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Raincoats or riches?
Contextualising *vararfeldir* through multi-perspective experiments

Abstract
Fleece pile cloaks or *vararfeldir* feature regularly in early medieval (870 CE to 1200 CE) Icelandic textual sources as a staple of north Atlantic trade. Archaeological finds and reconstruction projects have provided numerous insights. However, few studies have investigated how *vararfeldir* were used, or why they were produced and traded so extensively when other materials were available. This project used controlled experiments to compare the properties of reconstructed *vararfeldir* with contemporary materials, while a public consultation provided alternative perspectives. The resulting data suggest that the demand for *vararfeldir* may have been driven by more complex forces than previously assumed, including specific practical needs, production advantages and subjective concepts. This provides broader insights into the perceptions and priorities of early medieval society and suggests numerous avenues for future investigation. The results highlight the potential for multiperspective, contextualised investigations to broaden understanding of textiles as societally-embedded technologies.

Keywords: Experimental, *vararfeldir*, pile, Iceland, early medieval, sensory, materiality

Introduction
The north Atlantic region, including modern-day Greenland, Iceland, Norway, the Faroe Islands and the British Isles, was dominated by extensive trade networks during the Early Medieval period (870 CE to 1200 CE), and Iceland was at the heart of the trade in wool textiles (Gelsinger 1981, 13; Dennis et al. 2000, 247; Priest-Dorman 2001, 8; Hayeur Smith 2015, 25–26). In addition to producing standardised wool fabric (*vaðmál*), Icelandic written sources give intriguing glimpses into the production and exchange of shaggy fleece pile cloaks (plural *vararfeldir*; singular *vararfeldr*) for consumers both locally and overseas, particularly in Norway and the British Isles. While research into archaeological finds has built up a detailed picture of how *vararfeldir* were constructed (Kløve Juuhl 2013; Hakonardottir et al. 2016, 180; Mader 2017; LaFleur 2017), very little is known about how they were used, making it difficult to understand why there was such demand for them, or what role they had in society beyond being a trade product.

This research investigated these questions using a variety of experimental methodologies in order to approach them in a more holistic, contextualised way than had previously been attempted. The results provide new insights into the complex experiences of the people who made and used *vararfeldir*, and how these unique textiles fitted into the wider landscape of material production, trade and usage in early medieval Iceland and the wider north Atlantic region.

Evidence
Written sources suggest that pile cloaks were produced in Iceland from the first settlement in the late ninth century until about 1200 CE (Guðjónsson 1962, 69). *Grágás*, the earliest surviving Icelandic legal text, valid between 1117 CE and 1271 CE (Hayeur Smith 2020, 57), includes a description of a market-standard *vararfeldr* meaning "trade cloak":

> *"In accordance with General Assembly regulation … a trade-cloak is worth two ounce-units, four*

> *thumb-ells long and two broad, thirteen tufts across the piece. If cloaks are of better quality than that, their value is subject to assessment"* (Dennis et al. 2000, 207).

Based on this description, the typical *vararfeldr* has been interpreted as a rectangular garment, which was constructed by inserting additional material into the textile to form a pile structure (Guðjónsson 1962, 68; Priest-Dorman 2001, 8).

Following Guðjónsson's interpretation of the early Icelandic unit of measurement "thumb-ells" (*þumalálnir*), these measurements have been taken to describe a textile 204.8 cm long and 102.4 cm wide (1962, 68). The description suggests that these cloaks were standardised to some extent for the trade market but it is not clear how much variation there actually was. The reference to "better quality cloaks" clearly suggests variation within the tradition, but *Grágás* gives no indication as to how the versions differed or why some were preferred over others.

Several archaeological textile finds have features corresponding to this description (fig. 1). In particular, two twill weave wool fragments from Heynes in south-west Iceland, dated 900 CE to 1100 CE, have locks of unspun fleece woven into the textile, creating a shaggy, fur-like surface (Guðjónsson 1962, 66–69). Similar examples of fleece pile textile have been found elsewhere, most notably in several key sites along early medieval trade routes including Dublin (Ireland), York (United Kingdom), Birka (Sweden), and the Isle of Man (United Kingdom) (Crowfoot, 1966, 80–81; Pritchard 1992, 93–98; Walton 1989, 336; Priest-Dorman 2001, 13). The precise construction techniques observed in these finds vary, and it is difficult to know whether they represent Icelandic exports, as there were contemporary pile textile traditions elsewhere, most notably in Ireland (Wincott Heckett 1992, 160–161; Guðjónsson 1962, 70–71; Priest-Dorman 2001, 8; Pritchard 1992, 98). Due to this uncertainty, this research focused primarily on the Heynes fragments and the *Grágás* description, as they are most likely to represent the Icelandic production tradition.

Fig. 1: Archaeological finds of pile fabric from the north Atlantic region, including Heynes (Iceland) shown in red with similar finds in blue (data compiled from Guðjónsson 1962, 65-69; Priest-Dorman 2001, 9-14; Walton 1989, 336; Crowfoot 1949, 25; Crowfoot, 1966, 25, 80-81; Pritchard 1992, 93-98; Walton 1989, 336) (Image: Julia Hopkin, after Google Maps)

The purpose of pile cloaks

Vararfeldir are primarily presented as trade items in written sources from the period. *Heimskringla* describes entire shipments exported to Norway (Sturluson et al. 2011, 129) and *Grágás* sets out their value within the 'commodity-money' system of the time relative to silver and other trade goods such as furs, livestock and *vaðmál* (Dennis et al. 2000, 247; Hayeur Smith 2020, 56). Perhaps most significantly, *Grágás* specifies that *vararfeldir* could be used by Icelanders to pay taxes in Norway: "males … shall pay land dues, six trade-cloaks and six ells of homespun or half a mark of silver … when men come to an anchorage or to shore-moorings" (Dennis et al. 2000, 211). Sagas such as *Heimskringla* are likely to be subject to literary exaggeration, and may not accurately reflect the extent to which *vararfeldir* were traded. However, these legal references suggest that *vararfeldir* were in sufficient demand in both Iceland and Norway to be exchanged with the expectation that they would retain their value. The recipient would either be able to use the item him or herself or have confidence that there was a market in which to exchange them. Several different terms were used for pile cloaks but *Grágás* repeatedly refers to them as *vararfeldr* ("trade cloaks") which suggests that this economic role was an important way in which these cloaks were perceived. However, these references give little indication of how the final consumers of *vararfeldir* used them, making it difficult to understand why they were so in demand.

There are a few descriptions in Icelandic sagas of *vararfeldir* being worn but it is often not clear exactly why they were worn or how they were intended to function. Norwegian king Óláfr Tryggvason is described as wearing one on top of his "bad weather clothes" following a sea voyage (Sturluson et al. 2011, 166), which suggests it provided protection against the weather. Icelandic characters in *Njáls saga* and *Grettis saga* (Anonymous and DaSent 1861, chapter 22; Anonymous and Hight 1914, chapter 35) wear them as impromptu disguises. In *Heimskringla*, King Haraldr

"Greycloak" seems to wear one simply for novelty value (Sturluson et al. 2011, 129). These descriptions do not point to a single consistent use for *vararfeldir*, and the rarity of these references, along with the likelihood of artistic licence being used in saga narratives, makes it difficult to know how accurately they represent the ways *vararfeldir* were used in reality.

Previous academic interest in *vararfeldir* has focused on their role in the early Icelandic economy (Gelsinger 1981, 13, 69; Ingimundarson 1992, 219; Durrenberger 1992, 42; Hayeur Smith 2015, 25–26) or analysis of the construction details seen in the archaeological evidence (Guðjónsson 1962; Walton 1989, 336; Pritchard 1992, 95; Priest-Dorman 2001). Numerous reconstruction projects have provided insights into their visual appearance (Kløve Juuhl 2013; Hakonardottir et al. 2016, 180; Mader 2017; LaFleur 2017) but they have produced only limited documentation of their production choices, experiences of the production process, and the physical properties of the finished products.

Several studies have also included suggestions as to how and why *vararfeldir* could have been used but these have been hypothetical. The dominant idea has been that they were used as protective clothing in cold or wet weather, often based on comparisons with the uses of pile fabric in other contexts (Guðjónsson 1962, 70; Barber 1992, 149–150; Hayeur Smith 2020, 112): for example, written references indicate that the wool pile garments popular in Ireland from the 15th to 17th centuries CE were considered particularly effective against wet weather (Wincott Heckett 1992, 163–164). Many pile textiles, including *vararfeldir*, have also been repeatedly compared with fur or sheepskin, often being described as "fake fur", suggesting that their popularity was based on conceptual associations with similar materials (Gelsinger 1981, 13; Barber 1992, 183; Priest-Dorman 2001; Owen-Crocker 2004, 182; 9; Ewing 2009, 153; Mannering 2017, 177). While many of these ideas are very appealing in theory, no previously published investigation has studied the functions of *vararfeldir* in depth, experimentally tested how they function in practice or placed their functionality into the wider context of the time.

The experimental approach

This research aimed to provide more concrete information about how *vararfeldir* functioned, to help suggest why people created, traded, and used them, and understand how they fitted into the wider context of the early medieval north Atlantic world. As the scope of the project was limited by the time and budget of a masters dissertation, it was intended as a preliminary study, to provide initial insights into the properties and possible uses of *vararfeldir*, generate ideas that could be studied further in the future, and explore methodologies that could be of value to other investigations.

The question of why people in the past acted in the way they did is an easy and common question to ask but, in practice, can be deeply challenging to answer. The concept of technological choice frames people's actions as a series of conscious or subconscious choices between different methods of dealing with their situation (Lemonnier 1993, 2; Sillar and Tite 2000, 3, 11). This concept provided a key framework for developing the methodology for this project.

Research into technological choice has indicated that while functional considerations often seem to be the most obvious factors driving people's decisions, in many cases other priorities, such as social or conceptual factors, can be just as or even more important than practical ones – to the point where some choices and behaviours are actually counterproductive in a functional sense (Lemonnier 1993, 2; Olofsson et al. 2015, 76; Sillar and Tite 2000, 9). On this basis, it was important to avoid restricting the investigation to purely functional considerations. In particular, factors such as phenomenology and materiality were highlighted as particularly valuable when investigating clothing, which is so intimately connected with the human body (Harris 2014, 37; Joyce 2005, 147–149) and instrumental in mediating between the body, the environment, and people's actions within it (Gilligan 2010, 68; Cartwright 2015, 53). Phenomenology refers to how people experience objects through their senses (Thomas 2006, 2; Harris 2008, 84–85). Materiality considers the social and conceptual ways in which people interact with objects (Harris 2008, 82; Graves-Brown 2000, 1).

This project combined several methodologies in order for the investigation to consider the wide variety of possible factors and the context in which these choices were made. Controlled tests of reconstructed materials produced quantifiable data on their physical properties and insights into their functionality. Observations on the sensory qualities of the materials and the experience of producing them were made, but it was also a priority to include a wider range of viewpoints. A public consultation was also carried out, involving 60 people, to provide alternative perspectives on the materials' sensory and conceptual qualities, and generate new suggestions for factors to investigate in the future. Harris' experiments have demonstrated the potential of recording modern perceptions of archaeological cloth types for

generating new ideas and highlighting ones that have been previously overlooked (Harris 2008; 2010; 2014), and her method of conducting handling sessions followed by questionnaires formed the basis for the methods used in this experiment.

Investigations into technological choices have also emphasised that all stages of the item's life cycle, including production, consumption, re-use and disposal, can affect people's choices (Sillar and Tite 2000, 3-4). As previous experiments with *vararfeldir* have focused on their production, this research centred around their use, and how people interacted with them as consumers. Some insights were gained into their production process but it would be valuable to investigate this in more detail, along with other stages of their use lives, such as reuse and disposal, in the future. As Icelandic textile finds in general show a high level of reuse (Hayeur Smith 2020, 59) and the Heynes fragments themselves show signs of being altered or reused (Guðjónsson 1962, 67), these later stages of use are of particular significance to the understanding of how *vararfeldir* circulated and were consumed as household commodities as well as in their role as trade goods.

Contextualising *vararfeldir*

A core element of this investigation was the awareness that *vararfeldir* were just one option in a range of materials available at the time, and it was essential to consider this wider technological landscape to understand them in their original context.

Numerous textile types were available in this period but fabrics with pile were in the minority (Hayeur Smith 2015, 25; Andersson Strand 2015, 18). In records of the Icelandic textile trade, *vararfeldir* always appear secondary to *vaðmál* (standardised wool fabric) in terms of the quantities traded and their ubiquity as a trade and currency item (Hayeur Smith 2015, 23; Hayeur Smith 2020, 57–58). The demand for *vararfeldir* cannot be fully understood without acknowledging the predominance of non-pile fabric.

There is also plenty of written and archaeological evidence for extensive trading in furs and skins in early medieval Europe, including wild species such as fox, squirrel, marten and ermine, as well as sheepskins and other domestic animal products (Ericson et al.,1988, 85; Dennis et al. 2000, 207). In both *Grágás* and *The Voyage of Ohthere,* furs are used to represent wealth (Dennis et al. 2000, 207, 209; Fell and Lund 1984, 19-21), while in *Gunnlaugs saga ormstungu,* a fur-lined cloak serves an important sociopolitical role as a royal gift to a loyal retainer (Anonymous and Attwood 2015, 19). Furs also feature heavily in the descriptions of

Fig. 2: The project samples: wool fabric (1); dense pile fabric (2); less dense pile fabric (3); sheepskin proxy (4); and rabbit fur (5). The woven and skin samples measured approximately 29 cm x 23.5 cm and 16 cm x 15 cm respectively (Image: Julia Hopkin)

Norse exchanges with other groups, such as the taxes levied on Saami leaders in *Egils saga* (Anonymous and Scudder 2001, 20) and exchanges with indigenous communities in North America in *Eiríks saga rauða* (Anonymous and Kunz 2001, 670). This suggests that the trade in furs had deeper significance than simple economic benefits. As with pile cloaks, it is not always clear what furs were used for but since many of their possible functions and those of *vaðmál* are similar to those suggested for *vararfeldir*, their coexistence in exchange networks makes it difficult to imagine why the latter were so popular, and even more important to investigate them in their shared context.

In order to examine *vararfeldir*'s role in relation to these other materials, this project carried out the same experiments on small-scale samples of two types of reconstructed *vararfeldr* fabric (samples 2 and 3) and samples representing some of the main alternative materials available at the time: plain wool fabric (sample 1), sheepskin (sample 4), and fur (sample

Sample	Material
1	Wool textile without pile
2	Wool textile with dense pile based on the Heynes finds
3	Wool textile with less dense pile based on the *Grágás* description
4	Icelandic sheepskin proxy (fat tanned sheepskin with Icelandic fleece)
5	Rabbit fur

Table 1: Overview of the samples created for the project

5) (table 1, fig. 2). This direct comparison aimed at identifying ways in which *vararfeldir* may have been exceptional, and thus provide potential reasons for selecting them over other materials.

Methodology

Creating the samples

The woven textile samples (samples 1 to 3) were created by the author using a reconstructed warp-weighted loom (fig. 3). The woven samples measured approximately 29 cm x 23.5 cm with some slight variation (up to 0.5 cm larger or smaller). The fabric for all the samples was a 2/2 twill based on Guðjónsson's description of the Heynes fragments (1962, 66–67). This source gives only a vague description that the warp threads are finer and more tightly spun than the weft threads. For this reason, yarns with a similar thread count to the original fragments (table 2) were chosen. The yarns (Ístex Einband for the warp and Ístex Léttlopi for the weft) are commercial single-ply yarns spun from Icelandic wool. Commercial yarn was used owing to the limited time frame of the project but it also ensured greater consistency between the samples than would have been possible with handspun yarn, as well as ensuring that they can be replicated in future projects. The same fabric was created for all the samples, and they were woven on the same warp to ensure consistency. Pile was inserted into samples 2 and 3 during the weaving process to represent the fragments from Heynes and the cloaks described in *Grágás*. Details that are not mentioned in *Grágás* were made according to the Heynes fragments. The material used to create the pile in the Heynes fragments has not been subjected to microscopic

Fig. 3: The small-scale warp-weighted loom used to weave the textile samples (Image: Julia Hopkin)

Piece	Weave	Yarn thickness		Yarn twist		Thread count (per 1 cm)	
		Warp	Weft	Warp	Weft	Warp	Weft
Heynes 1 Large piece (Guðjónsson 1962, 66-67)	2/2 twill	"Comparatively fine"	"Coarse but rather uneven"	"Tightly spun" Z Single	"Slightly spun" S Single	9	4
Heynes 2 Small piece (Guðjónsson 1962, 66-67)	2/2 twill	"Coarser than warp in large piece"	Not recorded	"Less tightly spun than warp in large piece" Z Single	"Slightly spun" S Single	7	5
Sample 1 Plain fabric	2/2 twill	12 wraps per cm (Ístex Einband)	6 wraps per cm (Ístex Léttlopi)	70-80° Z Single	70-80° Z Single	8.6	5.5
Sample 2 Dense pile						9.25	5
Sample 3 Less dense pile						9	5.75

Table 2: Details of the woven samples 1 to 3 compared with Guðjónsson's description of the Heynes fragments (Guðjónsson 1962, 66-67)

Fig. 4: Detail of sample 3 (less dense pile fabric based on *Grágás*) showing a lock of fleece inserted under four threads in one shed, and looped around the final thread (left side) to form the pile structure (Image: Julia Hopkin)

analysis but Guðjónsson described it as most similar to the *tog* (outer coat) of Icelandic fleece (1962, 66). To create the samples for this project, individual locks of wool were separated from an Icelandic fleece, and the *thel* (undercoat) pulled out by hand, leaving only the *tog*, while keeping the lock structure intact.

The pile insertion method followed Guðjónsson's diagram of the Heynes fragments (1962, 20). One shed was opened, and a fleece lock passed from right to left beneath four threads, then looped back around to pass underneath the fourth thread again (fig. 4). A second shed was then opened in addition to the first. The main weft was passed, and weaving continued as usual for the next three weft passes. The finished fabric looked very similar to the original finds, with the pile forming distinctive loops on the front of the fabric, and no sign of the pile showing on the back (Guðjónsson 1962, 66–67). In both samples the pile was inserted into every fourth row, following the Heynes fragments, as *Grágás* only mentions the spacing of the locks in one direction.

The key difference between the samples was the spacing of the pile locks within each row. The spacing based on the Heynes fragments (sample 2) resulted in a very dense pile (fig. 5a), whereas sample 3 was based on a calculation from the *Grágás* description and turned out to be much less dense (fig. 5b, table 3) – a difference also noted by Guðjónsson (1962, 69). The difference is clearly visible in the samples, which led to a hypothesis that the denser cloaks might have been the "better" cloaks described in *Grágás*, as they used more wool, and seemed like they would be more functionally effective and visually appealing.

Creating small-scale samples does not give precisely the same experience as creating a full-scale

Fig. 5: Detail of the pile textile samples showing the visible difference between: a -sample 2 with the higher density pile based on the Heynes fragments; and b - the lower density of the pile in sample 3 based on the description in *Grágás* (Images: Julia Hopkin)

Piece	Frequency of pile rows	Spacing of pile within row	Interval between pile insertions within row (cm)	Number of warps pile is passed under (in one shed)	Number of warps between pile locks (in one shed)	Total warps per lock (all four sheds)
Heynes fragments (Guðjónsson 1962, 66-67)	Every 4 rows	Irregular	Unknown	4-8	Unknown	20 (approx.)
Grágás description (Dennis et al. 2000, 207)	Unknown	Unknown	7.87	Unknown	Unknown	Unknown
Sample 2 (Heynes)	Every 4 rows	Regular	1-1.2	4	2	24
Sample 3 (*Grágás*)	Every 4 rows	Irregular	7.5	4-5	18	Irregular

Table 3: The pile spacing used in project samples 2 to 3 compared with Guðjónsson's description of the Heynes fragments and calculations made from the details in *Grágás* (Guðjónsson 1962, 66-67; Dennis et al. 2000, 207)

reconstruction. Using commercial yarns meant that it was not possible to investigate the production stages prior to weaving. Nevertheless, producing the samples provided insights into the production processes for the different materials, including the time required to weave each sample and prepare the fleece for the pile, the quantity of wool used, and the experience of producing them for a modern-day maker.

The fur and skin samples were intended to represent types available in the early medieval north Atlantic. However, exactly matching the species was challenging, due to the difficulty in sourcing these materials and the risk of them being damaged during the practical tests. As Icelandic sheepskin was difficult to source, a proxy was created by sewing a section of Icelandic fleece to commercially produced fat-tanned sheepskin (chamois), thus closely mimicking the structure of an actual skin, while using the same type of fleece as used for the pile. The skin samples were irregular shapes due to the nature of the skins. The rabbit skin sample was approximately 29 cm x 20 cm wid, and the sheepskin proxy approximately 16 cm x 15 cm wide.

Fine fur from small mammals was also difficult to obtain. Fox and ermine furs were loaned for the public handling sessions (see below) but it was not possible to obtain furs from these species that could be damaged during the experiments using water. Rabbit fur was used as a proxy, as it was much more easily available for the purposes of these experiments. Although rabbit is not native to the north Atlantic region and was not commonly available in the area during the Early Medieval period, rabbit fur has a similar structure to other small mammals, with thin skin and fine, dense fur. Repeating the practical experiments using a wider range of early medieval fur and skin types should be a priority for future experiments.

Fig. 6: The equipment used for testing the samples' insulation properties, showing sample 1 with a heat pack inside, the uninsulated heat pack used as a control, and the dual probe thermometer used to measure the temperature of both heat packs from outside the refrigerator (Image: Julia Hopkin)

Testing the physical properties

A series of controlled experiments investigated the materials' physical properties. The experiments investigated a selection of key properties focusing on the possibility that they could have been used in cold or wet weather. More rigorous testing was not possible with the small-scale samples and limited equipment available.

The samples were first tested for their insulation properties. Each sample was folded in half and the edges sewn closed. A heat pack with a thermometer attached to it was placed inside (fig. 6). These were placed in a refrigerator for an hour with an uninsulated heat pack (also with a thermometer attached) as a control. The temperature of both heat packs was measured at five-minute intervals, allowing the total heat loss over the course of the hour to be calculated. This was repeated with the samples dry and fully saturated with water. For those with pile or fur, this was also repeated with the pile facing inwards and outwards.

To investigate their water resistance, each sample was attached to a thin layer of sponge and mounted on a wooden frame at an approximately 45° angle with buckets set up to catch any water that ran off (fig. 7). Tap water was sprayed onto each sample in increasing quantities representing different weather conditions (table 4). Each time, the quantity of water that completely ran off the sample, that was absorbed into the material itself, and that passed through the material and soaked into the sponge behind it was measured.

Following suggestions during the public consultation (see below), an additional test was conducted to investigate how long the samples took to dry. After each application of water during the water resistance test, the samples were hung up, and their weights recorded at 20-minute intervals for one hour. After the final test, all the samples were completely immersed in a bucket of water and weighed at regular intervals until they were fully dry, allowing a comparison of the maximum time required for drying. This was calculated by weighing the sample, bucket and sponge after the water had been applied, and subtracting the weight of all three when dry.

Fig. 7: The equipment used for the water resistance experiment showing sample 3 attached to a layer of foam, mounted at approximately 45˚ on a wooden frame, with a bucket placed underneath to collect water which ran off the sample (Image: Julia Hopkin)

Stage	Water level	Application method	Approximate water quantity (ml)	Distance from sample (cm)	Real world conditions represented
1	Light spray	Spray bottle, 20 sprays on a light setting	10	40	Brief light rain, sea spray
2	Medium spray	Spray bottle, 50 sprays on a stronger setting	20-30	40	Brief medium rain, heavy splash
3	Heavy soaking	2x 5 second bursts from a watering can	100	10	Brief very heavy rain, drenching from a large wave
4	Full saturation	Immersed in a bucket of water	n/a	n/a	Full immersion in a large body of water

Table 4: The stages of water application used in the water resistance and drying experiments

Collecting alternative perspectives

It was possible to observe the sensory qualities of the materials while creating and preparing the samples. To quantify these observations and allow comparisons of these qualities at different stages of use, each sample was rated on a numbered scale for a range of sensory qualities. This was carried out both before and after the practical testing enabling a basic comparison of how they changed during use. Repeating this survey with more participants would provide a more comprehensive view of the materials' sensory qualities. The logistics of the public consultation meant it was not possible to use this approach on a larger scale in this project but it should be a priority for future investigations.

The public consultation took place during the Viking Market at Fotevikens Museum (Sweden) in June 2019, and included 60 participants, including experts in textile and tanning technologies, craftspeople, reenactors, and the visiting public. The participants represented a wide range of ages, genders, and cultural backgrounds. The participants handled the samples and were asked a series of structured questions about their sensory experiences and the factors that they would consider when deciding how to use the materials. The participants were all asked the same questions so that their answers could be compared and the frequency of key ideas measured. Many participants also contributed additional ideas and comments. These responses could not be quantified but provided valuable anecdotal insights into the complexities of real-world usage.

Findings and discussion

Physical properties

Analysing the data together revealed new insights into the functionality of these materials. One of the most striking results of the practical experiments was that the pile textile samples did not stand out as notably more effective than the other materials during either the insulation or water resistance tests. When the samples were dry, the pile textile samples were slightly better insulators than the plain fabric, but were less insulating than the sheepskin sample, and broadly similar to the fur sample (fig. 8). In the water resistance tests, the fur was consistently most effective at shedding water (fig. 9). Neither of the pile textiles allowed water to entirely penetrate through, as the plain fabric did when fully drenched. They soaked up water rather than shedding it, particularly when larger quantities of water were added. In terms of these most straightforward aspects of insulation and water protection, *vararfeldir* do not seem to have been the optimal material available. This makes it unlikely that the dry insulation or water resistance properties of *vararfeldir* would have been enough to generate demand on their own and suggests that other factors were responsible.

However, the pile textile samples stood out in other areas. In particular, the heat retention of the samples changed drastically when they were wet. The skin samples were noticeably less insulating wet than dry, with the rabbit fur becoming colder than the uninsulated heat pack, suggesting it was actively leaching warmth away from the heat source. In

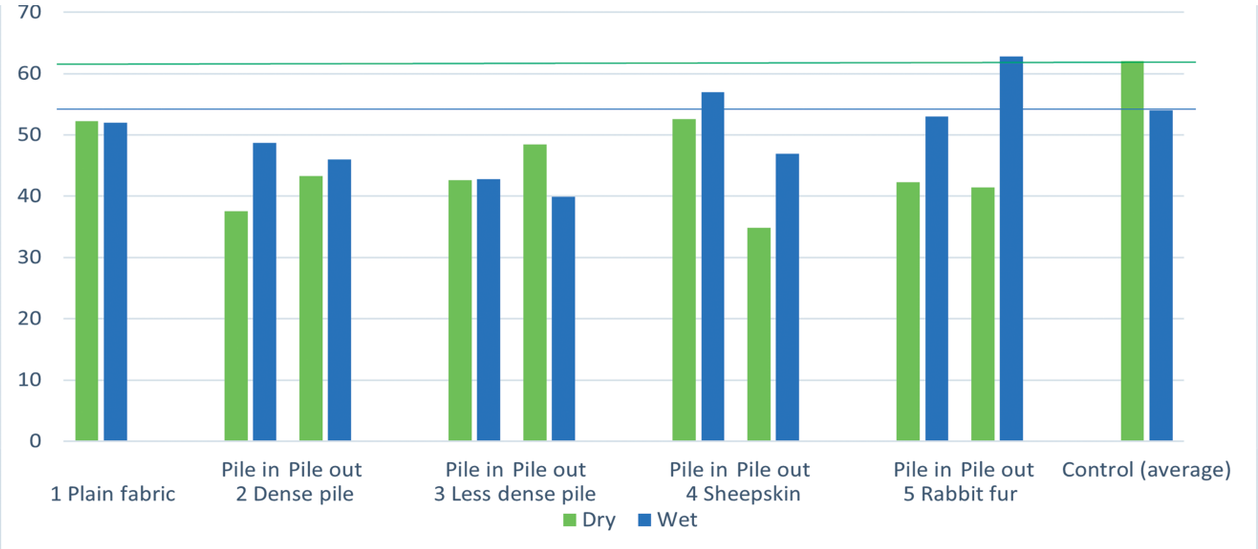

Fig. 8: Results from the insulation test showing the total heat loss (°C) from all the samples after one hour in a refrigerator (Image: Julia Hopkin)

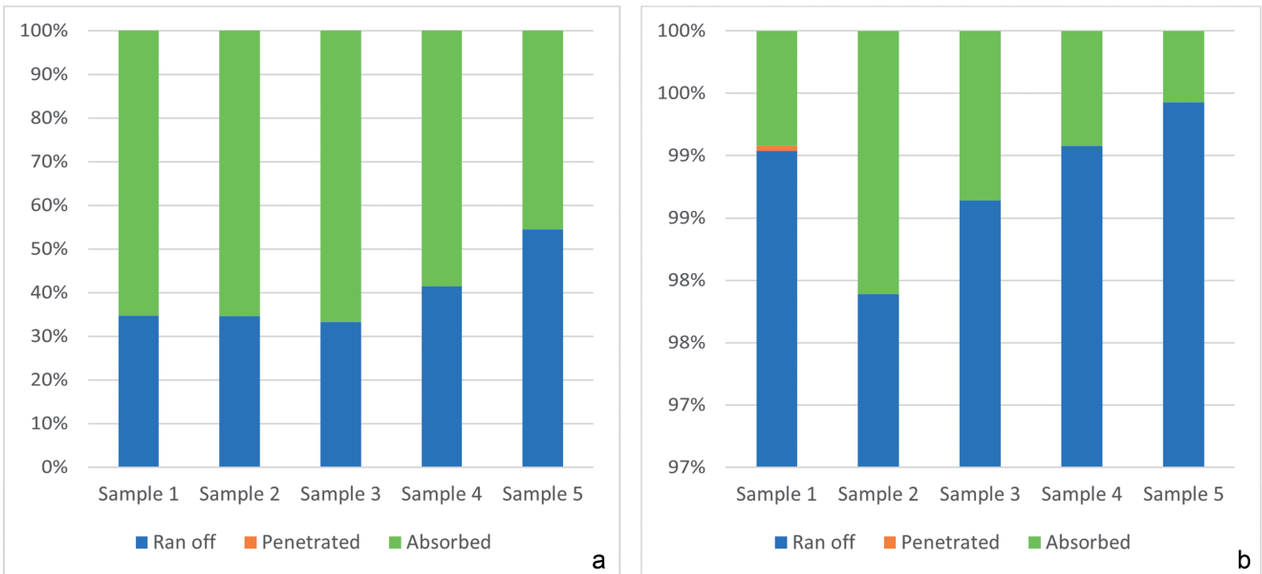

Fig. 9: Results from the water resistance tests showing the proportion of water which ran off, penetrated, and was absorbed by each sample following application of water using: a – medium spray; and b – heavy soaking. Note that different scales have been used for each (Images: Julia Hopkin)

comparison, the pile fabric samples were more consistent between wet and dry insulation, with the less dense pile fabric retaining the most heat overall when wet. Plain fabric was fairly consistent between wet and dry but retained less heat than the pile textile samples in both tests. It was also noticeable that in wet conditions the pile fabric samples were more effective insulators with the pile facing out, which may also have been a more suitable arrangement for resisting water. These advantages in cold, wet conditions are particularly notable in the context of Hayeur Smith's observation that pile fabrics are more frequently found in Greenlandic contexts than Icelandic ones, which could represent adaptations to colder climates (Hayeur Smith 2020, 112).

The drying experiments provided an added dimension to these observations. The fur consistently dried fastest after water was sprayed or poured onto the surface, as it was most effective at shedding water (fig. 10a). However, after full saturation, the fur was comparable

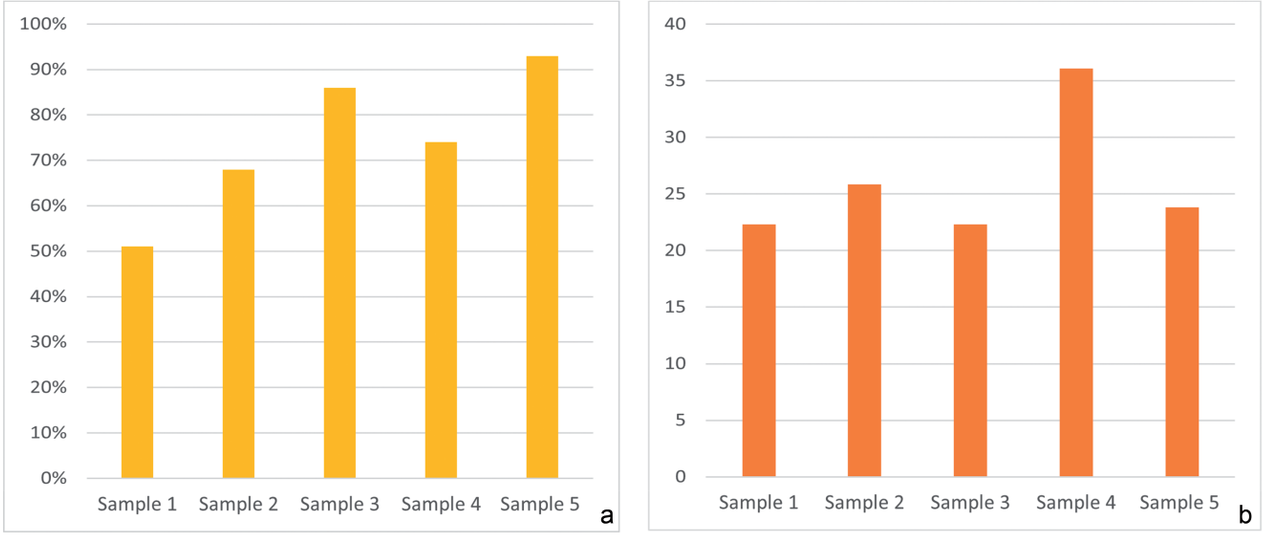

Fig. 10: Results from the drying tests showing: a - the percentage of water absorbed during the medium spray water application which had dried after an hour; and b - the maximum number of hours required for each sample to dry after full saturation(Images: Julia Hopkin)

Sample	Production process	Insulation		Water resistance	Drying (from full saturation)
		Dry	Wet		
1 Plain fabric	Fastest production	Least insulating	Less insulating than pile samples, similar to when dry	Moderate ability to shed water, but allowed water to penetrate during heavy soaking	Fastest at drying, equal to less dense pile
2 Dense pile	Weaving much slower than plain fabric, slowest pile preparation. More flexible process than fur	Moderately insulating, more insulating than less dense pile	Slightly less insulating than less dense pile	Least successful at shedding water but did not allow water to penetrate	Moderate drying speed, slower than rabbit fur
3 Less dense pile	Weaving slightly slower than dense pile, pile preparation much faster. More flexible process than fur	Moderately insulating, less insulating than dense pile	Most insulating	Moderately successful at shedding water	Fastest at drying, equal to plain fabric
4 Sheepskin	Speed not recorded, less flexible process	Most insulating	Slightly more insulating than rabbit fur but still poor insulation	More successful at shedding water than pile samples	Considerably slower than other materials
5 Rabbit fur	Speed not recorded, less flexible process	Moderately insulating	Least insulating and actively leaching heat	Most successful at shedding water	Moderate drying speed, faster than dense pile

Table 5: Summary of the physical properties of the samples according to the experiments with the best performing sample in each experiment in green and the worst performing in red

to the other samples (fig. 10b). The sheepskin took by far the longest to dry. Significantly, although the pile fabrics were expected to dry more slowly than the plain fabric, the less dense pile fabric was consistently more effective than plain fabric at drying surface water, and equally effective at drying from full saturation.

Comparing the materials' sensory qualities before and after water exposure revealed that both skin-based samples changed after water exposure, becoming stiffer with a rougher texture, and noisier when moving. These changes would make the skin-based materials much less suitable than the others in wear unless additional maintenance (such as resoftening) was carried out. However, the pile materials did not show any major sensory changes. This ability to dry more quickly and be wearable after water exposure without additional maintenance could have been a key advantage of pile textiles over skin materials. Notably, these results have a parallel in anecdotal evidence of 19th century Swedish and Finnish fishermen using rag or yarn-pile rugs rather than skins as blankets while sleeping in their boats, as they provided insulation and water protection without becoming stiff after drying (Nordic Homecraft 2013). This suggests that

these factors can be sufficient to influence real-world technological choices.

Following these tests, pile fabric does not seem to have been the single most insulating or water-resistant material available at the time. However, it appears to be more insulating than plain fabric. Its properties of insulating well while wet, drying quickly and not requiring additional maintenance after use in wet conditions set it apart from skin-based materials. Combining the results from these experiments (table 5) suggests that *vararfeldir* may indeed have been the most functionally effective choice for wearing as protective clothing in very wet conditions but for more complex reasons than previously assumed. This fits well with the description of Óláfr Tryggvason wearing a pile cloak during an ocean voyage (Sturluson et al. 2011, 166), while giving new perspectives on why people might have chosen to wear them in that context, and deeper insights into the experiences they might have had while doing so.

Pile density

Comparing the two different types of pile textile also provided new insights into the reference in *Grágás* that some cloaks were of "better quality" than others (Dennis et al. 2000, 207), and the hypothesis that this could have referred to cloaks with denser pile, such as the fragments uncovered at Heynes. Pile density did have a noticeable impact on the results in the practical experiments but, surprisingly, the denser pile fabric was not always more functionally effective than the less dense version. It was more insulating when dry and less insulating when wet, and it tended to absorb more water and become heavier than the less dense pile fabric, as well as drying a lot more slowly. It seems unlikely then, that denser pile cloaks would have been regarded as functionally better if their main purpose was use in wet conditions.

This could mean that this idea of "better" cloaks referred to less dense pile fabric, or cloaks with features that made them more functionally effective in other ways. It is possible that these differences in density represent specialised materials designed for specific purposes. However, it is also possible that "better" simply did not refer to functionality. Denser cloaks could have been worn for non-functional reasons which outweighed their practical limitations in wet conditions, such as the quantity of raw materials they required, preferences relating to their visual appearance, or other conceptual factors. This concept of "better" could have been based on these non-functional factors. While this evidence does not give any further indication about which factors were most important, or what type of pile was preferred, investigating these materials further, and reconsidering this concept of "better", could help develop a deeper understanding of the wider priorities and attitudes of this society.

The production process

Although it was not the main focus of this research, it was possible to observe and compare the different production processes for the various materials while producing the samples. As expected, the pile materials took considerably longer to produce than the plain textile, especially when the length of time required to prepare the fleece locks by pulling them from the fleece and separating the *tog* and *thel* is also considered (table 6). Although the production methods used did not allow for a comparison between the time required to produce the textile and skin-based samples, it was noticeable that the pile fabric gave a lot more flexibility to produce a wide range of different materials. Unlike the skin-based samples, it was possible to choose to use only specific sections of the fleece, and control how they were arranged in the pile by altering the density or making decorative patterns. As previously discussed, the density of the pile made a clear difference to the fabric's physical properties, and having this control over the finished result would have given the original

Sample	Average time to weave 1 cm (mins)	Average time to prepare fleece for one pile row (mins)	Total length (cm)	Total width (cm)
1 Plain fabric	14.9	0	28.5-30	23.5-24
2 Dense pile	18.3	18.3	29-29.5	23
3 Less dense pile	19.3	6.5	29	24

Table 6: Time required to produce the textile samples 1 to 3

producers considerable flexibility to make a material that suited their practical needs or the resources they had available, as well as aesthetic preferences. Pile fabric with decorative patterns is represented in at least one early medieval archaeological example - a striped pile fabric with alternating rows of red and blue dyed fleece from Birka (Sweden) (Priest-Dorman 2001, 13). Guðjónsson also mentions sources describing a variety of more complex fabrics, including striped pile and fabric with pile on both sides (Guðjónsson 1962, 69). These examples indicate that some producers of the period did take advantage of their ability to manipulate the features of pile fabric, and this flexibility could well have been a reason for people choosing to use pile textiles over furs.

Non-functional factors

The numerous different perspectives collected during the public consultation further emphasised the many complex factors that could have influenced people's material choices.

Fleece pile fabrics were new to all the participants. However, they all had opinions on how well the materials would work, and how they would use them, and many of these opinions were complicated and strongly held. These opinions could only have been based on immediate sensory experiences along with the participants' preconceptions and other associations. This emphasises the potency of these sensory and conceptual factors in informing technological choices and highlights the importance of investigating these factors in more depth in the future.

One of the main reasons for comparing *vararfeldir* with skin-based materials was the well-established assumption that pile fabric was used because of its similarity to sheepskin or fur. During the consultation, 22 participants mentioned this factor, but while 16 of those people thought they were similar, the other six thought they were completely different, and there were numerous different opinions about whether or not similarity would be a benefit. Some participants thought the *vararfeldir* samples were good imitations of sheepskin, with added practical benefits, while others saw them as similar but not enough to be convincing, and some even found them unpleasant or uncomfortable to look at. At the same time, several participants preferred the less dense pile fabric, as the unique pile structure was more obvious, and they thought the denser pile fabric was less interesting or valuable as it looked too similar to sheepskin, which they viewed as cheaper and less unique. This wide range of opinions emphasises the subjectivity of these associations between materials, and how even people with similar perceptions can respond and behave in very different, and sometimes unexpected ways. It seems that more caution is needed before assuming that *vararfeldir* were valued because of a straightforward similarity with furs or sheepskin, as these associations can vary significantly, even in a relatively small group of modern people.

The results of these experiments also highlighted the subtlety of the factors behind technological choices, and how easily they can be overlooked by limited methodologies. The properties that appeared to set *vararfeldir* apart from the other materials during the controlled experiments were very subtle, only observable in combination and with an awareness of the complex needs of using them in a real environment. The drying properties of materials used in wet conditions has not previously been considered in discussions of *vararfeldir*, and it was not part of the original plan for the experiments. It was added following suggestions from consultation participants who had prior experience of using similar materials in wet conditions and the results proved to be very insightful. This emphasises the value of engaging numerous perspectives to help inform experimental methodologies. It highlights the importance of including communities with practical expertise, who bring attention to the nuances of real-world usage that can easily go unrecognised in academic contexts, and be overlooked in experimental projects, especially where realistic testing is not possible.

Further considerations

Several suggestions for developing these experiments further have already been mentioned, particularly carrying out more detailed sensory surveys with multiple participants, comparing pile materials with a wider variety of skin and fur types evidenced in the period, and developing the practical experiments though more realistic testing, by, for example using full-scale reconstructions in real weather conditions. Realistic experiments would also be particularly valuable in investigating how different properties would work in combination with each other, and suggesting other factors that might only become apparent in the complexities of the real-world environment.

Opening up the discussion through the public consultation also generated numerous new ideas for factors to investigate in future experiments. In addition to the materials' drying properties, these suggestions included wind resistance, how long the materials would be useable, and the impact of lanolin or other surface coatings, as well as more complex ideas such

as how small they could be compacted for travelling, their cushioning potential for sleeping or sitting on, the bulk they would add to a person's appearance, and their potential for reuse. The idea of multipurpose materials has particular relevance when considering the signs of alteration or reuse found in the Heynes fragments, which were sewn together, with additional yarn loops attached (Guðjónsson 1962, 66–67), and the high degree of cloth recycling observed in north Atlantic textile assemblages (Hayeur Smith 2020, 59, 161). It would be very valuable to consider these later stages of a *vararfeldr*'s use life in more depth.

Several results from this experiment would also benefit from wider contextual investigation: for example, adding the pile locks to the experimental samples represented a significant investment of resources including the time required to prepare fleece for the pile. However, the impact of this must be considered in the wider context of fibre preparation for textile production. There is evidence that the undercoat and outer coat of the fleece were routinely separated and used for different purposes in this period (Hayeur Smith 2020), which would mean that adding pile consisting only of outer coat would not represent as much of an additional investment of time and resources as it might initially appear. Similarly, it is tempting to view woven pile fabric as a less costly, and more sustainable alternative to sheepskin, as it did not require the animal to be killed. However, the relative value of these materials would have been very dependent on the farming practices of the time. Conceptual factors, such as which materials were more of a novelty, would also have been heavily influenced by the distribution of pile textile production, the number of people capable of producing it, and the availability of fur (which was dependent on species distribution and local hunting practices). All of these need much broader investigation to understand fully.

Conclusion

By taking a broad, contextualised approach, this research has developed new knowledge about the properties of *vararfeldir* in their wider context and begun to shed light on why these cloaks might have been so much in demand.

The investigation of their physical properties has suggested that *vararfeldir* could have been chosen for their exceptional suitability for use in wet weather but for very different reasons than had previously been assumed. Producing the samples for the project highlighted the flexibility afforded by their production process, and the ability to produce a range of different practical or decorative features.

Consulting a wide range of perspectives highlighted the complexity of the factors that can influence technological choice, provided numerous alternatives to a simple functional explanation, and challenged the traditional assumption that the appeal of *vararfeldir* was necessarily related to their similarity to sheepskin or fur.

These results have broader implications for the understanding of the early medieval world. Comparing different densities of pile fabric has enabled reflections on the intriguing statement in *Grágás* that some cloaks were preferable to others and suggested that this may not represent a straightforward functional assessment but could reveal more complex societal priorities.

Numerous practical and sensory properties, possible ways of using *vararfeldir*, and contextual considerations have also been suggested, providing many avenues for future research. While a comprehensive understanding of how and why *vararfeldir* were used remains a long way off, this investigation has deepened understanding of the factors that may have contributed to it, and provided a stronger evidence base on which to build future investigations.

The key to the depth and range of this project's impact was its contextualised, multistranded experimental approach. By placing pile textiles in the context of other materials that might have been used alongside them, supplementing controlled testing with sensory observations and perspectives from numerous participants, considering non-functional factors, and building on the expertise of experienced communities, the experiments provided a wide range of insights, enabling the archaeological and documentary evidence to be viewed in a new way.

Investigating *vararfeldir* as just one part of an interconnected textile landscape has expanded the understanding of societal forces in which these textiles were embedded, from people's practical needs, social preferences and day-to-day experiences, to available resources, competing materials, the unique environmental requirements of communities around the north Atlantic, and the vast trade networks that united them. Far from simply providing details of one unique type of textile, these results have demonstrated the potential of holistic, contextualised methodologies to transform understanding of textiles and the societies that produced and used them.

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