) new materialistic philosophy and framework provides a holistic lens through which I can view how nature, humans and animals together create value and meaning. A lens that goes beyond both symbolic immaterial values, attributed to an object or an idea that communicates a symbolic meaning, and economic value, measured in benefit provided by a product to a group of people in units of currency (later also referred to as monetary value) in creating total value. In short, an object or material has intrinsic value regardless of how we see it. Barad describes a framework that lays out a philosophical and practical approach that highlights a "turn to matter" (Fox & Alldred, 2019). The "turn to matter" emphasises the materiality of the world, instead of only language, discourse, and culture. This approach offers matter and materiality a part in the creation of value and meaning. An alternative to viewing value creation from an exclusively human perspective, as we are accustomed to perceiving our surroundings. This means that non-humans like animals and things, and nature and materials, play an equally important role in the creation of our everyday life. In *new materialism* [10] there is not a choice between seeing the becoming of the

[10] The new in *new* materialism indicates discontinuity from earlier materialistic thought from Marx amongst others. Here focus is on social institutions and a political and economic context of material consumption and production (Fox & Alldred, 2019).

world through either epistemology or ontology – but both; it deals with and studies the nature of knowledge and offers understanding about the nature of being.

I interpret this as learning about and experiencing a deep understanding of my material and how I interact with it. It is about understanding what I learn as knowledge from the material by being aware of knowing *how* I can know it, and at the same time the things I am working with - the sheep, the wool, tools, values, and properties. None of these factors are disconnected from one another. Further, Barad (2007) also adds an ethical aspect which claims that this might be an ethic-epistemological way of being in the world. For me, this puts my scientific work under a scrutiny of ethics – the methodology raises questions about value as moral principles that regulate my behaviour and thinking during my work.

The New materialistic framework that Karen Barad (ibid) has developed also contains knowledge making. For Barad knowledge is not something that is obtained from afar. Instead, she argues that as we are not outside observers of the world, we gain knowledge because we are of the world. She continues that this view insists on understanding thinking, observing, and theorising practices of engagement must be considered as part of the world in which we have our being. For me, this implies that since I am part of this world and culturally (by national inheritance) connected to the sheep in this world, it is together with the wool that I understand, experience, and explore the material.

Karen Barad´s new materialistic theory is a performative approach [11] which states an action-based relationship between being, knowledge making, and hands on material in a close collaboration. To me, the new materialistic perspective therefore invites choosing a method that highlights the importance of practice as research in addition to a theoretical approach that can be relational, and thus brings *agency* to the material. By agency, I mean that it makes the material an active participant in creation (Knappett & Malafouris, 2008) – an influence in the act of making. With this backdrop I have chosen to work with J. Gibson's (2015) affordance theory. Affordance theory lays a foundation for working with a relational aspect with my material where I can explore possibilities

[11] Gamble, Hanan and Nail (2019) calls Barads approach performative new materialism due to the fact that in her view observations never “disclose pre-existing values” or properties but, in fact, also always play a role in constituting them (2019, p. 122).

for action. Gibson (ibid) also shares a similar perspective on values and meaning with Barad. For Gibson, values and meanings are external to the perceiver. A concept that undermines traditional dualism of the objective and subjective (Costall, 2012), indicating a new way of seeing meaning and value in environmental things and their relations. By doing so, Gibson's (2015) affordance theory gave the philosophical discourse and the western way of thought a new angle – are values phenomenal or physical, or only in the world of mind? Stating that affordances are distinguished from values, that they are neither in this world, or another, as there is only one environment for all of us – nature, animal, and human. To perceive an affordance is not to perceive a value-free-physical object to which meaning then is added as a validated endorsement; it is a process of perceiving an already value-rich ecological object (ibid) - like wool.

Importantly, I aim to see the material value by trying to avoid the commercial doctrine - I am not allowed to bring industrial thinking that states double coated wool as problematic, nor that pigmented wool has lower lightfastness than man-made synthetic dyes give a textile. Nor is it of any interest to value softer fibres as more important than coarse hairs in the fleece or take any consideration to the different lengths that the wool has. By discarding these conditions, I strive to meet the material halfway. Openness, curiosity, and partnership are terms I take with me in this work. With this backdrop of material importance in understanding, knowing, and exploring the world I will, in my research, use new materialistic philosophy as a lens through which I see spring wool as important and valuable as wool subsidised and valued by industry and agricultural agreements.

4.2 Affordance

To answer the second and third question of my inquiry, I will use a framework of Affordance theory. In this theoretical chapter works from Gibson (2015), Norman (2013), and Barati and Karana (2019) *are introduced. The practical work that follows explores what spring wool from Norwegian Old Spæl Sheep can offer when using wet felting as a technique. The results are analysed in chapter 7.*

When using affordance theory, it can be useful to see how it has developed though out the years. Affordance has gone from being a relational concept implying certain environment-provided action-opportunities in ecological psychology (Lanamäki et al., 2015), to formulating perceived and actual

properties of the thing (Norman, 2013), to discovering novel opportunities in a material (Barati & Karana).

4.2.1 The affordance of the environment

Affordance[12] originates from the writings of James J. Gibson. He, an ecological psychologist, presented a new term, derived from the verb "to afford", when trying to understand "how we see when we are in the environment", and "how we see when things are good for an animal"? (Gibson, 2015). Gibson thereby founded a new conceptual framework that describes the way nature and animals coexist and a way it is perceived. An affordance is a characteristic of the environment that exists relative to the animal but independent of perception. A framework later called the Gibsonian psychology (Torenvliet, 2003).

Affordance is not about the world of physics and the way a surface can be perceived, giving a surface four dimensions or properties: horizontal, flat, extended, or rigid when measured with standard units or scales (Gibson, 2015). Instead, Gibson (2015) presents a radical hypothesis that all surfaces must be measured in relation to the animal living on, within and for it. The affordance of the environment is thus what it offers to the animal, or what it furnishes and provides – either for good or ill causes.

4.2.2 The design of everyday things

From Gibson and an environmental perspective on affordance theory, I move into the human sphere and Don Norman's (2013) continuation of affordance usage. This perspective is important due to its relevance when I, in this research, create felted textiles that later can be turned into both artefacts and products. According to Norman (Ibid), affordance are possible interactions between environment and people, where some affordances are perceivable to the person, and some are not. He states that perceived affordances often act as signifiers. A signifier is a kind of communication that signals what type of action the design is meant for. In other words, what type of actions are possible and how they should be performed. If a signifier is not perceivable, they fail to function. An affordance to Norman (2013) is relational. He states that: *an affordance is a*

[12] The term affordance is widely used both in language and academic texts. The usage of the term indicates it is a well-used term and theory, but also can creates difficulties defining the term.

relationship between properties of an object and the capabilities of the agent that determine just how the object should be used (2013, p. 10). Therefore, an affordance exists, depending upon properties of both the agent and the object and the usage of the term has moved from environment to social or cultural structures. In object related design is has become a well-used theory, which brings us to how affordances can affect a design approach and material investigations.

4.3 Novel affordances in a material

Bahar Barati and Elvin Karana, two scholars in the field of Industrial design engineering, have written several articles about material and design engineering. In the article "Affordances as Materials Potentials", they state that a conservative design approach to materials and their potential sets a framework consisting of form, function, and user experience (Barati & Karana, 2019). Instead, they propose a material potential framework that opens to an approach where materials can be seen as generativity – having their own ability to produce or bring into being. This framework investigates and focuses on the material potential - i.e., what they have to offer.

In their argumentation, Barati and Karana (2019) highlights that a scientific understanding of materials often is made possible mostly through probing or measuring structures and properties. Therefore, allowing *the designer to treat the materials more like bundles of properties* (2019, p. 107), then through learning about them through hands-on explorations. This pedagogic and pragmatic hands on and sensory encounter with a material was an approach they say was presented by The Bauhaus[13]. For Bauhaus, the intimate connection between learning about the materials divers and essential characteristics through direct experience with them, was vital. To discover material hidden potentials, Barati and Karana offer a framework that highlights ideas from the Bauhaus way of working. By adding a fourth category to design and material making, it is not only about form, function, and user experience, but also about affordances. Affordances that are novel, stating that they have not yet been found – or as they say it is about abilities and qualities that have not yet been actualised (Barati & Karana, 2019). They also stress the fact that there has been too little discussion around the creative contribution of designing where there is an absence of a final product.

[13] The Bauhaus refers to the German school Staatliches Bauhaus for all arts, established in 1919.

With this backdrop of affordance theories, the relational aspect is highlighted as important. But it is not clear when and for whom it appears, and how novel affordances of a material are found. Questions I might have to be aware of when entering my practical work. As stated by Lanamäki and colleagues (2016): the trouble of affordance as "relational" is that a "relation" can have many different meanings in what context it is given, and they ask what kind of relationship is it and when does it occur? In my results, it can therefore be vital to try and understand to whom, why and when an affordance will appear.

4.3.1 Textile terms for analytic and descriptive reasons

When describing the different felted samples, I produce in my practical work I will also need describing textile terms for analytic reasons. These terms can be presented as *performance* aspects that include aesthetic and functional performance (Dedhia, 2019). The aesthetic performance - or attractiveness - refers to the appearance of the textile. In my research shine and *hand* are important aspects. *Hand* is a wide term for the kinaesthetic [14] or movement aspects of a textile. A term for describing hand, or the surface appearance of a material, can be the word matière (Albers, 1965). The term *hand*, refers to the emotional sensations resulting from touching, moving, or squeezing the textile with the human hand. In this thesis hand will cover aspects as: Compressibility, Density, Extensibility, Texture, and flexibility. Elements of aesthetic performance on a raw material can be difficult to describe, due to their subjective nature; It is hard to objectively measure these features.

[14] Kinaesthetic is describes a perceiving how the body moves, but in this context, it will define how the fabric is perceived or experienced with my hand.

5 Method

According to Befring (1992) the research concept includes all academic efforts that contribute to providing new insight or new knowledge about a particular area. In this academic work, I as a researcher need to select specific strategies or approaches. This is called research methods.

5.1 Practice as Research

With the new materialistic approach that highlights an action-based relational meeting with the material, I have chosen to work with a method that involves practice as research and emphasises an understanding of new knowledge creation that happens *during* the practical work, and not only by analysing the samples afterwards. The relationship between myself and the material, my thoughts, experiences, and feelings along the way can influence my answers and reflections. The research-oriented practice method Practice as Research - PaR by Nelson (2013), is chosen. As Nelson states: *PaR is a model and method that involves a research project in which practice is a key method of inquiry, (…) and that knowledge which is a matter of doing rather than abstractly conceived (2013, p. 8).*

Since my thesis is a thorough material investigation with wool and its different felting characteristics, performed by myself, it is crucial that I understand the framework of my practical work and how new findings can spring to life. As I see it, PaR offers me that framework. According to Nelson (2013), it is a multi-mode research inquiry that should include a product, documentation of the process, and complementary writing locating my practice in a conceptual framework. In my work the felted samples and tests represent the product *and* my empirical data. Documentation of the practical work is done through pictures during the process, and a final booklet which contains a selection of my results. The practice and its outcome are placed within a framework of new materialism as a philosophical lens and affordance as theory, in addition to the historical context of sheep, wool and felt. These perspectives will contribute to understanding the field of inquiry and the results.

To include a practitioner-research way of going through the usage of PaR, I will build in moments of critical reflection along the process. The documenting of the process will be in a way that can capture moments of insight – here pictures and reflective writings will play an important role. The

practice will, as stated before, be in a field of similar research practices, and be related to a bigger and broader contemporary debate. Here the debate about sustainability, resource usage, and material knowledge is vital.

The three main areas of the Par model are *know-that*, *know-what*, and *know-how*. While *know-that* contains knowledge about what works - like felting as a technique, wool morphology, and characteristics, it also embraces the method and methodology itself. This aspect involves tacit knowledge that is later made explicit. The area of *know-wha*t is outside and more distant knowledge. Here the conceptual philosophical perspective of new materialism and the theoretical framework of affordance, and previous research within my field is found. Lastly, the know-how area is my inside and subjective knowledge that I experience when working with my material. Here haptic[15], performative knowledge works side by side with embodied and tacit knowledge - explained as how my body meets the material through felting as a technique, how I experience the wool when working with it amongst some. The model is dynamic, and it is through interaction that the areas contribute to my scientific work. The model can be visualised like this:

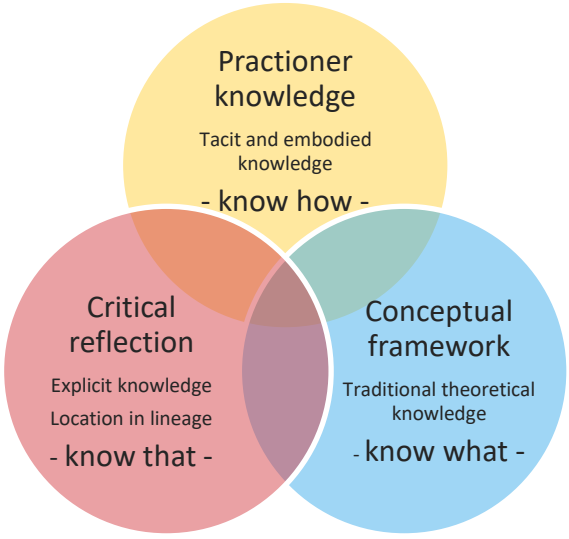


Fig.2- PaR model my interpretation

5.1.1 Critical reflection on own method

One of the purposes of this thesis is to explore affordances and felting characteristics in spring wool from Norwegian Spæl Sheep. Parts of my data collecting will take a descriptive and instrumental

[15] Relating to the sense of touch in non-verbal communication

purpose. But at the same time, I do not conduct my experiments in the laboratory where I distance myself, to obtain an objective point of view on my samples. Nor do I let a mini mill produce them for me. I do research both on and in the material, and my body, the pressure from my hands, and the experience with the wool can help to get answers to my research. In addition to this, I am trying to lay the modern commercial thinking and its prejudices about this type of wool behind. A perspective that might be challenging to me because of my background within the yarn making industry.

6 Practical work - presentation of results and findings

My practical work is based on exploring spring wool for affordances. This is done by addressing the material during manual felting and together with industrial machinery. Industrial tools might provide important insight for future developments. The intention is to establish new knowledge about this material using an old technique. In this chapter, I will present my practical work that includes information about my pre-project, relevant decisions made during the way, my different testing and sample making during felting. The chapter also contains results and reflections, which are organised under performance and reflective thoughts. My work in this research can be view like the hierarchy below (table 1):

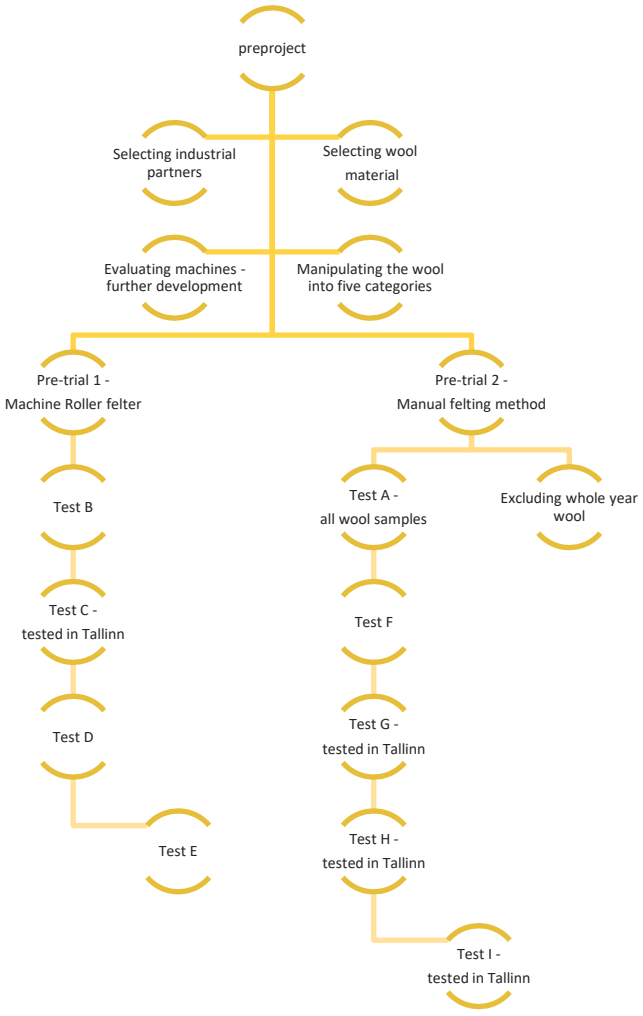


Table 1 - Practical work

6.1 Pre-project

The pre-project was my way of understanding the field and context in which I wanted to do my further research. During this time, I felted wool from several of the Norwegian sheep breeds like: NKS, *blæset* sheep, pelt sheep, and Norwegian Old Spæl/Pigmented Spæl Sheep. I also conducted a survey targeting farmers members of *Gammelnorsk spælsau lag*. Questions about waste wool, economy, and usage of wool were asked. I also conducted a survey at the wool day in Oslo, where people from the wool industry, designers, wool/fibre company owners attended[16].

6.2 Selecting material for my practical inquiry

Since spring wool is not sorted into its own class anymore, I contacted *Gammelnorsk spælsau lag* and their chairman of the board, Sandnes. During late summer of 2021, I received several bags of spring wool for this thesis. Later during autumn, I went back collecting more wool for further exploring. All the wool was from spring shearing in 2021. I sorted it into four different colours: light white /off white, brown, grey, and black.

6.2.1 Washing

I have chosen to wash the wool before processing it, because the two mills I have chosen to work with do not take unwashed wool in their production lines. In addition, the possibility for reproduction later is an important aspect for me.

6.2.2 Processed wool – Selbu spinneri and Oslo mikrospinneri

I chose to work with Selbu Spinneri and Oslo Mikrospinneri due to their versatile production lines. The machinery at Oslo Mikrospinneri involves three machines integrated into one, leaving almost all the guard hair as a by-product. This machinery includes the opening process, also called the picker stage, where wool is opened into single fibres. This assists the following stages of dehairing and combing. At Selbu Spinneri, these operations are separated: the picker, the de-hairer/ fibre separator, and the carder. The work of the dehairer is to separate different types of wool fibres, like softer down and coarser guard hair. It also sorts out various types of debris like hay, grass, or other impurities in the wool. Different types of settings, like speed of the rollers of the machine, have different types of impact on the separation of the wool. The last step of the mechanical procedure

[16] Here the answering rate were so low, that I have decided not to include the data in my thesis.

is carder. This machinery aligns and combs the wool creating a batt. The batt is gathered on a roll for further work, like felting.

These industrial options gave me five different wool manipulations. To not alter too much to replicate my results, I let the standard settings presented to me by the two mills lay the foundation of my samples. For further research or verifiability, all settings are saved and stored. A full run-through of all the names given the wool samples in the research and their manipulation is presented in annex 2.

6.2.3 Choosing machines to work with

When wanting to try wet felting with industrial machinery, Selbu Spinneri have two options. One is the Belfast felter[17] and the other is a roller felter. In the Belfast felter, I must cover the whole surface of the machine – an area of 170 x 100 cm – and lay out an amount of approximately 600 – 800 g in total. With my limited amount of wool from the sorted categories, this is not an option. In addition, the machine only produces a pre-felt during 4 x 30 minutes (2 hours). After that, the procedure is to use the washing machine to reach maximum fulling. If I use that washing machine to operate the fulling stage of the felt, I lose connection to the process itself. I must also consider all the variables presented to me with that specific washer - like amount of water, temperature, how much weight is the felt bringing to the equation, rounds per minute, amount of time etc. Variables hard to verify at another stage in my process, making me fully dependable on that specific washing machine. The roller felter has more options regarding pressure and time and might be able to produce a fulled felt. I chose that machine.

6.3 Tests and results

I will in the following tests explore both machinery and hands on felting. Manual, hands-on felting is crucial to meet my material halfway and be close to the whole process. Machinery can provide me with knowledge on how upscaling the manual samples can be performed, and if the machine can be well suited for future developments. I first conducted two pre-trials. In pre-trial 1, I tried the roller felter with wool from the pre-project. In pre-trial 2, I lay out a hands-on felting method for

[17] More can be read about Belfast M.M. and their felt maker here: https://minimills.net/specialty-products/

producing further test samples. After this, I move into sample testing A-I. Performance results like aesthetic and technical are presented, and reflective thoughts describes. Test G-I, and C have functional result aspects because they have been tested for Abrasion mass loss (*ISO 12947-3:1998(En), Textiles — Determination of the Abrasion Resistance of Fabrics by the Martindale Method — Part 3: Determination of Mass Loss*, n.d.) , air permeability (*ISO 9237:1995(En), Textiles — Determination of the Permeability of Fabrics to Air*, n.d.), and tensile strength (*ISO 13934-1:2013(En), Textiles — Tensile Properties of Fabrics — Part 1: Determination of Maximum Force and Elongation at Maximum Force Using the Strip Method*, n.d.) in the textile laboratory university of Tallinn.

6.3.1 Pre-trial 1

When not having a specific product in mind as the outcome of my research, I just chose a template that later could be felted manually for comparison. The template of 60 x 60 cm is used as a base for laying out the wool. Total amount on a 60 x 60 cm square template is 200 grams. My first sample is with brown spælsau fall wool used in the pre-project (I use fall wool due to a limited amount of spring wool). The roller felter from FeltCrafts[18] operates by rolling the wool inside a plastic roll instead of a flat surface, giving me more choices when adding the amount of wool and constructing the size of the area. I can lay out as little or as much – it does have an upper limit to how big of a distance there is between the upper and lower rolls. The machine has settings for pressure and speed of the rolls, both which can influence the felting process. In addition to a timer that counts minutes of process activated.
The sample is prepared as following (later mentioned as standard procedure):

A big sheet of bubble plastic is laid out on the table. The wool is placed in layers, every layer is crosswise laid down on top of the other layer. This to enhance the grip that the wool fibres get on each other when travelling inwards during the felting process. Four layers are chosen to have an even amount of fibres in both directions. Water mixed with "Effekt" – a fairy soap– measuring a Ph of 11 – is sprayed on the wool, letting it sweat visually on the surface. Water is kept at a temperature of between 55-60 degree Celsius. The bubble plastic is rolled together with the wool

[18] More can be read about the rolling felter from FeltCrafts here: https://feltcrafts.com/feltmaking-machines-needle-felting/

around a circular foam inner roll. The roll is tied around the edges with cotton threads, preventing it from opening. The felt is turned clockwise 90 degree Celsius after every roll.

Pre-trial 1 is run for 4 x 30 minutes. The pressure is measured after the upper roll starts to touch the wool roll. I turn the pressure arm 7 times. The roll is removed after every run, laid back on the table. It is opened, turning the wool clockwise 90 degrees Celsius. I spray it with another sweating layer of water with soap and roll it back up again. After these 4 times of 30 minutes, I unravel the wool roll again. The wool fibres have started to stick to one another. I remove the foam, turn the wool upside down, and spray it again with soap water. The wool roll is then tightly rolled around itself and wrapped up in bubble plastic. Ends are tied as before. The machine is set on more pressure, 9 turns, speed is raised to 3 and 4 x 30 minutes again. My plan was to make the felt tighten and shrink increasingly to a fulling stage. I open and turn as before after every 30 minutes. The felting process has started, but not enough.

When measuring shrinkage of a surface, the formula for percentage decrease is:$\% \, shrinkage = \frac{(\, old \, value \, - new \, value)}{old \, value} \times 100.$

The sides of the felt have decreased to 50 x 57. This gives a total shrinkage of ≈ 21 percent.

($\% \, shrinkage = \frac{(\, 3600 \, - 2850)}{3600} \times 100$)

Reflective thoughts:

Timewise, working with the machine is proven to be very time consuming. One test took me 4 hours to make, consisted of only 200 grams, and did not reach a fulled stage. I move forward to working by hand.

6.3.2 Pre-trial 2

Inspired by a felting course I took during the fall of 2021, I use a template of 20 x 20 cm with 10 grams of wool in four layers. In the beginning, I used the roll with plastic to create a pre-felt. After that the pre-felt is rolled inside a towel. At the end, the now hardened felt is rolled into itself, and then into a bamboo mat to reach maximum fulling and shrinkage. Different amounts of pressure should be applied at the three stages.

Reflecting thoughts:

The manual method is more efficient, compared to using the machine. It is also more tactile. The stages between the four wool layers and pre-felt are clearly visible and tactile after the 4 x 100 rolls. The red template marks the original size of wool before pre-felt shrinkage.

Four layers of wool 4.0

←

Pre-felted 4.0 wool →

The samples are laid to dry on a bamboo mat overnight to dry. The impact on my joints in hands, wrists and shoulders is also painful. There might be a need for resting and stretching between sample making. From here tests to gather empirical data are performed using this method. The manual hands-on felting method is described in full in annex 3.

6.4 Test

6.4.1 Test A

Test A is carried out on all the 39 samples using the manual method. The template of 20 x 20 cm and the 10 grams of wool is a manageable size and volume when making so many samples. Four layers are chosen to create even crosswise grip for shrinkage. The amount of rolling: 100, 15, 25, and 25, is further developed from the course I took. This to better suit the research. Creating neat edges at the pre-felt stage is important to be able to measure an even shrinkage, and to learn how to make textiles that fits specific needs. Using a bamboo mat at the end increases the pressure on the felt during fulling, giving the felt a good, flat surface. After step 1 - 47, the felt is rinsed in lukewarm water, and placed to dry naturally (Fig.3 and 4).

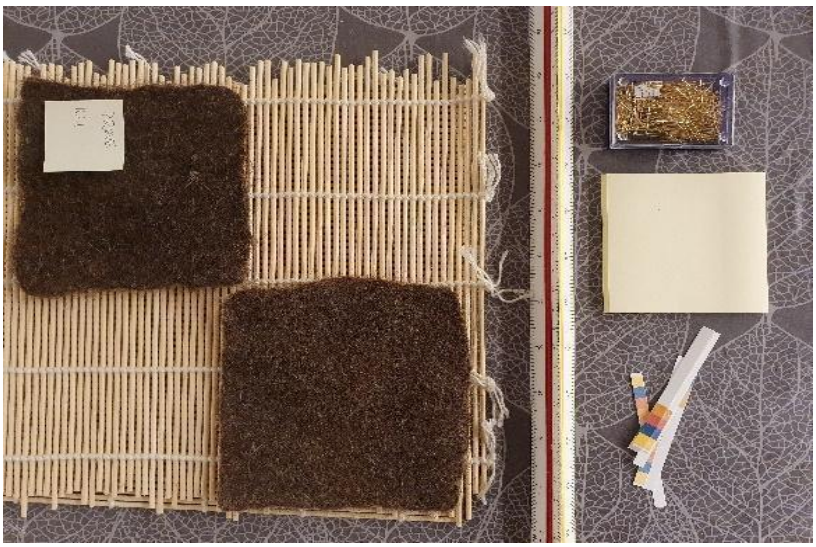


Fig.3 - Test A samples laid to dry

(Due to a need for limiting the data material in this research, I decided to exclude samples 5.0, 5.3 6.0, 6.3, 9.2 and 9.3 in further analyses, they are made of whole year wool)

Fig.4 - Samples test A

Results Test A

Performance:

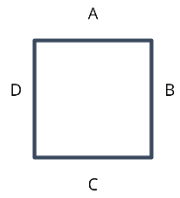
Samples 1.0 to 4.0 are very soft to the skin. When touching it with the upper palm of my hand, I do not experience it as coarse. When moving it up and down on the soft skin of my inner wrist, I notice that there are coarser hairs that prickle my skin. All the samples are medium flexible, giving in to two folds on the small area that they cover. Samples 3.0 and 4.0 still have just a slight stretch left, while 1.0 and 2.0 are denser. The surface is rather even with just a few hairs sticking out, giving the samples a light halo[19]. 1.0 and 4.0 do show some tendency to bulk. The samples all have a smooth surface, with a slightly dull and matte finish. There is no compressibility in the samples. 1.0 – 3.0 all show signs of colour shift from small amounts of guard hairs still in the felt. 4.0 is the most consistent in colour, displaying an even light brown shade.

Samples 8.1 to 12.4 all show similar characteristics. Samples ending with 1 stand out due to several reasons. They are all very rough to the hand, with low extensibility and resilience. The density is high and flexibility low. Texture is vivid and detailed. Guard hairs are caught in between softer down, giving the surface a bulky and dynamic look. This feature is most visible in sample 8.1, 9.1.1 and 11.1. They all have loops of long hairs on the surface swirling around, contributing to an exciting feature with extra shine. The halo on the samples is high, stretching out about 1-2 cm. Colour consistency is highest in samples 10.1 and 12.1. The other samples all show high inconsistency due to the darker or lighter colours of guard hairs in the wool. The inconsistency contributes to the vibrant and lively look of the textile in the same way as the bulky and loopy texture does.

Samples x.2, x.3, and x.4 all have similar features. They are dense, but still have a slight stretch and resilience. The flexibility is greater than the previous 1 sample, but still low. Colour consistency is remarkably similar in all the samples within their own group. Guard hairs are evenly mixed inside and, on the surface, giving the samples an evenly speckled and mixed colour. Halo is low to medium, and the felt has a slightly dull exterior. They are softer to the hand than samples x.1, but harsher than 1.0 - 4.0. They are very comparable in touch, as they tingle and prickle the hand with the coarser, sticking hairs. I detect a slight difference in sample 12 and 10. They are just a bit smoother than the others. Sample 9 and 11 are thought to be the coarsest samples of them all.

[19] Seen from a horizontal side angle

As a technical evaluation, I have decided to take a closer look at how these different samples in test A shrinks during felting. Shrinkage gives the crafter a way to later reproduce or predict measurements for future work. I have measured all samples on side C and D, calculating a total area of the felted sample presented under total shrinkage of the area.



Example 1.0 has a new value and area of 137.5 cm2. The old value was 400 cm2 (template of 20 x 20 cm). Using the formula, we get

$$66\ \%\ shrinkage = \frac{(\ 400\ -137.5)}{400} \times 100$$

All results showing total area shrinkage can be found in annex 4. Percentage is shown with no decimal always adding up to one whole if 0.50 or higher and decreasing if 0.49 or lower.

By looking closer to the five manipulation stages, we find different results. Observing the 4 samples manipulated at Oslo mikrospinneri ending with 0 where almost all the guard hairs have been removed, the shrinkage is measured between 58-66%. This gives an average of 64%. The samples through the picker at Selbu spinneri x.1 where all the guard hairs have been kept, gives a very different result. Here the total area shrinkage is higher with a span from 70 – 77% on the 7 samples felted. The numbers present an average of 73%.

Results from samples x.2 that have been processed through both the picker and the dehairer, opening and extracting some of the coarser guard hairs show a percentage from 60 – 71%. Presenting an average of 68%. The most manipulated and processed samples are the x.3 that have been through all three stages of the production line: the picker, dehairer and the carder. This wool has in addition to the opening and separation stage, also been combed and aligned, creating a neat and parallel batt. The results show a shrinkage from 64 – 70%, presenting an average of 68 %.

The last samples x.4 was processed through the picker and the carder, not separating guard hairs in the dehairer, instead aligning, and combining them straight through the carder. Here the average is 68%.

Test A provides a result that, from this small quantity of samples, shows that leaving all the guard hairs intact and not combing or separating anything gives a higher shrinkage percent in four out of seven samples. These samples felt quicker and needed less time and effort to reach a fulling stage. The slight detectable extensibility in 1.0 to 4.0, indicates that these samples might reach the same shrinkage, but need more time and fulling to do so. Samples x.2, x.3, and x.4 all show 68% of shrinkage. Not carding the wool before felting like samples 8.2 – 12.1.2 does not seem to have had any greater impact on the maximum shrinkage at this level. The amount of guard hairs might also be slightly different in the three different samples, but this does not show much in the results.

The ratio on these tests between number of grams of wool and the area of the template is 10 grams/400 cm^2. It gives me a ratio of 0.025 g / 1 cm^2.

Reflecting thoughts:
There is both a visual and tactile change of the felt before and after it has been dipped in hot water. This is happening at the hardening stage. After I dip the samples in warm water, they somewhat transform from being quite soft and lustrous to duller and matt. It is also at this stage – the hardening – that shorter and coarser fibres in some wool samples start to leave the felt. This is mostly visible in samples 9, 10 and 11. I realise, while rolling these samples over and over during the different stages, that my body adapts quickly to changes in pressure applied. Before I changed the pressure on the machine, now it is my body that acts like a pressure handle. It is like my body has developed different settings during the felting. Leaning more forward, changing angle from the shoulder and down to the elbow, and adding different amounts of pressure. When all the samples are done, my hands, elbows, and shoulders are tired. A challenge when doing everything by hand, is that if I get tired this might affect the pressure, applied length when rolling, and remembering how many turns I have made

6.4.2 Test B

Fig.5 - Test B wool 8.1

The aesthetic features in samples 8.1 - 12.1.1 intrigue me. In test B I try to recapture them using the roller felter. I double the ratio to 0.05, to achieve a softer and thicker piece of felt. Adding 80 grams of wool 8.1 on a template of 40 x 40 cm gives me a ratio of 0.05. (80 / 1600 = 0.05). The standard layout is performed. The roll was placed in the machine, with a time frame of 4 x 10 minutes. Pressure of 6 turns and a speed of 2. The felt has not reached more than a pre-felt, and I do another 4 x 15 minutes with the same speed and pressure.

Results test B

Performance:

This sample is coarse, but despite that there is almost no prickle on the skin. Flexibility is medium to high, even though it is thicker than previous samples in Test A. The surface is vivid and vibrant due to the very visible guard hairs. They create an exciting and dynamic aesthetic look with colour shifts of grey, beige, and black. The surface is lumpy and uneven. Loops of long hairs are visible, both on the surface and on most of the edges where they stretch outwards like wool on a sheep (Fig.5). The very visible guard hairs contribute to an exciting feature of shine. The inconsistency in colour gives the felted textile a thrilling look. and adds extra shine**.** It has a medium extensibility which shows when giving in to pulling and stretching it. The compressibility is also medium, there is room for squeezing it together and making it thinner by pressure. 8.1 has a new size of 35 x 34 cm and a shrinkage of approximately 25%.

Reflecting thoughts:

The machine is very time consuming. Time spent in the roller felter, in total 1 hour and 40 min, has only produced a pre-felt stage. The extra time did not begin the hardening or the fulling process. This is visible both in the low shrinkage and the softer, stretchy, and flexible felt. It is uncertain if more pressure could have been applied to reach a fulled felt, or if it is only a matter of more time.

The felt was afterwards washed on a wool program in a washing machine. The test has not produced desired features searched for.

6.4.3 Test C

The pre-felt done in the roller felter is still interesting. The softness it displays, even with all guard hairs. This feature I want to understand more about, and I chose wool nr 11.1 – 11.4 to work with. This wool is the coarsest of my collected categories. I go back to the 0.025 ratio to evaluate if it is the ratio, or the pre-felt stage that contributes to this effect.

Standard procedure when laying out the wool on a 40 x 40 template this time. All four wool samples are placed on the same bubble plastic (Fig.6). Pressure is set to 4 and the speed is 2. I chose less time due to the lower ratio. Timeframe is the same, 4 x 10 minutes. I remove the roll after every 10 minutes to turn the wool 90 degrees. After the first 40 minutes, the felt is checked. The wool has begun to grip, but not as much as I want for a good pre-felt stage. It is still possible to loosen fibres from the felt (Fig.7). Samples seem a bit dry. They get more soapy water before rolling them back into the plastic and placing them in the roller felter. The machine is set to pressure 6 to speed up the process and speed of the machine is the same. Another 4 x 10 minutes are performed (Fig.8 and 9). The felt was washed on a wool program in a washer machine.

Fig.6 - Test C wool on template

Fig.7 - Test C sample 11.3 pre-felt

Fig.8 – Test C sample 11.1 pre-felt

Fig.9 - Test C sample 11.1 pre-felt

Results test C

Performance:

All these samples are soft to the skin. There is no harsh prickling when striking the surface with my hand. When placing the felt against the soft skin on the inside of my wrist, I experience resistance when moving it back and forth. The resistance of fibres is just slightly more prominent in samples 11.2 - 11.4. But, still not enough to get a coarse or itchy feeling. 11.2 - 11.4 all have a high flexibility. 11.2 has a slightly visible change in colour compared to 11.3 and 11.4. 11.3 and 11.4 are the most similar. Felt 11.2 - 11.4 are, even though many of the guard hairs have been removed, coarser and denser than 11.1 Samples 11.2-11.4 are very similar. The surface is covered with beige guard hairs that with the darker brown finer fibres have intertwined to create a felt that is monotone and seems calm. The colours have mixed evenly all over giving the felt a speckled nuance. In 11.1 frequent locks of guard hairs are close to the surface, and in this sample, they are much more accessible than in test A. Some of the hairs are not felted completely into the textile. Instead, they hover somewhat over the surface, giving the felt a natural, vivid look. This feature also gives the felt a natural variation in colour and a dynamic, vibrant look. The exterior shows strong resemblance to the wool when it was still on the sheep. The surface is uneven, so is the structure. The halo is quite low in all the samples. 11.1 might have a slight tendency to have higher compressibility, but all giving a medium rate. Density is low in all samples. There is good stretch and extensibility in all the samples, again due to stopping the felting before the fulling starts. There are also quite many parts

of uneven thickness. Total shrinkage at this test is between 38 - 43% where the 11.1 again is felting faster. The sides are between 30 – 32 cm and have shrunken appr. 20-25%. This result in shrinkage resonates quite well with test B, although the ratio was different. This could indicate that when aiming for a pre-felt textile with this type of wool a 25% decrease in sides can be expected.

Reflective thoughts:
1 hour and 20 minutes is enough to create a neat pre-felt in all the samples. Time consuming, but now it produced 4 samples. During the last 4 x 10 minutes, the wool started to get a good grip and I chose to end the test. In test A, the hardening stage and fulling showed a process where coarser fibres were pushed out of the felt. This does not happen in the pre-felt stage. When working on this test I experience a sudden hesitation to the pragmatic method I have chosen. My body wants to stop weighing wool in neat little piles. Stop laying out perfect and even layers on top of each other. Stop counting the same numbers repeatedly. It is almost as if the wool wants to influence me to throw it down on the table and felt it as it is. It does not need perfection in layers and amount of rolling, instead just work with it. I am a bit confused about what happened. Pragmatic and technical as I am, I continue with my method and chosen procedure – for now.

6.4.4 Test D

The machine has still not been able to produce a fully fulled felt. I pondered on how to adjust the settings and set up a new test. Wool nr 11.1 and 11.3 are chosen, which represents the most and least processed. The standard procedure is prepared and placed in the machine. Time is set on 4 x 10 minutes, upping pressure to 6 and speed as before at 2. Turning every time 90 degrees. This time it had reached a nicer pre-felt, not needing another 40 minutes like test C. Another 4 x 10 minutes are set, the pressure constant, but increasing the speed to 6. The samples were washed on a wool program in a washer machine.

Fig.10 - Test D samples on template

Results test D

Performance:

Results here do not differ much from test C. Maybe I detect a slightly denser felt. Surface appearance like colour and halo are like test C. Also stretch and flexibility is much alike C. 11.1 is still a lot more uneven all over, than the more processed 11.3. The shrinkage is between 15 - 25% on the sides. Slight increase from test C. total shrinkage is between 38% and 43%.

Reflective thoughts:

This test D does not differ much from the previous C. Only a slight increase in shrinkage on 11.1. The 11.1 still felts quicker than more processed wool. Still no tendency to start either the hardening or fulling stage (Fig.10). Upping the speed on the machine has done nothing to initiate further felting. What did change was that by adding extra pressure – from 4 to 6 – I got a ready pre-felt after just 40 minutes with a ratio of wool of 0.025. and maybe a higher shrinkage. But, to get a fully felted textile with maximum shrinkage, 1 hour and 20 minutes was not enough. A very time-consuming procedure.

6.4.5 Test E

Not being able to let this machinery fulling issue go, I wondered how the procedure that Selbu Spinneri had - the fulling done in the washer machine - would impact test D. I performed the same procedure as in test D with wool 11.1 and 11.3, fully aware of variables in machine washing would

be hard to detect and analyse. The pre-felt is then washed on a program for fine laundry, 40 degrees with wool detergent.

Fig.11 - Test D sample 11.1

Fig.12 - Test D sample 11.3

Results test E

Performance:

Now I have visible and tactile change in the felt (Fig.11 and 12). The surface on 11.1 is much more like in test A. Frequent locks of guard hairs are close to the surface, creating a vivid and detailed surface appearance. This feature also gives the felt a natural change in colour. Beige and darker brown guard hairs loop, mix and move on the surface, giving the felt a dynamic, bulky exterior. Edges have longer locks that protrude, making it uneven, hairy, and organic in its shape. Lots of resemblances to natural wool on a sheep. A softer surface with areas of coarse hairs prickling the skin on my hand and palm. 11.3 is calmer to the eye. Rough and coarse all over when stroking it with my palm and hand. The felt has an almost evenly mixed colour with a darker brown look. It is quite even in shape, only edges displaying a few hairy parts. The visual effect is monotone and seems calm, but still small uneven areas are visible. When touching it with the palm of my hand it generates a feeling of pebbles - bumpy aspect. This feature gives the felt a more dynamic visual characteristic than similar samples in test A. Flexibility is low – medium. Density is high, letting only

a minor extensibility be experienced. While 11.1 again has felted more with a shrinkage of 45 – 47 % on the sides, 11.3 has 40 – 42%. The total area shrinkage for 11.1 is 70% and for 11.3 it is 65%. This resonates quite well with the results from test A.

Reflective thoughts:
According to test A, 11.1 could have had more fulling. This aspect is also detectable in test E. 11.1 gives away just slightly when stretching it, not completely dense. Surface wise they differ due to the bulkier appearance. This indicates that when fulling the felt in a washer machine, the movement lets the fibres travel more outwards creating bulks or bubbles. When fulling the felt with a bamboo mat, the surface created is instead flat and smooth. Using the washer machine was not intended as part of my exploration in the start, but here I felt it was interesting to try to see how the felt could move from pre-felt to fulled. There is no way to follow the hardening process, which is all happening during the washing program.

All the tests from B – E are done in the machine, but I still have not been able to get a fulled felted textile from it. The amount of pressure – only measured by turns on a handle counted from when the upper roll starts to touch the felt inside – can be affected by size of roll, amount of bubble plastic around the wool, the amount of wool laid inside, to name a few factors. It is also difficult to comprehend measurements like turning 4, 6 or 9 rounds, or how time affects the process. How many rolls are there during 10 minutes on speed 2, 4 or 6 etc. Or how are they affected by the ratio of wool laid out? The speed up to this point has only seemed to make a minor difference. Most of the knowledge I have gained so far has come from my hands-on experience with the wool, the manual felting method, and my own body. If manually felted samples should be reproduced by this machine, knowledge of the machine will be crucial. Maybe the machine is too weak? Maximum shrinkage was so far only obtained by the washer machine and through manual felting.

In the next test, I wanted to follow the thought that came to me during test C. This was when it seemed like the wool suddenly reached out to me, telling me to stop being so planned and organised. I chose to listen to the inspiration of the wool and created test F.

6.4.6 Test F

No standard procedures are performed here. I reached out for the wool close to hand. It was the white/grey wool from 8.1 and 3.0. The softer wool is placed randomly on a piece of plastic, and the coarser 8.1 is thrown on top in small bundles. Some of the 8.1 end up on the sides in a cluster, while most end up on top or next to the 3.0. Spray is added and it is rolled up in bubble plastic and rolled until I felt that I have done enough. The second test is done with only 8.1, with the same course of action.

Fig.13 - Test E sample 8.1+3.0

Fig.14 - Test E sample 8.1

Results test E

Performance:

This test resulted in two different small pieces of felt (Fig.13 and 14). One that mostly consists of only 8.1 and one piece that has a softer layer of 4.0 encapsulating the coarser 8.1 wool. Both pieces are thin, and I see clearly how the guard hairs build and create networks of fibres throughout the whole felt. I lift it to the light; it has a very intricate pattern visible.

Both these samples generate a soft, pleasant touch when stroking them on my palm and inner wrist. 8.1 is very soft to the skin, but when sliding my hand back and forth it detects a resistance in one direction. Here, coarse fibres meet my skin and almost try to hold it back. My delicate skin on my neck complains when touching the sample, indicating that while it is still softer than almost all

other samples, the softest skin on my neck does not want it close. On 8.1 + 4.0, the skin just slides over, easy and without interruptions. This sample was also tried against the delicate skin on my neck, which did not complain as much as the previous sample did and is the absolute softest and most gentle sample in all my tests.

In both samples, guard hairs build and create networks of fibres throughout the whole felt. When held against light, a very intricate pattern inside becomes visible. It is bulky and has a messy, uneven surface. The unevenness is enhancing the spectrum of light that shines through. In 8.1, locks of guard hairs are still connected and are organised in curves, lines, and organic directions on the exterior. They attract the attention of my eye. Extensibility is high and density low. It has a high compressibility and medium halo. 4.0+8.1 has a very high extensibility, low density, with a high compressibility. No shrinkage is measured in this test.

Reflective thoughts:
Both felted textiles have reached a fine pre-felt stage, capturing all fibres. I have no overview of how much pressure, time or rolls that have been used. I was just rolling and moving the wool around, maybe guided more by the material I was working with than the method and procedure chosen before. I am glad I did this test. The results working with light, transparency and inner networks and structures, are very interesting.

6.5 Tests for textile laboratory

During my research I was granted permission to have samples tested in a textile laboratory. These tests could enable my research to also include functional aspects, which could generate results useful to designers or industrial processes later. I found this opportunity very exciting and accepted the offer. Test G - I are specifically made for this purpose. In addition, test C was chosen, due to its soft and flexible pre-felted stage that differed from tests G - I. Adding C could generate a bigger diversity in the results. The findings will only be presented in short. A full version and analyses of the data retrieved will be published in a later article.

These tests measure for functional aspects like thermal and strength properties. Grey wool from 1.0, 9.1.1, and 9.1.3 were chosen for the tests, because I had enough of this wool to create multiple samples. Working by hand has proven to be most efficient and more controllable, therefore all

these tests and samples are felted manually. The three different manipulations stages are presented. 1.0 has almost no guard hairs left, 9.1 has all, and 9.3 has as much as possible after being fully processed. Test results might provide answers of how the amount of guard hairs affect durability or insulation properties of the felted textiles. (Aesthetic features like kinaesthetic, will not be evaluated in these tests since they will be very similar to former tests already evaluated).

6.5.1 Test G

Trial with sample 1.0

Using a 40x40 template with 40 grams of wool I kept my ratio at 0.025. I followed the standard procedure and manual felting method like in test A (Fig.15 – 18), but I did not stop after the 25 rolls with the bamboo mat. I had to roll the felt 4 more times with the bamboo mat to make it straight along the edges and keep the square intact. After these 4 extra times, the fully felted sample was rinsed in lukewarm water and laid to dry.

Fig.15 - Trial samples 1.0 loose wool

Fig.16 - soapy water on fibre

Fig.17 - aligning the edges

Fig.18 - prefelt

Shrinkage is measured to 67%, which is about the same as in test A. The pre-felt stage is fine after 100 rolls with bubble plastic and roll. The hardening stage also goes well inside the towel. 4 more runs with the bamboo mat is necessary to create a neat square when fulling the felt.

After receiving information about sizes for the laboratory tests, I need to upscale more. For testing, the felt needs to have a size of 30x30 cm. The test therefore needs a template of 50x50 cm. With the same ratio of 0.025, a total of 60 grams divided into four layers is needed. In test A, these wool categories had a linear shrinkage percent at appr. 38 – 50%. This would make a 50 x 50 template ok for 1.0 and 9.1.3, but maybe just a bit small for 9.1.1.

Results Test G

Performance:

The 1.0 size is 32x34 cm, which gives a total shrinkage of 56%. This result is a bit less than in test A, and that gives an indication that when upscaling I have more wool, which needs more work at the fulling. It can also be that when working manually on a bigger piece, my hand needs to work back and forth, creating less pressure as it moves. This might also explain the edges protruding during hardening. I need to keep moving my hands back and forth to add pressure to the whole felt. For 9.1.1 I must stop at just four goes with the bamboo mat, the felt is already down to 28 x 29 cm. It is fulled quite hard, but it could have had further work. Shrinkage at this stage is 67%, so according to the test A I could have done at least a few more centimetres. A bigger template could have been

used to maximise the felting. Compressibility and extensibility in all samples are low. Flexibility low-medium, and density medium-high.

Reflective thoughts:
Standard procedure is used. For 1.0 and 9.1.3 I do four more turns during hard pressure with the towel, and four more turns during bamboo mat to reach the fulling stage I need. For 9.1.1, only four more times in the towel at the hardening stage is required.

The wool in 9.1.1 appeals to me - a lot. I feel that more and more when working with it. I love how the coherent lock of wool is messy and imperfectly arranged before being laid down on the plastic (Fig.19).

Fig.19 - Wool 9.1.1

The felt goes easily through the different stages of pre-felt, hardening and fulling. Like the 1.0, I experience some troubles with the edges, but not at all at the same level. I do four more turns with the towel at the hardening stage, and it is quite nice and square-like. No need for further work. Up-scaling is proven more difficult in all the samples due to several different reasons. First, it is harder to place the wool evenly throughout the four layers. At the pre-felt stage, I must move wool from the edges and neatly place it where I see thin areas. This was not necessary before. I also must neaten the felt and stretch it during the different turns during pre-felting. There are small folders showing up at the edges. Secondly, the edges are proving much more difficult to felt during the hardening process in the towel. It can be because now my fingers and hands must move back and forth over a larger area of the roll. Thirdly, the wet towel underneath is not anymore, an option, I

must keep the roll steady and the pressure even during the counting. Without the wet towel, the roll moves along the bench creating problems during adding pressure and rolling.

Another result that is more visible and tactile when making the samples bigger, is the change of the felt before and after it has been dipped in hot water. This is at the hardening stage. After the warm bath it transforms from a softer, flexible, and shiny felt, to a felt that seems duller, firmer, and less shiny. Like in test A, fibres also start to protrude at this stage, making my hands black with short dark fibres still in the wool. The hardening stage enhanced the problem of the edges poking out. Instead of just going four turns in the towel with hard pressure, there needed to be four more turns starting with the edges towards the middle. This same thing needed to be done during fulling stage. my bamboo mats did not withstand the pressure and broke into small pieces.

6.5.2 Test H

Test H was prepared to give a somewhat hardened pre-felt, therefore not needing a high shrinkage. By looking back at test results, indicating 15 – 25% linear shrinkage from test C and D, I used a template of 40 x 40 cm.

Results test H

Performance:

Flexibility and extensibility in all samples are high.

Compressibility is medium, and density is low.

Total shrinkage is for 1.0 38%, 9.1.1 43%, and 9.1.3 41%.

Reflective thoughts:

Standard procedure is used, and the manual method is completed after just 4 times with 20 rolls during hardening in the towel, still dipping the felt into warm water. My body works well through the different stages of the felting process (Fig.20). Upscaling 40x40 is easier than 50x50.

Fig.20 - Test H sample 9.1.3

6.5.3 Test I

In this test the ratio is doubled to see if there are results that could indicate higher insulation properties when increasing the amount of wool. Same procedure as in test H is performed.

Results test I

Performance:

Total shrinkage is for 1.0 33%, 9.1.1 39%, and 9.1.3 34%. Shrinkage at this ratio is, as also presented in test B, slightly less than with a lower ratio. Again, 9.1.1 has the biggest decrease in size. Flexibility, extensibility, and compressibility are all low. Density is high (Fig.21).

Reflective thoughts:

I find it easier working with a double ratio when creating even layers on the template. The resulting felt that has a more even structure also indicates this. The idea of getting a similar flexible and soft felt, has failed. The felt is much denser and firmer than desired. It might seem that I have put too much pressure during the hardening stage, even though I only rolled it lightly four times in the towel. My body therefore needs to learn how to put less pressure or angle during the hardening stage. Or stop sooner. Maybe just more rolling at the pre-felt stage would give me the desired result. This applies for all the results in test I (Fig.21).

Fig.21 - Test I all three samples

Results Abrasion test

The test is done in a James Heal Martindale machine. Three samples from each felt are cut into circular shapes and placed in the machine (Fig.22 and 24). The machine rubs and turns the fabric under pressure. Total amount of turns before degrading the textile is measured. Mass loss is weighed between every new setting. The average measured from the three samples were used for calculating mass loss. Standard testing requires at least 5 samples taken from a textile measuring 1000 * 1500 mm, something I could not provide due to a very limited amount of spring wool. This must be taken into consideration when reading the results.

Fig.22 - Martindale abrasion test

Results from Test G showed that the weakest felted textile, or that felt that did withstand the least abrasion and rubbing, was 1.0. These samples had to be taken out of the machine after 40 000 turns. 9.1.1 and 9.1.3 continued another 10 000 turns before the test was ended (Fig.23). These samples could have had more, but due to time limits in the lab, 50 000 turns were said to still give an indication of results. These results can indicate that guard hairs play a role in withstanding abrasion and thereby can give felted textile longer life in a product. The way the guard hairs are arranged in the felt - loose, scattered and disarranged in addition to combed, aligned, and parallel - display similar results of abrasion strength. The result states that it can be both the amount of guard hairs and the way the batt is produced that can indicate the results.

Fig.23 - Worn down test sample

Fig.24 - Cutting test samples

Also in test H, the samples that could take abrasion, and therefore can have a higher product lifespan were 9.1.1 and 9.1.3. They both withstood 25 000 turns. The weakest of the samples was 1.0. It did not take more than 20 000. These results support the previous results. The amount of guard hairs gives the felted textile more abrasion resistance, allowing it to withstand more rubbing action without being destroyed. As this test shows, this is also applicable for a felt that is only pre-felted and not fulled. But again, it is not only the amount of coarse hairs that implies better resistance, but also the arrangement of fibres. Compared to test G, where the felt was fulled, these felts were only at a hardened pre-felt stage. The results state that a fulled felt, compared to a pre-hardened, has a higher abrasion resistance. The felt stage is therefore also a factor to consider. Test I could not be done abrasion testing on, due to the thickness of the felt. It did not fit in the machine.

6.5.4 Test C

Advised by the laboratory, I also incorporated test C in the lab testing. This test shows different results than the previous two did. Here both sample 11.1, 11.2, and 11.4 were finished and had reached a high loss in weight after 20 000 turns. The only sample continuing was 11.3. It reached mass loss at 30 000 turns. According to these results the most durable felt was the sample fully processed through the carder. Although 11.2 and 11.3 might have more guard hairs, they lasted 10 000 turns less than 11.3. and 11.1. Again, the results indicate that it is the alignment of fibres, creating an even felt and not the amount of coarser guard hairs that contributes to most abrasion resistance in a pre-felt.

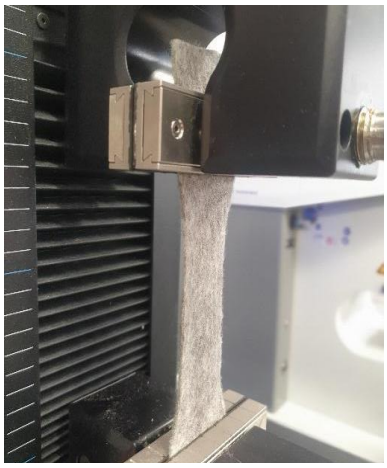


Fig.25 - Tensile strenght test

Results from Tensile strength test

Tensile strength was made with two strips from each felted sample (Fig.25). One vertical and one horizontal. The average results extracted from these strips are presented as results.

In test G - I, 9.1.3 shows the highest score. For 9.1.1 the results are less than 50% than for 9.1.3. 1.0 differs in the tests, where G and I is about 40% less and H about 20% less than the

high score of 9.1.3. In all, Test I have the highest score, followed by G and then H. In test C, 11.1 stands out as the weakest of them, but 11.2, 11.3 and 11.4 are more similar. Also in this test, 11.3 has the highest score, marginally better than 11.4.

In elongation the results are mixed. In G 9.1.1 has the highest score, in H 1.0 and 9.1.1 are similar, and in I 9.1.3 is on top. Test G and I are both at almost the same score, while H is 8% less. Still, the result from elongation is much more aligned than results from maximum forces are. Test C displays less score in force, but high results in elongation in contrast to the other G – I.

Results from Air permeability test

In this test 5 different tests on each felt sample were made. One in the middle, and one on each of the four corners (Fig.26). An average is calculated for a more reliable result. In some tests there were scores that deviated. After advice from the test lab, these have been removed to present a more viable result.

Fig.26 - Air pearmability test

In three of the tests, 9.1.1 has the highest score to the others. It is in G, H and C. This indicates that when just opening the wool and keeping all guard hairs and finer down, the amount of air that can flow through is higher than when processing and evening out the wool more before felting it. Test C has the absolute highest score where 1.11 has a score of 1602 in contrast to 9.11 in G of 665, and 9.1.1 in H at 1193. These findings can be understood as a soft pre-felt with high compressibility makes air flow a lot easier than in a dense, firm fulled felt.

Test G and I are quite similar in scores, stretching between units of 575 and 669. But in test I 9.1.3 has the highest score at 669, followed by 1.0 at 654 and 9.1.1 640. Test I had a wool density ratio double that of the other tests, which makes it thicker than the other tests. This can indicate that even though the felt is just after pre-felt, its thickness allows less air to flow through. In all tests 1.0 and 9.1.3 have similar results. This indicates that the amount of guard hairs does not play such an important role here.

7 Analysis

In this chapter, I will implement an analysis of what my findings mean considering theoretical perspectives.

7.1.1 Material knowledge in felting

Felting propensities of wool are not easy to categorise. Presented by both Sjöberg (2009), and Damgaard (1994), finer fibres have the highest ability to felt, and they felt faster. In this research that would have given me results that showed 1.0-1.4 with highest shrinkage. This is not the case. However, there is a remark by Damgaard (ibid) that states that coarser hairs can act as a contraction variable. She writes that short fibres with fine micron, mixed with long shiny guard hairs, will felt rapidly. And, that the guard hairs will sling around the shorter, finer down and hold them firmly together. But it needs to be carded well to make them well distributed. This is more in line with my results, where all samples made with *tog* and *thel* felt faster and with a higher shrinkage rate than those with mostly softer *thel*. But at the same time, it is not completely true. The carded and fully processed wool (x.3 samples) generally have a lower shrinking rate than the samples that were only opened (x.1 samples).

On the other hand, Sjöberg (2009) writes that inconsistencies when placing the wool contributes to better grip. This can be shown in data from samples 8.1, 9.1.1, 11.1 and 12.1.1 which all were placed more in small bundles of fibres than with a parallel batt. Here the fibres, when given space to move in all directions, have an easier way to get a good grip and create a durable felt. These samples have between 3 - 9 percent higher shrinkage than the next sample within their group, which could answer to Sjöberg's (ibid) remarks about grip.

Other observations made by both Sjöberg (2009) and Damgaard (1996) are recordable in the results. As Sjöberg (2009) explains, a fully carded wool batt, where all wool fibres have been thoroughly separated, creates an even surface, and felt, but at the same time, this decreases the aesthetic appearance of shine. This can be visible in the samples ending with x.2, x.3, and x.4. But, when compared to felted samples from the pre-project made by NKS, they all have a higher lustre. In general, felt made with lustrous *tog* will create a higher shine – carded or not. Further on Damgaard explains (1996,) that firmness also contributes to less or more elasticity. This my findings confirms. All samples show a decrease in elasticity when there is a high firmness or density.

According to Sjöberg (2009), short fibres have a hard time interlocking within the felt. My results both confirm and refute this statement. In all the wool samples named 9, it was clear that during the hardening and fulling short, black hairs travelled out into my hands. This did not happen during pre-felting. A result that can indicate that the shorter fibres travel the most and loosen their grip during the hardening and fulling stages when the felt really starts to shrink and get firm and dense. Wool in samples 9 had coarser *tog* only 2 cm long. A result that for future felting could imply that even though felting is a good way to interlock wool that contains fibres of various lengths, one should be aware of fibres shorter than 2 cm. Or one could try and separate them and only felt the finer *thel* where this negative effect was less visible, since shorter hairs are sorted out during industrial preparation. One other way of using the wool with those short fibres could be to leave it at a pre-felt stage, but that might give a result that later would present similar concerns during use.

Further on, I find that several discoveries are interesting. It is not only about thick layers when creating a soft felt. As test B reveals, the manipulation aspect is vital, so is the ratio of wool on a template, and the stage where I end the felting process. This can also be said for the fact that more thinner layers added will create a firmer felt. The spæl sheep wool with its coarser *tog* will automatically create a firmer felt than felt made from crossbred wool. This I understood during my pre-project. But the ratio is also important. Recall test I, where the ratio of 0.5 made a tough, hard felt only at the beginning of the hardening stage. But again, it could have been due to the pressure added. Test B had the same ratio but stayed soft and flexible due to what must have been a very soft pressure in the machine regarding the timespan during felting.

The rolling technique used in both manual and industrial procedures made it clear that turning 90 degrees after every turn was crucial to achieving an evenly felted sample. But in addition, the felt needed help with folding the edges to make a neat and clean shape of the sample. This was more visible when adding more layers, with a higher ratio like in test I. Also, upscaling the template in test G gave this indication, in addition to the fact that when working hands-on with a bigger template, my hands could not put an even pressure everywhere on the roll at the same time. This aspect I believe created folds in the pre-felt that needed smoothing during process.

My empirical data substantiates that spring wool, with either long or short *tog* or long or short *thel*, felts rapidly and well. It can be processed either with or without the carding option, giving a variety of aesthetical and functional characteristics. Sentral findings regarding felt ability of spring wool are:

- When removing coarser tog, the felt seems to need more time to obtain maximum fulling.
- With all coarser tog, less time is needed to achieve maximum fulling.
- The firmer the felt, the less shine it will display.
- A variety of compressibility can be attained by altering either the ratio of amount of wool on a surface, or the stage of felting.
- The extensibility is affected by the stages of felting and the ratio.
- Aesthetic features like aliveness or dullness, dynamic or calm, organic or mixed can be obtained by felting processed wool.
- The ratio of wool on a surface affects several aspects like amount of work before fulling or aesthetic characteristics like compressibility, extensibility, and flexibility.
- When making small samples or felted textiles, working by hand is less time consuming than working with the roller felter.
- Samples made by hand using a given method and calculated for shrinkage, can be reliable data when upscaling projects later.
- Upscaling the felt in size requires more time during rolling. It also requires more precision, when done manually than when felted in the machine, to make shrinkage and surface even.

7.1.2 Affordance - a theoretical tool for understanding more about wool

When looking back to how Gibson (2015) explained that affordances in the environment cannot be measured by physics and properties like flat, horizontal, or rigid, I tried initially not to pay attention to properties like softer *thel* or coarser *tog*, or that some fibres are shorter or longer than others in the wool. These properties belong to a more industrial standard units that could have been used for further ideas of production like making a strong, firm, dense, and durable felt for interior purposes. Instead, I have tried to follow possibilities for action.

First, what strikes me as an important possibility for action, is to separate the *tog* and *thel*. These fibres offer an action of pulling them apart. This affordance, I have connected to by letting different industrial machinery separate or manipulate the wool. A second possibility for action is the ability to felt. This affordance has to do with the specific technical features of the individual fibre. To

explore this action, I have tried to follow the results, as I went along with my tests. There was never a specific end product in mind, therefore I could be led by curiosity about the characteristics of the felt, the way the technique was performed and how manual and industrial felting could provide stages of felt. Even though the ability to felt is a very known property of wool material, my practical work has resulted in a wide variety of felted textiles. By ending the procedure after three stages of felting – pre-felt, hardening, or fulling – a broad range of characteristics of felt are presented. This aspect of felting as a craft was new to me, but I strongly believe that for an experienced felter and crafter, these phases are well known. At the same time, it is uncertain if anyone in Norway has felted this type of wool in this manner before, or if these stages of felt are novel. If a designer should want to work further with samples ending with x.1, maximum usage of the wool will be performed. Almost no waste can be measured during production, and *tog* and *thel* would find a way to continue to coexist in a product or felted textile.

Secondly, the felted textiles produced during testing have a variety of characteristics that again produce various affordances. High or low flexibility, offer action to fold, bend, turn or squeeze in further work. High density affords to rub hard, step on, beat for long periods without breaking, handle rough, put in environments that require a durable and long-lasting textile. Lower density does not but adds to a more flexible felt. High density and firmness can also provide the designer or craftsperson stability when creating form or building on, or a surface that is hard to penetrate. Transparency, like the one visible in test F, offers light to shine through, therefore giving the felt a totally new aspect of visual effects. Here the *tog* plays an important role, offering the viewer, maker, or designer a whole new spectre of networks inside the felt. The affordance of transparency offers to look at and through, to be put in places where there is light, to use for creating atmospheric settings. It also offers a hidden effect if used both with and without light.

Extensibility offers pulling, or not pulling the felted item or textile. The room for stretching the felt into new shapes can offer exactly that - new shapes. The change in volume of the felt under pressure, is offered by compressibility. Together with low density, these two features can offer actions of pressing, letting air blow through, trying to keep warm air inside or exploring cushioning usage. Or the felt can be constructed in thick layers making it ideal for soft shock absorbing surfaces. With a high compressibility and lower density, there might also be room for actions like absorbing liquids.

Performance characteristics of the felted textiles can also easily be categorised as properties. Aesthetic characteristics like surface appearances of vividness, colour consistency, bulkiness, halo, calmness, dullness, or shine offers a user or maker different options in creating an artefact or product. When doing so, they might be perceived as actual properties of the object. I still don't know how the felted textiles will turn out, or if they will be used in further research or product development. They might also display felted negative sides in design that I am not aware of at this point. But the woollen felt still is, as Gibson (2015) explains: “what the environment offers (...) either for good or ill”.

Norman’s (2013) relational aspect of finding affordances between the environment and people is another aspect. The ability to felt was known to me from before, therefore it is a perceivable property of the wool and ready for action. So is the fact that this type of wool consists of two types of fibres and that these can be separated. The signifiers – felt ability and wool type - are therefore known to me and communicate two forms of actions. The environmental property of the wool interacts with me as an agent together with my pre-knowledge, and the affordances exist. Another action that the felted textiles offer is to be split or cut. This is due to its non-woven inner structure. This aspect I was also familiar with and knew about the advantages of cutting without having to address sides that split, or inner structure with stitches that dissolve when cut through. This signifier is more from the man-made felted textile and could be analysed as a relation between thing and people - or felt and crafter/researcher.

But none of these affordances are novel, neither to me nor to others that to some extent know about wool and its characteristics. So, when Barati and Karana (2019) suggest novel affordances as unactualized qualities and abilities, I say they highlight other aspects. Felting spring wool - only opened and not fully processed - have to my notion never been done before. The felted textiles ending with x.1, might therefore be a novel affordance, or what Barati and Karana (ibid) address as an ability not yet actualized. These test samples also show a quality of the wool that might be novel - the high shrinkage percent and fast felting ability. In four out of seven samples, the rate was higher. The kinaesthetic qualities are also different from any felted textiles I have encountered before. Another novel affordance is the transparency feature in felt from test F. This aspect I had never seen before in felted items from spæl sheep.

The relationships presented until now consist of my relation to wool, both as a craftsperson and an industrial worker. I am an agent that perceives wool and felt based on my background knowledge of wool as a material, felting as a craft and as an industrial yarn maker. Other relational aspects involve industrial machinery as an agent.

In Barati and Karanas (2019) framework they highlighted that the materials should be seen as generative, having their own ability to bring into being. An aspect also highlighted in Barads new materialism. This generative aspect of a material underlines the fact that the wool has its own agency. One finding that I would like to highlight is when I was felting the test G for Tallinn. At some point, I just stop what I am doing, lift the wool from 9.1.1 and I'm struck by a feeling, as if the wool wants to affect me in some way. This experience inspired a deeper reflection – what if the material that we today consider useless, this beautiful, grey, and lively wool that I'm studying, is the actual wool that will connect us with our textile history? The wool is not processed, so it looks almost as it did when on the sheep. Reflecting on this, I wonder, when understanding agency as an active participant in creation, perhaps that specific lock of wool influenced me to see history right in front of me and inspired me to work on developing ways of utilising this material. During the research process, that was not the only time I experienced that the wool acted as an influencer on the making.

When performing all the 39 repetitions of test A, I felt a strong urge to stop. Stop counting, turning, doing the same thing over and over to try to create samples that could be measured and calculated for technical features like shrinkage percent. During test C, again I felt the same urge to stop planning, counting, and instead just grab some wool and felt it. This urge resulted in test F where I found one of the potentially novel affordances of transparency and inner networking. Of course, all possibilities for action are presented by the material and can therefore be a form of influencing - the agency of the wool.

Unlocking novel affordances hasn't been limited to just me, during my research in this material. To broaden my experience with felting in dialogue with others, I held a workshop in felting with spæl sheep wool together with different textile crafters, artists, and mini mill workers. One of the participants came up to me with her thin, soft pre-felted light brown textile made from spæl sheep.

She said that she had no clue that felt made of this material could exhibit such characteristics. In her artistic work, she often applied embroidery on woven fabrics. When using thicker woollen yarn, her experience was that woven fabrics created visible holes where the yarn was pulled through. She did not use felt, because she never thought it could inhabit such features as the one presented to me. But this felted textile that she held in her hands, was both flexible, thin, and firm. It also had the characteristic, as all felt does, that it is a non-woven textile. Due to these above-mentioned appreciated features, she could pierce it anywhere she wanted, with as thick thread as needed, without following an inner structure of warp and weft, and at the same time not worrying about visible holes around the thread, which positively impacts her work. This was novel to me and unlocked by her background and experience in embroidery as a craft technique. In this case, the non-woven structure of the felt acted as a signifier but was only perceivable to her. To me it failed because I did not comprehend what it was signalling. This situation and realisation underline the fact that I have blind spots as a researcher when exploring the material.

7.1.3 The world of matière

Another important discovery for me in this research has been the challenge to verbalise and describe aesthetic features of the surface of the felted textiles samples. This can be because a felted textile does not have a repeated and harmonic structure, like a woven textile can have. The felted textile consists of fibres in arbitrary directions and the surface can be perceived as chaotic, and therefore hard to decode at first glance. As mentioned before, the matière – the surface appearance of a material -can be very subjective (Albers, 1965).

These emotional sensations result from touching, moving, or squeezing the fabric with my body. In my attempts to describe my sensations I started with words like even or uneven, or soft or coarse. Simple words that just stated contrasts and not so much the full spectrum of the felt that was in front of me. This aspect, the tactility of my materials, is not for the mind, it is for the hand or body. Like Albers (1965) has said: function, which is an inner structure of a material or textile, can be constructed through the intellect. Matière, which is a tactile approach that must be felt non-analytically and receptively, cannot and requires sensibility. I needed to sit down with all my felted textile samples, place them in front of me and just be together with them without any disruptions. It was a mess, 52 pieces of felt all over the tiny room. I worked the palm of my hand over them, stroked them against the soft skin of my inner wrist, and put them next to the thin skin of my neck.

I squeezed them tightly, or loosely, pushed them down, stretched them out. All 52 samples over and over.

I laid samples on each thigh, letting my two hands or palms touch them simultaneously to see if I could experience differences. Slowly the body started to respond to the felt. I also sat just looking at them, turning them over and around. Looking at them closely, or from far away. Words like vivid, exciting, dynamic started to come to mind when trying to describe the felted wool in samples ending with x.1. The other samples ending with x.2, x.3, and x.4 seemed quite alike to me and they gave me a sense of calmness. These surfaces are much more even in texture, blended in colour and somewhat speckled. When compared visually, a kind of dullness was experienced on samples x.2, x.3, and x.4, in contrast to the vibrant and loopy samples x.1. To work with new materials - by touching and feeling them - is also something that Barati and Karana (2019) address. They lean on research that shows this can compensate for the lack of property files or data sheets of materials. Experiencing the felted samples made me grow in my articulation about them, and I see a verbal development, and an increased sensibility for just absorbing the material with my hands.

8 Discussion

8.1 Summary of central finding and insights

In this discussion chapter, I will first go through central findings that concerns wool characteristics and felting. After that I will discuss how working with affordance theory has been. Finally, insights concerning PaR as a method will be evaluated.

8.1.1 Regarding wool and felt

The first step in my procedure with the wool concerns washing or not washing. I stated that one of the reasons why I decided to wash the wool in my research was due to industrial preferences and reproducibility. If I had not washed the wool, I could have carded everything on my own, using a table carder, in addition to separating the *tog* from the *thel* by myself. I presume my research then would have taken a more artistic or crafts related perspective. There is one wool industry in Kåfjordalen where they card unwashed wool. This might have been an option, if my objective was to felt wool that still contains the natural fat called lanolin. I could also have felted the wool raw, without any process. It is only mentioned once in all the literature I have read, that lanolin and natural sweat in the wool, can act positively in the felting procedure (Sjöberg, 2009). But then, Sjöberg (2009) later states that by there are many advantages to washing the wool before felting; one can avoid moth infesting later, dirty wool can prevent the fibres getting close enough, old fat can make the wool more difficult to card and dirty wool also can create stains if folding felted textiles for storage (ibid). By considering these factors I concluded that I was going to wash the wool.

What I find missing in theoretical books about felting, and that I can contribute with, is knowledge and information about the different manipulation procedures and stages of felt made from spring wool and how these contribute to the great variety of characteristics. I believe that the booklet, where I have gathered all the characteristics and results, can be a guide for artists or crafters if they want to use spring wool in felting. Today, as Sjöberg (2009) mentions, there is a lack of fixed values or measurements in felting as a craft and material. She says that a weaver can order yarn with a definition of 7/2 which gives her a specific 2-ply yarn with 3500 metres per kilo. This categorisation is missing in felting.

Then one could argue that knitting or weaving is not relying on so many variables as felting is, but that's not completely true. From my own experience, I know that the same definition of yarn can give completely different garments. Knitting gauge can also vary a lot from knitter to knitter, although the yarn has the same amount of metre per kg. Trying to create some definitions and fixed rates for felting need not be so problematic, it just needs more interest and work. As a start, this research displays how industrial help today can process several different wool batts for crafters and artists. Norwegian crafters would not only have to choose fully carded batts but could – if the mills are up for selling these products – get a variety of processed wool to work with.

Several factors have affected my results. First, I would like to mention that the results are based on a pH of 11, which is lower than it could have been. I could have gone higher – up to 14 – to get a faster and firmer felt, but I did not know how differences in fairy soap would affect the pH level when I started my tests. Since I had already begun, I chose to stick with 11 pH. Secondly, I could have felted in acidic fluids, which could have given my results higher elasticity. This because acid and lower pH levels, don't break down the keratin protein in the wool letting the elasticity in the fibre remain intact. Thirdly, I have not evaluated time when felting by hand. I have focused on how many times I have rolled the felt, and what pressure I have added. While the number of rolls are not subjective, the length of the rolling is. Mine have been quite short and rapid. If I would have gone for longer rolls, the amount of pressure on the felt and time spent would have increased. So, this aspect includes a subjective aspect. As well does the pressure that varies from light to hard during my manual felting method. All these descriptions are embodied and tacit knowledge that I cannot translate into words to make the reproduction easier. The three stages of felt are not subjective, it is how you get there that is. I have additionally decided to avoid techniques that would give my felt a more artistic surface, like using dyes, applique, or motifs; to me, this would have shifted my focus away from exploring the affordances truly *in* the material.

The feltability of wool depends on both fibre thickness and crimp, and combinations of fibres in the felt. In addition to these aspects, nutrition, climate, and grazing areas of the sheep can affect the quality of the wool and indirectly affect the felting propensities. These might have been contributing to the research.

Questions about time consumption are contradictory. The industrial roller felter has proven to be a lot more time-consuming for producing a fulled felt than working by hand. To the contrary, the machine could probably take larger pieces of felt than I could do if I wanted to upscale the

production in quantity. In addition, the pressure is more evenly distributed and could therefore create a more even felt. Working with machinery in the future can therefore be a way to supplement more crafts related and artistic hands-on work. However, and this is important, hands-on material engagements have proven to be much more efficient in getting to know the material and its possibilities. And the machinery I worked with proved to be insufficient in describing settings to reach a certain type of felt. I would consequently advise to make room for lots of trials if engaging in felting with this machine. And that proper material knowledge and technical skills in felting is useful.

My research has been based on a small selection of wool. Through an arbitrary selection of wool from one farmer a variety of felted textile samples has been produced. It is worth mentioning that the wool used in my research had good quality, was free from all debris, and well sorted. This might not have been the case in other wool samples, and therefore might not be representative for all spring wool. To make the research more technical and scientific, I would have to have collected already categorised wool from Norila or I would have had to gather all the spring wool available in Norway, categorise it, and thereafter choose a specific selection that would have constituted my material. Standardised tests of fibres, like micron and crimp before felting could also have contributed to a more objective perspective.

8.1.2 Finding the *whom* and the *when* inside the relational aspect

When working with affordances it was made quite clear to me that the concept was relational, and that there might be trouble defining for whom and when different affordances appear. My findings state that perceiving affordances in this research – and arguing if they are novel or not - are dependent on different aspects like previous knowledge of wool and felting, disciplinary background, and exploration.

First, it was due to my industrial background and knowledge about machinery today that I came upon the fast and high shrinkage property of spring wool consisting of a coarser *tog* when letting the picker open the wool before felting. If not choosing to work with possibilities for action, I probably would have just gone for the standard carding procedure at Selbu Spinneri. A choice that would then have given me carded batt from the four different colours I had to work with. This of course could have given me other results, and maybe I would have thought more about what properties this batt had and what it could be used for in terms of products, than continuing to

explore the material further for action related aspects. When using industrial technology, I hoped that if any samples should be granted further focus, it would be easy to replicate the batt – and produce them in greater scale for commercial purposes. Due to my own experience in working in a mill for many years and extensive knowledge about wool, I was granted access to the mills production lines. This made it possible for me to examine the wool in a much wider perspective than hiring them for the work, thus only using standard procedures. Meeting this affordance could of course also have been done by hand in a more artistic manner.

Secondly, my pre knowledge about wool and felt has been an important aspect of perceiving affordances. I am not an expert felter. To become one was not my goal either. I know more about wool than I do about felting. Hence, the different stages of felting, the pre-felt, hardening and fulling stage was new to me, but not novel in a wider sense. This I understood at the course I took at IFA – International Felting Association. The affordance can still be important, because it displays a great variety in all the samples made from spring wool that can be useful for further work. Also here, the way of working with affordances as ways to offer possible action has benefited the research. Third, the way that I experienced the influence of my material during test C and G, was interesting. I would have loved to continue with the affordance of transparency in future work with this material.

During the exploration, I was not aware of my blind spots. This aspect of the research was made clear when teaching a fellow crafter in a workshop. Her distinct technical background in embroidery made her see other affordances than I did. She also did not know about the fact that wool, consisting of both *tog* and *thel*, could felt in this way. Her blind spots would have been the felt ability and pre-knowledge about this specific breed of sheep. Recognizing this blind spot makes me aware that there could be others. Thus, it is very difficult to state that any of my findings are novel affordances or not. They might be to me, but not to others, all depending on what type of background one has, or how one interacts with the wool when exploring this material. If the spring wool material and felting technique are to have as high usage as possible, I suggest that we need to gather interdisciplinary fields of design, architecture, industry, craft, art and so forth. By doing so we can together highlight possibilities for action perceived and continue working together to explore ways of utilising this material. If we do not work together, we might miss possibilities for action due to our own blind spots.

I would like to visualise this by using a graphic model that is inspired by the Johari window and Luft (1984) and his work on awareness in interpersonal behaviour[20]. The Johari window has four quadrants: open, blind, hidden, and unknown. These quadrants can be known to self, not known to self, known to others, and not known to others. To visualise how aspects like how and for whom affordances in my thesis have been perceived, a matrix model like this can be useful. It looks like this:

When starting the research all quadrants are equal in size. Inside the four fields there are things that others know that I do not, as well as there are aspects that I know that others do not. And we must acknowledge the fact that certain aspects are completely novel or unknown to all of us (Fig.27).

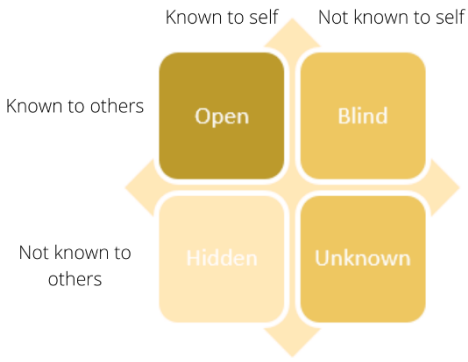


Fig.27 - Quadrants starting point

The finding of felt abilities and characteristics of only opened wool like in samples x.1, made the open field in this research wider. It was not known to me but known to the material and industrial machinery. Here also lies knowledge that came from the workshop participant. She saw different affordances than I did, which contributed to making the open field wider and more accessible for future material research. The shift in blind to open can be showed like this (Fig.28):

[20] The model is simplified and need to be considered as my interpretation of how to use the model in this research.

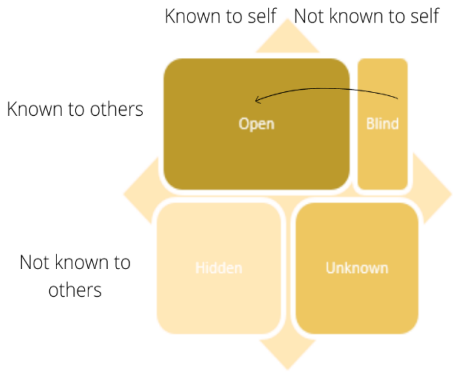


Fig.28 - From blind to open area

But the interaction that we had during this workshop did not only open my blind areas, but it also revealed information and knowledge to her that was hidden. This decrease in the hidden area can be displayed like this (Fig.29):

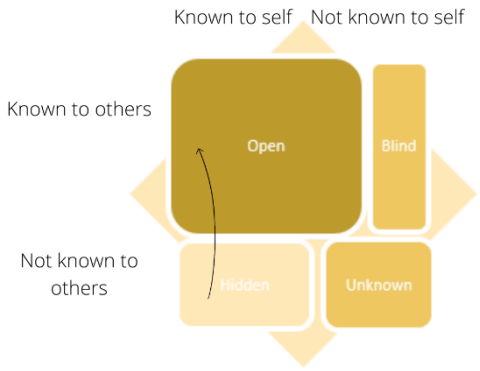


Fig.29 - From hidden to open area

The unknown area could have been unlocked by the coincidence when exploring the material and transparency with intricate inner networks was revealed. It was a novel discovery to me, but since I have not yet revealed my findings or presented them for experienced and professional felters or wool crafters, I am humble about stating that the transparency of spring wool is a novel affordance.

One thing I do find important to emphasise is the fact that when working with affordance and affordance theory I have tried to stay true to the original ideas of Gibson (2015) when it comes to seeing value in the ecological object – here the wool material. While it has been addressed and argued that the meaning of affordance has become confused and distorted when entering the

human social arena (Torenvliet, 2003), I argue that when using new materialistic philosophy as a lens, where value goes beyond symbolic or monetary human spheres and instead focuses on value in all living things – animal, nature, and humans, this aspect is respected and continued.

Maybe it is this aspect, the aspect of material value, that I feel is missing in Barati and Karana's (2019) article. They do refer to Gibson, but only to state that it "is cutting across traditional subject-object dualities", and "that affordances are possibilities for action offered to the animal by its environment, (…)". The first statement might highlight the agency in the material, and the second is Gibson's definition of the term, but they do not address the fact that it had to do with perceiving an already valuable ecological object. This part about working with an already valuable object and what responsibilities or ethical aspects then follows, are not dealt with. Instead, it is only about how a designer – a human – can discover new and novel ways of creating designed objects[21]. The environmental and resource usage aspect is not given any room. But then again, the article is about the human perspective on creativity, material-driven design, and material-development. Not ecology or sustainability. I believe we can do both, and to me, when using Gibson's (2015) affordance theory, it is extra important to take in consideration the natural world and its ecological value when thinking about future development of products or industry.

There is another aspect to consider. While Gibson (2015) underscored that affordance were characteristic of the environment, existing relative to the animals, not needing perception, Norman (2013) argued that they instead are actual and perceived properties of a thing that determine how it can be used. To stay true to Gibson's theory, I stress that the affordances of wool as a material and the felted textiles are qualities and abilities that are always there. They are not discovered by me; it is just that I could perceive them at that moment. This needs to be said about all the affordances, novel or not, that were experienced during the practical work. They are part of the material and not my perception or cognition. But even so, as discussed in the previous sub-chapter, when focusing on material affordances and not perceived properties of a thing, losing contact with perceiving the already value-rich ecological object can still be easy. On the other hand, this research has categorised performance aspects - aesthetic and functional - that can be seen as properties of

[21] They do mention "Transgression of Norms, but this I interpret to be more about breaking social and cultural norms when using a material that were "usually considered to be undesirable" (Barati & Karana, 2019, p. 115) , than seeing the full aspect of environmental concerns, value or prospects in using a natural material.

the felt and what they offer a user. Then also I entered Norman's (2015) theory of user perspective and human product related sphere. Maybe I also would have failed?

8.1.3 Working with a practice-based research method - PaR

It is important to understand, while taking on a method that includes practice in its research that it is not only about being a practitioner in action. Nelson (2013) makes it very clear that PaR only arises *where an insightful practice is submitted as a substantial part of evidence of a research inquiry*. (2013, p. 9) This means I needed to keep a close eye on my research questions during my work. I cannot simply felt wool to exercise the PaR model but need to felt the wool to answer my research and inquiry. This aspect I have tried to fulfil by always keeping affordance and material exploration in mind. The tests I have made do not contribute to giving the research an end product by definition, but rather encourage making one. I have built tests on each other, always exploring further what characteristics one test gave me. By crossing from one tested felted textile, to the next, while keeping in mind why I was moving on and what I wanted to explore - its affordances - and at the same time striving to remain true to my method. All gathered data from my practical tests equally contributes to the empirical work of which then will give an answer to my research inquiry. The felted samples have provided a basis for many ideas for further products along the process, which can be explored, but I have chosen not to do so. I have instead kept following explorations in my sample making - from manual, to machine, from pre-felt to fulling. All data has then been evaluated, analysed, and presented in writing as a contribution to the woollen felted textiles.

During my work with PaR, I have obtained several different types of knowledge throughout the research. Through hands-on experience with the wool, I have accessed a huge amount of detailed knowledge about spring wool as a material. It ranges from understanding more about the fibre than I did before, to improving my awareness of the processes that felting as a technique offer and how different characteristics that felt made from this type of wool can offer. If I should rephrase Nelson's (2013) three areas of PaR, they would be obtained like this:

In my *know-that* I have experienced different stages of felt, how wool changes appearances after being dipped into water during felting, how difficult it sometimes has been working systemically with a technique that is so tactile and sensual. I have also reflected on how my body worked during

felting, moving, pressing, lifting the wool, and moving the felt. In *know-wha*t, perspectives from Barad (2007), Gibson (2015), Norman (2013), Barati and Karana (2019), Sjöberg (2009) , and Damgaard (1994) have made an impact on me. I have learned much about philosophical aspects of value, design approaches, and felting as tradition and craft. Knowledge that makes me view the world differently than before. Lastly, the *know-how*, is my inside and subjective knowledge obtained from working with the material. While doing practical work I have developed new skills. My body quickly adapted to my manual felting method and after a short time I did not have to think anymore when working - except for the counting. My body and hands moved with and on top of the wool like it had not done anything before. My body shifted its angle or worked harder or less with different muscles when adding or releasing pressure, my fingers worked quickly and sharply when creating neat edges on the felt. Knowledge that is tacit and embodied and is not explained further as the scope of my thesis that does not deal with tacit knowledge nor embodied cognition.

8.2 What are the implications of the results?

I now have a much better understanding about the severe importance felting as a craft has had on both human survival, expressing oneself with artistic touch in a wool material and the historical aspects of the material wealth our ancestors have had.

8.2.1 Small scale industry

Using spring wool from Norwegian Old Spæl Sheep can be a way of realising a potential from the human past. The craft of felting has gotten me very close to the material and the process, even though I have simultaneously worked with industrial machinery. It is interesting that the word felt stems from the PIE (Proto-Indo-European language) root *pel, which means to strike, or to thrust (*Felt | Etymology, Origin and Meaning of Felt by Etymonline*, n.d.). The craft really is driven by action between human and material - nothing else needed.

There are some factors that make wet felting hard, both on the body and for the financial profit for companies. Even though consumers today are willing to pay more for local, natural products, there is still an upper limit. A katank, a traditional felted boot, can take up to a few hours to make and needs a substantial amount of material. Even though wool is not the most expensive factor in this equation, labour is, which affects sales prices. Industrial help can therefore be a necessity to assist manual felting in the future.

Counted 1 of January, there were 13894 Norwegian Old Spæl Sheep ewes (A.L. Sandnes, personal communication, May 2022) in Norway. When one ewe gives approximately 1 kg of wool, we would have just under 1.4 ton of spring wool to work with. This is not enough for creating a big industry but could generate a good amount of wool for small local felt industries, or crafters and artists. If we take in consideration that there also are 3935 ewes under one year, 905 rams, and 744 rams under one year (A.L. Sandnes, personal communication, May 2022), the amount of tons to work with would improve. If wanting to upscale even more, one could include sheep that are not breed approved together with wool from another pigmented spæl - the Pigmented Spæl sheep. Small-scale, local wool industry can have a positive impact on the future (I. G. Klepp, Burgess, et al., 2022)

Seeing the impact that small local yarn producing mini mills like Selbu Spinneri, and Oslo Mikrospinneri have had on the use of Norwegian wool, I say there can be potential for positive prospects for the future – also for felt. The mills work and positive impact has affected endangered wool types like Old Norse Sheep and Grey Trønder sheep, but also use of other wool types. When discussing monetary value with Volent, the owner of Oslo Mikrospinneri, she mentions that when beginning production of a worsted yarn made of 30 % lambswool from Old Norse Sheep, Norilia has agreed to resuming sorting this quality for her. In this yarn she utilises the soft *thel*, while almost all the coarser *tog* is sorted out. Volent states that if she continues to order 1.5 ton every year, this will generate payment to the farmers. But she also mentions that it is also easy to lose track of the value throughout the process and that she hopes innovation regarding use of the coarser *tog* will be dealt with (personal communication, October 2021).

This states that the way from no-monetary value and waste to beneficial is short and can be changed by a very small and local business, which is fortunate. It also states that long-time obligations from industries - small to medium in size - are crucial for increasing monetary value for the wool and farmers. And like presented in the former subchapter, we have more than 1.5 ton of spring wool to put into production to generate monetary value back to the farmers. In addition, it communicates that it is not really the material per se that is worthless, it is that we are not able to find usage for it that generates any economic or monetary value. And that the ecological value is not taken into the equation. Which again puts responsibility on humans to do more to remember

the ecological value and better make use of wool material from breeds like Old Norse Sheep and Norwegian Old Spæl Sheep.

At the same time, is it ethically right to only use the softer *thel*, due to its more wanted and appreciated features amongst consumers? In one way, yes. If this generates monetary value to the material and the farmers will get paid for the wool and their work with cultivating our land, it is positive. The social, symbolic, and economic value might also enhance due to this fact that there is soft, wonderful yarn being sold that tells a story about caring for our sheep - all of them! A narrative that again could enhance influence on further work and research. And it is important that we do not only *use* the wool, but that it generates monetary value back to the farmers. From another perspective it is not ethical, unless we really work with usage of the coarser *tog* that in this process is sorted out and thrown away. This is of course not only the responsibility of a small business that's trying to give farmers some monetary value for their wool, but a political and social responsibility.

Our historical record shows national and international material knowledge, usage in various craft techniques, like felting, knitting, and weaving, and innovative products working with both *tog* and *thel*. We should be able to realise the historical potential in the future and felting spring wool could be a good way to start. If choosing to work with wool that has only been through an opening process, then almost no waste will be measurable in the production line, and *tog* and *thel* would find a way to continue to coexist in a product or felted material also after it has left the sheep. This does call for almost completely clean wool, free from debris. If choosing one of the other examples of manipulation, more energy and labour will be required in addition to more leftover coarser *tog* that needs to be put into some form of usage. Vital in all choices, is that farmers continue to work with the wool quality.

What might the future hold? According to my survey, 59% answered that they will not replace working with Norwegian Old Spæl Sheep to the more profitable NKS, even though they receive no money for their work. This prospect is good, because then there will be wool to work with in future research or design/product development. The farmers also display quite collective opinions when it comes to making use of both *tog* and *thel*. While 47% say that it is important to them that both *tog* and *thel* is used in products made from their wool, 75% answer that they would prefer to deliver their wool to a company or producer that makes use of both types of fibres. These answers indicate

that from the farmers point of view, future products don't necessarily need to be made from both fibres, but it is important that if we use *thel*, we should also use *tog* in other areas. To the farmers, making use of *all* the wool is imperative.

For the Norwegian institute for bioeconomy, these sheep are worthy of preservation (Holene & Sæther, 2020). In their action plan for 2021-2025 they highlight, amongst many other aspects, that they support development of niche products and that it is important to recruit new producers (Holene & Sæther, 2020). Problematic areas might be knowledge about the potential for niche products made from these breeds, or problems with creating a production volume that generates profit. My research can contribute to both. This research presents knowledge that can be used either for direct interaction with the material or use as a base for further research. Today there is no industry for felting textiles in Norway - not small or large. This highlights room for innovation in the field. If an industry is established, other types of wool could be processed in addition to spring wool from Norwegian Old Spæl Sheep.

But the way we humans interact with things is complexly entangled. Ian Hodder (2014) explains that our relationships with stuff are that they involve more than networks of humans and things, a symmetry of relations. Rather, our relations with things are often asymmetrical, leading to entrapments in particular pathways from which it is difficult to escape. Hodder (ibid) continues that when using this definition, it is accepted that humans and things are relationally produced. But the focus on dependence rather than on relationality draws attention to the ways in which humans get entrapped in their relations with things. Humans get caught in a double bind, depending on things that depend on humans. If I look at the discussion within the textile and fashion business, this dependency is quite clear. All over Europe, there is versatile and useful wool that today is considered worthless in monetary value and therefore is either thrown away or sold so cheap that the farmers do not get paid. In addition, wool is considered environmentally dangerous according to the Higg Index, a *suite of tools that enables brands, retailers and others 'to accurately measure and score a company or product's sustainability performance* (I. G. Klepp, Laitala, et al., 2022, p. 39).

Instead of changing this situation for wool, governments spend energy and money on focusing on EU-regulations that work on recycling, upcycling, or cleaning up after man-made fibres like polyester. Polyester, that by Higg index is more sustainable due to its long lifespan and limited

usage of natural resources during production. The paradox is that humans produce so much waste from man-made fibres in our clothing, read the mentioned polyester fibre, that this problem needs to be fixed in some way or the other. Innovation to revaluate or think of new industry for a locally produced natural material like pigmented wool, gets lost along the way in politics.

The good part in all this is that focus from many fields, both agriculture and textile industry, is on regenerative ways of interacting with our lands (Burgess & White, 2019; I. G. Klepp, Burgess, et al., 2022). The focus on building local circular textile systems and economies with the goal to create a closed circulatory system where everything is reused and recycled (Klepp et al., 2016), as well as using local materials. In both these ways of interaction between nature and humans, I believe spring wool from Norwegian Old Spæl Sheep, or any other breed with pigmented, double coated wool, can play a part in the future. And felting has in this research proved to have a lot to offer.

The fact that no tools are required in felting, might provide an advantage for farmers, or local producers in their surroundings. Felting is an easy way to transform this type of wool into commercial products. But to make use of all the wool that today is thrown away, only manual felting is not an answer. Industrial help and machinery will play a role in future developments for a sustainable future. My experiences with felting machinery are that it is too unreliable and mostly built for hobby related activities. To build on future developments, I would strongly advise industrial designers or engineers to look at how the world of mini mills for yarn production has bloomed during the last 10 years. Today these small and locally producing industries can be seen all over the world, producing and making use of local wool resources for consumers, designers, or other end-users. There is a huge potential for creating a felting industry. One that positively could impact rural areas the same way that small yarn mini mills have done. In such work, we would rely on present industrial and technical innovation *and* remembering and actualizing the great potential that felting and material knowledge in pigmented sheep breeds had in our history. Knowledge about the material and felting has shown to be vital pre-knowledge when using the machines. I therefore raise the question about knowing about felting and wool before getting into this line of business or craft. In addition, machinery today has shown to be a time-consuming operation. This again stresses the need for more developed machinery or having a side income with other product making.

To me it is important that we continue doing research in this field - the field of felting propensities of pigmented breeds like the Norwegian spæl sheep. The fact that this research has shown mostly positive effects when felting spring wool due to its ability to interlock short fibres, in addition to not giving so much focus to different fibre lengths within the fleece, can indicate that it is a good way of making use of it.

8.2.2 So, the past is not the solution?

No, it would be naive to think that we can go back in time. What I feel Barad (2007) and the new materialistic philosophy bring forth when it comes to values is an umbrella that emphasises value creation across interdisciplinary fields like ecology, economy, and culture. To me, space is created to see both the natural value of nature in conservation, the sheep, and their wool, but still remember that today we all, humans, nature, and animals, live within and around a complex, entangled, capitalistic system where consumers and economic value play an important role for production and industry. It would therefore be naive to think that we can go back and just adapt what history has to offer in material knowledge, techniques, or ways of living. Like in physics, time does not go backwards. What we can do, like this research shows, is to remember and actualize knowledge and ways of living and try to see how these, within our system, are compatible with more long-term healthy ecosystems. It is our duty to steward the Norwegian Old Spæl Sheep that we have benefited from during 5000 years in Norway. Just because we do not anymore *have to* use the wool to survive, does not make our responsibility to do so less vital. It makes it more crucial than ever. The Norwegian Old Spæl Sheep today depend on us to have a good life, since we have domesticated it and bred it into needing shearing. A factor that highly stresses the responsibility for using the wool.

I do understand the importance the white crossbred sheep has today and let us not distract ourselves from its importance. But it should not be at the cost of the double-coated breeds, but in addition to them. If we cannot bring forth an industry that uses wool consisting of two types of fibres with excellent properties and long historical and cultural importance, who is then the primitive species? Us or them? To call a sheep primitive is one way of saying that it is related to an early stage of evolutionary development, which in a sense is true. But to call the modern, white sheep a refined sheep, which refers to having unwanted elements removed, or elegant and

cultured in appearance, might state a different meaning of primitive. It states a definition of seeing the prehistoric sheep as basic, unsophisticated, or simple. I would say that in my research this type of wool has shown to be advanced in the great varieties of creating felt, responding to industrial separation processes, and giving a huge amount of different aesthetic characteristics both in surface and colour, in addition to several functional aspects. I therefore argue that if we don't find innovative methods in utilising this sheep and its wool, it is humans that have now become primitive in the sense of being simple and unsophisticated in terms of convenience. In contrast to the wool that all along has been this advanced. It is easy to reject a natural material as complex due to all its variables in production. But I say that this is not the natural material´s fault, it is rather a development that suggests a loss in understanding properties of the material and how to interact with it under given circumstances.

The people that lived making sails and that took the time to separate and utilise the coarser *tog* and softer *thel*, did it because it was a way of surviving. They had developed exceptional material understanding, knowledge that we today have lost - while we depend mostly on international import. But if we were ever again to solely survive on our own resources, would we have the luxury to let this type of wool and its broad range of uses go to waste? According to Rawles and Holland (1994), only what is wholly natural is truly irreplaceable and therefore worth every effort to conserve. The Norwegian Old Spæl Sheep that is close to a direct descendent from the first mouflon sheep is exactly that - wholly naturally made, with little human interference. It is naturally made, in contrast to the modern, refined, white crossbred sheep that is man-made. To Rawles and Holland (ibid), what humans have created, they can shape again, so its destruction matters less. Not that the white sheep is in any real danger or should not have a great play in the future. Focus on preserving and cultivating this sheep is secure in both industrial and scientific perspectives. This view highlights the importance of not letting the naturally made pigmented sheep breeds disappear, and when being innovative for future developments, we must remember that what nature creates can be even more important to preserve than what humans make.

I hope that my research has provided the scientific field some answers that can be reflected on to preserve the future as a realisation of the potential of the past. When addressing the question of realising the potential of our past with wool without losing track of its ecological, symbolic, and monetary value, I feel that a historical and holistic connection is being made. When working with

affordance theory and new materialism, there is as much meaning in the material and its agency as there is in me as a crafter and researcher. For us in the Nordic countries, the wool material has been, and still is a big part of our identity. To remember this valuable connection between past and present when laying out ideas for future development that are compatible with long-term health of ecosystems, I say that we create a space that is respectful and aware of both the past, present and future for animals, nature, and humans. An awareness that opens to a specific wool related consciousness. I call it *woolness*.

9 Conclusion

By making use of spring wool from Norwegian spæl sheep, we can realise a potential from the past. Our Nordic past shows highly appreciated products made from double-coated, pigmented wool like the one Norwegian Old Spæl Sheep has today. Viking sails, fisherman mittens, boat carpets, cloth like “vadmel” and tapestry, all having a high symbolic or monetary value. While some of these products were made from spring wool, others were not. Highly developed skills in both material and technique, have been required. In the Nordic countries, felting never received the same status as knitting or weaving, though it can still be a useful technique for future developments.

The potential can be realised when using tog and/or thel into products that have their features based on the natural properties of the wool. To maximise the potential, I suggest both types of fibres should be used in the future, and that it is key not to lose contact with the natural ecological value of the wool. My results state that spring wool felts fast and well, and the wet felted textiles show a great variety of future usage, based on affordances of looking through, rubbing hard, cushioning, shock absorbing, folding, or squeezing to mention a few. In addition to a manifold of aesthetic, technical and functional features. The coarser tog has proven to play an important role in durability aspects, but so has the way the wool is prepared before felting. For future developments, collaboration between interdisciplinary fields is recommended to enhance finding material possibilities. Findings also stresses engineering innovation, to create small scale felting machines to build new industries upon. But more research must be made.

10 Suggestions for further and future research

There are many interesting aspects in this line of research that could be investigated or explored further, but I would like to highlight three areas as most important:

Research in spring wool quality today, and how features like crimp, micron, elasticity, length, and porosity affect the propensities in felting?
Which products could the felted textile in this research generate, and how would shorter fibres affect product appearances?
How can engineering and industrial development create small scale felting machines that could contribute to circular economic systems for felt, like the ones made for yarn making?

Fig.30 – Livredderen Norwegian Old Spæl Sheep © N.O Mevatne

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12 List of tables and charts

Annexes