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# Evidence for a Stone Age fibre technology – a closer look at the prehistoric String Theory

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## Abstract

The aim of the present study was to take a closer look into the evidence for a theory of prehistoric string manufacture, formulated by the British archaeologist Karen Hardy in the article *Prehistoric string theory. How twisted fibers helped to shape the world* (Hardy, 2008). A problem with the article, with the relevance and validity of the presented evidence as substance for the theory, was the mixture of references and arguments from different scientific areas and methodologies.

In this study three research questions are discussed, related to the overall idea of a substantial Grounded Theory of prehistoric string manufacture. They concern the validity of the evidence (RQ 1), the constitution of a textile materiality in the Upper Palaeolithic (RQ 2), and the support for a theory of a technological mind for plant fibre manufacture in the early Stone Age (RQ 3).

The methodology for embarking on a mission to evaluate evidence taken from mostly fragmented or perished material calls for a reflective perspective, almost as in archaeological fieldwork. The analysis undertaken relates to the direct and indirect evidence postulated by Hardy (2008), but with added arguments from the author of this study, after deep reading of some of her references and new search for further arguments for the initial evidence. The analysis resulted in a qualitative evaluation of each of the perceived 9 proofs of evidences for a String Theory. Five of these got their substance from archaeological records and four from ethnographic studies, see figure 1 in Appendix 1a and list of her references in Appendix 1b.

The overall evaluation of the evidence showed an uneven quality profile for their validity and relevance for the String Theory. However, there were some very good arguments and evidence for an early prehistoric string technology, even as early as 1.8 million years BP, based on the evidence of perforated beads and pendant as well as the long history of a string knotting technique. The reported evidence for a more advanced string technology/textile manufacture in Upper Palaeolithic, through direct textile findings and textile imprints and impressions in clay, has high quality as well as the findings from Mesolithic burials and settlements. The substance for the String Theory from the ethnographic evidence generally have a low relevance and validity due to the disparity in the reported methodologies and its more or less contemporary primary setting in tropical highland cultures from New Guinea.

In conclusion, the answers to the study's research question can be summarized in the following way: the discovery and formulation of a prehistoric String Theory is a challenge for further research into the materiality and technological minds of the early Stone Age.

*Keywords:* Grounded Theory, prehistoric fiber string theory, materiality, knotting, perforated beads, textile impression in clay, cordage, fishing and hunting gear, Upper Palaeolithic, Mesolithic, textile ethnographia

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# 1. Introduction

What is the substance of an archaeological theory of ancient textile technologies? Is it scientifically possible to construct a theory that is evidence-based on material which has essentially perished? The publication of a theory of prehistoric string technologies (Hardy, 2008) intrigued me so much that the aim of the present study is to take a closer look at her theory of early use of plant fibres to manufacture a variety of textiles.

This introduction to the study contains a short presentation of the background to my own interest in the chosen topic; theory construction and ancient textile technologies, starting with some data on textiles in archaeology; three perspectives for understanding textile materiality, and the theory of string making which motivated the study. In the final section of this chapter, the aim and the research questions for the study are presented. To support the readers understanding of plant fibre terminology in archaeological context, a more detailed description of the technologies is provided in Appendix 2.

## 1.1. Background

An interest for *ancient textile technologies* mirrors the author's interest in four areas: ancient textiles per se, textile technologies, learning aspects of textile manufacture and a growing need to understand the theoretical framework in archaeological sciences. In the early 1990s, I encountered the linguist and archaeologist Elizabeth Barber's book on *Prehistoric Textiles* (Barber, 1991), and since then I have wished to know more about the prehistoric development of textile technologies, as well as their impact on the prehistoric societies – cognitive, economic and social – that is, the role of their agency in history. My focus in this study is the presence of a textile technology in hunter-gatherer groups/cultures in Palaeolithic and Mesolithic Ages.

### Ancient textile technologies

Focus for Stone Age archaeologists are flint knapping technologies and the outcome of these activities. It has been considered so important in the development and lives of prehistoric humans that this activity even gave name to the very long period from 0.8 million years ago (Acheuléen) to around ca. 3,000 BC (Neolithic) – the Stone Age. Little of their technological skills remain today, it did not survive the introduction of metals like bronze and iron.

So what about textile technologies, that is the use and technologies for organic fibres (animal or plant)? Well, there are researchers in archaeology, as for example Robert Bednarik (1995, 2006), that claim that artefacts and technologies for textile making like ropes, strings for necklaces and small prey hunting nets, are as old as humankind, that is at least 1.8 million years. Looking around in our contemporary societies, we still see many of these ancient textile technologies. People still make rope in almost the same way (twisting bast with the same kind of material from trees), and e.g. a popular activity among children is finger knitting their own scarfs, quite unaware of the very long history of this technology. Textile manufacturing runs like a red string through history. This is an intriguing fact, since so little attention is paid in archaeological records which mainly deal with stone and metal artefacts. In my view, textiles and their fabrication must have been as important, or even more

important, in prehistoric societies due to the need of cloth and items for carrying and hunting as well as a time consuming technology in their daily activities.

### **Learning to manufacture textiles – revolutionary jumps or slow progression over time?**

So how did humans learn to use fibres and how was this technology developed? In modern times we can see that e.g. the invention of Spinning Jenny in the middle of the 1800s was a revolutionary (industrial) step to produce thread for cloth making at a speed that previously only could be dreamt of – and that was at a time when the spinning wheel was considered to be quick. Before the machine era, thread was manually fabricated, firstly by the development of the spindle and even before that without any tools, just the fingers. Some textile historians like Barber (1994) consider the development of string technology as revolutionary, introduced by modern man about forty thousand years ago (Barber, 1994:42); others claim a long and slow progression for about at least 800,000 years (Warner & Bednarik, 1996). However, in cultures where hand spinning still plays an important role, women tend to do it all the time, even while occupied with other activities, so Spinning Jenny has obviously not killed the old string making technology (yet).

### **Textile theories in archaeology**

So the role of textiles in humankind, and the learning and development of manufacturing technologies, calls for some kind of theory of textile making in archaeology. But can archaeology provide such a theory as solid as for the stone technologies? Must we wait until we have more Stone Age textile artefacts (quite unlikely due to their perishable nature), or is it possible to build a theory on a combination of pieces of evidence with different strength? The British archaeologist Karen Hardy, in her article *Prehistoric string theory. How twisted fibres helped to shape the world* (Hardy, 2008), has made an attempt to do this through the postulation of a prehistoric String Theory. Can this theory be accepted as an adequate theory of textile technologies in the Stone Age, or should we replace the theory due to too weak evidence?

## **1.2. Approaching the materiality of Palaeolithic**

To study the use and development of textile technologies in times when we have almost no artefacts or clues about the manufacturing techniques, might be considered as an impossible project. However, it is logical to think that in these – in time but not in geography – remote societies of hunter-gatherers, they had the same need as we have for clothes and utensils for carrying and fishing. So humans interacted with the things around them, as well as improved their social and technological skills to manufacture old and new things. This interaction between human and things is called materiality. The technological aspect of materiality can be studied in different ways. We can discern between three main approaches in archaeology today:

- a) A consumer-oriented approach: evolutionary/ behavioural archaeology  
 In this approach the scientist, often finding analogies in ethnographic studies, focuses on how people might have used, repaired and deposited the artefacts as they are found by the archaeologist. In the development of this method attention is also paid to the physical behaviour like learning the motor skills of manufacturing (Schiffer, 2011:338)
- b) A product-oriented approach: a chaîne-opératoire  
 In this method the focus is on the choice made during manufacturing, and analogies are often taken from experimental archaeology (Knappett, 2012:197). Evidence for ancient technologies is often found in detailed (even microscopic) studies of the found artefact and an effort to reconstruct the production method, e.g. the study of textile fragments (Andersson Strand, 2013).
- c) A thing-oriented approach: agency  
 In this approach, the focus is on the central role of things in societies, e.g. Hodder's "entanglement of things" (Hodder, 2011). Attention is then paid to the cultural biography of things and their technology, following the persistency of a technology or a thing through history, like for example the string shirt in "ritual" use for about 30,000 years (Barber, 2010). Olsen (2012:216) describes this fundamental insight, with reference to Bruno Latour, that the past is still all around us as the archaeology of memory: "*The realization of this potential requires that things themselves must be emancipated from their synchronous imprisonment, monotemporal imperative based on the seductive idea that what is rendered contemporary by the calendar necessarily belongs to the same time*" (Olsen, 2012:217).

### 1.3. The Prehistoric String Theory by Karen Hardy (2008)

As mentioned earlier, the long history of fibre string technologies and its role in the prehistoric societies is puzzling. Karen Hardy suggests a theory for the phenomena in her article titled *Prehistoric string theory. How twisted fibres helped to shape the world* (Hardy, 2008). Although not explicitly stated in the article we can safely formulate the theory in the following way:

**Twisting plant fibres into strings in the early Stone Age had a significant impact on human lives through the development of a fibre based technology for textile manufactures.**

The theory is based on empirical evidences from reported archaeological excavations, in analogy with ethnographic observations. Both strands contribute to the theory of the development of string making in Stone Age cultures (hunter-gatherer societies). The stated aim of her study is: "...to review the evidence for the early use of plant fibres in string-making. In addition, some of the functional, social and economic implications of string manufacture are explored with the help of ethnographic evidence." (Hardy, 2008:272).

In the introductory part of the article Hardy refers to others that have described early string behaviour and records (Warner & Bednarik, 1996). Her first argument for the role of string

making technologies is taken from ethnographic studies of the Dani culture on New Guinea through a direct long citation from Heider's descriptions (Hardy, 2008:273). It is to be understood that evidence based on ethnography has a heavy load in her argumentation for the string theory, a theoretical approach that Hodder (2012) classifies as an evolutionary perspective in archaeology. She then turns to references within the archaeological field for arguments that early string technology can be traced back in time at least 40,000 years ago and even longer, with a theoretical perspective that Hodder (2012) might classify as a human biological ecologic perspective, thus putting string making at the very centre of human activities. These two scientific approaches are the corner stones for the argumentation for a prehistoric string theory.

A theoretical assumption for her study, as described in the introduction to the article, is taken from Warner & Bednarik's contribution (1996) about Pleistocene knotting in the book of *History and Science of Knots* (Turner & van de Griend, 1996). But she also mentions among others Good's review of current research in archaeological textile (Good, 2001). Several pieces of evidence described in Good's review are directly used by Hardy, sometimes to an extent that they can be considered to be an update of Good's review (e.g. textile impressions in clay).

Another theoretical assumption is taken from Barber's book *Women's work: the first 20,000 years. Women, cloth and societies in early times* (Barber, 1994). Barber is the first to propose the concept *A String Revolution* (Barber, 1994:42-70). With this concept Barber implies a relative quick change into a fibre-based technology in accordance with the idea that it happened when *Homo sapiens* entered (or was discovered) in Europe around 40,000 BC.

*"As near as we can place it, the event<sup>1</sup> occurred twenty to thirty thousand years ago, right in the middle of the Upper Palaeolithic. While others were painting caves or knapping fancy flints, some genius hit upon the principle of twisting handfuls of little weak fibers together into long strong threads."* (Barber, 1994:43)

However, Karen Hardy also makes several references to the Australian archaeologist Robert Bednarik (Hardy, 2008:272), who like other cognitive evolutionists does not impose a quick but rather a gradual technological development, which with all probability started long before "modern" man, and not primarily in Europe but likely in Africa and Eurasia.

#### **1.4. Aim, problem and research questions**

The aim of the study is to take a closer look at the substance for a prehistoric String Theory as postulated by the British archaeologist Karen Hardy (2008).

The problem with the String Theory is that it is only mentioned in the title for the article (Hardy, 2008:271). Is it then just a provocative title, or is there a deeper meaning to the title? However, if we take her String Theory seriously, we have to understand her methodology. So

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<sup>1</sup> Barber (1994) is referring to the archaeological view that some forty thousand years ago humans (creative hunter-gatherers) began to act differently by producing novel tools such as awls, pins as well as cave art.

another problem is then how she scientifically arrives to the Theory. Is it a result of her investigated archaeological and ethnographic empirical evidence? Or has she already formulated a String Theory based on her references to Heider's ethnographic observations, Goods' list of evidences for early textile manufacture, Barber's concept of a string revolution and Warner & Bednarik's claim of an early use of strings (Hardy, 2008:271). Is her study then to be interpreted as undertaken to find further evidence for her theoretical claim? In the first case the theory proposal is constructed with an inductive approach. In the alternative case she starts with a formulated theory and finds further evidence to accept or reject the theory, a deductive approach. Neither case is explicit in the article. In an effort to understand the role of a String Theory for the prehistoric hunter-gatherer cultures, three research questions (RQ) for the present study were formulated:

- RQ 1. How is it possible to validate a prehistoric String Theory?
- RQ 2. What constitutes the textile materiality of the Stone Age?
- RQ 3. Do we have evidence for a theory of a Palaeolithic technological mind for string manufacture?

## 2. Method and material

The methodological and theoretical considerations concern the appropriate methods for evaluating the evidences underpinning a prehistoric String Theory.

### 2.1. Method: Reflecting on theory construction in archaeology

It is difficult to understand whether the String Theory is constituted through Hardy's study – or was it beforehand silently formulated by others, such as Barber's *String Revolution* (1994) or Warner & Bednarik's (1996) assumptions of a very early string technology? Although the evaluation of Hardy's pieces of evidence as they appear in her article (Hardy, 2008) is in focus for the present study, an evaluation of earlier – and later – contributions to the theory also needs to be undertaken. Thus, the source material will be twofold: Hardy's evidences and new and updated evidence gathered by the author.

Most studies and reports in archaeology are formulated within a hermeneutic research approach that is more words than statistics. The chosen scientific approach for the present study can very well be formulated by a quote from Ian Hodder's recent book on archaeological theory today: "*Archaeological theory is always 'of something'. Theory is, like digging, a 'doing'. It is a practice or praxis*" (Hodder, 1992)" (Hodder, 2012:5). The aim of this study is to do a little digging into the evidence for a theory of a fibre string manufacture in the early Stone Age.

### Evaluating evidence for a theory

According to Schiffer (1988) a theory is constituted by empirically grounded relations between variables that can explain our cultural past. Thus it must be possible to prove the value of the theory within the limits of practice set by existing knowledge. And the method "to prove" the theory will be to gather and validate evidences relevant for the application of

the theory to new phenomena. However, the evaluation of the relevance and validity of the evidence for a theory calls for a standardized method. In the two approaches: logic validation (statistics) versus logic argumentation (language), both validity and relevance of the evidence are at the fore. The validity can be evaluated by the strength of the argument (deductive-logical reasoning) or by its statistical significance.

In the present study, the author has constructed a modified version of a methodology for the evaluation of clinical practice in medical sciences (GRADE, 2013). The credibility of the evidence (only measured in relation to the proposed String Theory) will be evaluated according to a scale of four levels:

- High quality of the studies underpinning the evidence
- Average quality of the studies underpinning the evidence
- Limited quality of the studies underpinning the evidence
- Insufficient quality of the studies underpinning the evidence

Quality in this context is measured with following parameters: relevance of the study, design of the study, publication of the study, and others referring to the study.

## **2.2. Material: Literature reviews**

As source material for the study, only published literature has been used. The primary analysis was performed on Hardy's claimed evidence in the article from 2008, and the second analysis was done through a systematic review of articles in well-known scientific archaeological and anthropological journals.

### **Primary analysis: Evidence for Hardy's String theory**

In the first analysis of the evidence in Hardy's article (2008) all irrelevant references for her main issue have been eliminated. The remaining references – reflecting the main body of evidence – constitute this study's primary object for analysis. The constitution of the nine pieces of evidence as they are presented in the text below and in figure 1 in Appendix 1a is made by the author. For each of the nine evidences at least one of the references (see Appendix 1b) has been analysed and compared with the arguments postulated by Hardy (2008).

### **Second analysis: Other evidence**

Since Hardy's article was published five years ago in a well-known British archaeological journal (*Antiquity*), you would expect to find followers in the same journal either accepting or rejecting her theory. However as far as can be found until 2013, none have said anything about the theory, although many more archaeologists have published data that mostly support her theory. Other relevant journals e.g. *Journal of Archaeological Method and Theory*; *Archaeology*, *Ethnology & Anthropology of Eurasia*; *American Antiquity*; *Science*; *L'anthropologie* have also been investigated by the author to find any references to a String Theory or arguments that might support or reject a prehistoric String Theory.

### 2.3. Critical aspects of source selection and evaluation

There are several ways to do literature studies in archaeology. One aspect to take into consideration is that the written reports only give a second-hand interpretation of the actual prehistoric textile or the ethnographically reported fibre string technology as they are claimed to constitute the basis for a theory. Another critical aspect is the selection of representative evidence for a theory of such a perishable material as fibre-based artefacts. The problem of "invisible" evidence in archaeology is not easy to overcome, so deductive logic plays an important part in the reasoning and epistemology of this study. To justify claims is a little bit to "play with the theory", but hopefully in a reflective and open way, thus taking nothing for granted<sup>2</sup>. The source selection, due to language constraints is perhaps too narrow, especially since interesting literature for the theory is published in Russia and China.

## 3. Analysis of the evidence for a prehistoric string theory

For the justification of a postulated string theory, Karen Hardy (2008) uses indirect and direct archaeological evidence and compare the use and manufacture with ethnographic evidence, as illustrated in figure 1 (Appendix 1a). In the first part of the analysis we will evaluate the archaeological evidence both as it is referred to and used in Hardy's article (2008: 272-274), and as it may appear after a systematic review for new evidence (by the author). In the second part of the analysis we will evaluate ethnographic evidence as it is referred to by Hardy (2008: 274-277), and compare the arguments with experiences from experimental archaeology as well as from modern cultural approaches to fibre plant technologies. For the nine presented pieces of evidence in the analysis, first arguments are given with reference to Hardy's article, and then some other arguments are presented, fetched from the survey by the author. Finally, a conclusion regarding the validity and relevance for the string theory is given at the end of each so analysed evidence.

### 3.1. Analysis of archaeological evidence

The claimed "*Early evidence for string*" (Hardy, 2008:272) can be analysed as five different clusters of evidence: early string technologies, textile impressions in clay, direct textile fragments, secondary artefacts like perforated beads, and fishing, gathering and weaving tools. In Hardy's article the presentation of the evidence follows more or less a chronological order in the sense that the oldest evidence (knotting and twisting) is placed first in the article (from Upper Palaeolithic) as well as in the analysis here. See also Appendix 1a.

#### Evidence 1. Stringing and knotting techniques are very early in humankind

*"Warner and Bednarik's (1996) claim that the development of knotting began somewhere between 2.5 million and 250,000 years ago though manufactured string is not essential for knotting to take place"* (Hardy, 2008:272).

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<sup>2</sup> *Taken-for-granted* is a central concept in hermeneutic research, meaning that you should be aware of your own previous assumptions and epistemology.

*Argument for the evidence:* The argument for this claim is not elaborated in Hardy's article except as an introductory remark on perforated beads – see evidence 4. Warner & Bednarik (1996:3) assume that there ought to be such activities as stringing and knotting due to the demand for ropes and nets in the hunter-gatherer societies. Karen Hardy (2008:272) observes, with reference to Ingold (2000), that knotting and stringing techniques are not mutually dependent. You can knot fibres without twisting them and you can twist strings without knotting them. So the two techniques can have evolved independently both in time and in geography.

*Other arguments:* That the knotting technique as well as its development is very old according to Warner & Bednarik (1996) is supported by other authors in the same book (Turner & van der Griend, 1996). Turner (1996) claims that there is valid evidence for a scientific theory of knots (at least in mathematics) and through a typologization of the variety of knots it should be possible to say something about the evolution of this technology. According to Turner (1996:269) we can make a classification into three basic types of knots: a hitch (to secure a rope to an object), a bend (to join two ropes together in line), and a knot (to interweave to form a knob or stopper in a rope). In the same book, Warner (1996) speculates on how the initial knotting invention came about:

*"Tropical forests have many plants that wrap around other plants, sometimes strangling them, or pulling them over, and sometimes forming Overhand Knots or Half Hitches in the process. Spider webs can be large and thick, able to net and trap large insects. Some nesting birds and rodents can shred the fibres in palms and bark to weave into nests"* (Warner, 1996:20).

Van der Kleij (1996), a Danish archaeologist, discusses under which conditions we can expect to find traces of these perishable artefacts. He exemplifies his discussion of finding textiles with and without knots by using findings from ten Danish bogs. Three of them contained artefacts with knots from late Mesolithic and early Neolithic ages. The Tybrind Vig, a submerged settlement on west Fyn contained one of the oldest known textile finds in Europe (in needle-binding technique, see evidence 3). But they also found a fishhook that had a 5 mm long line tied in the front with a hitch. In the Sigersdal Mose, on North Zealand, a double-twined rope was found with remains of a knot. And finally from another Mesolithic submerged site, Skjoldnæs, *"the lower part of a leister, almost intact, with substantial pieces of lashing still in place. The lashing was probably made of nettle, and was tightly wound around the leister and fastened by a row of half-hitches"* (Van der Kleij, 1996:36).

*Quality of the evidence:* It is very plausible that the technique of knotting, together with the rope-technologies, is very old, since carrying things must have been quite essential in a hunter-gatherer community and rope must have been high in demand. If they were made of sinew or fibres can be discussed, but they were probably twisted and even plied to make the rope stronger. The careful descriptions of the development of knotting techniques in the book of knots (Turner & van der Griend, 1996), with so many other archaeologist's views and arguments for the technique, makes the evidence quite strong.

## Evidence 2. Textile imprints and impressions in clay

*"Further indirect evidence for the use of twisted fibres dating to around 27,000 BP comes in the form of imprints of complex items of woven material"* (Hardy, 2008:273).

*Arguments for the evidence:* For this evidence Hardy only gives a very short list of references primarily to studies on the Gravettian culture in Moravia (Czech Republic) by Soffer et al. (2000) and Adovasio et al. (1996). The reader needs to study the referred material in order to find out how the Moravian material is relevant for the postulated string theory.

In the evidence, Hardy (2008: 273) also claims plant fibre use, through cord-marked imprints in pottery from East Asia (Kuzmin, 2006) and from Khartoum (Khabir, 1987). However, none of those references are of any significance for her theory. Kuzmin's aim is to discuss the dating of the oldest pottery in East Asia and mentions only once "cord marks" with reference to another researcher (2006:368), and Khabir has a single mention of "twine impressions" (1987: 378) as an example of decoration on pottery from around 9,500 BP.

*Other arguments:* Two of the most interesting arguments for a prehistoric string theory (dated back to around 27,000 BP) can be found in the referenced article by Soffer, Adovasio & Hyland (2000). In their study of textile impression in clay from Moravia and other parts in Europe, they report on both actual textile imprints in burnt clay, and represented textile impressed in the dressed "Venus" figurines.

The first relevant and valid argument concerns 36 distinct textile imprints found on small fragments of fired and unfired clay, some of them described in detail in Advasio et al. (1996). The textile imprints were clearly made of twisted plant fibres, representing twined<sup>3</sup> basketry, braided cordage, knotted netting, plain woven and twilled textiles (Soffer et al. 2000: 512-513), see also Appendix 2.

For the second argument (dressed Venus figurines) Soffer and the research group agree:

*"We use the iconographic evidence for woven clothing often found on European 'Venus' figurines to argue that these technologies were employed by Upper Palaeolithic women, that they varied across Europe, and that they were sufficiently valued to be immortalized in fired clay, ivory and stone"* (Soffer et al., 2000).

By comparing the figurines from the Czech Republic with contemporary and similarly dressed figurines from Austria, France and Russia, the research team (Soffer et al., 2000) is able to give a good picture of the kind of stringed articles that were at hand. Re-examining a number of dressed figurines from the Gravettian period in museums, they could visually identify three different types of dress details: headgears, various body bandeaux, and at least one type of skirt. They could also discern a variety in the "dressing" related to their geographic site (West, Central, or East Europe). Very few of the figurines found so far are male, and none of them are dressed. And there was also a standardisation in this clay

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<sup>3</sup> Basketry can be made by twining, coiling or plaiting fibre strings. Twining is considered to be the oldest type of basketry making (Adovasio et al, 1996).

production, mainly the making of portable figurines of females and animals. In the conclusion of their careful empirical investigation of the dressed figurines they make a point of stressing that we should not see the depicted dresses on the almost nude perhaps fertile women as everyday clothes (Soffer et al., 2000:524). The French archaeologist Bougard (2011) has recently studied 316 figurines from Moravia, and she discovered that only 22 were complete figurines (she found 190 fragmentized figurines with traces of being purposefully burnt in fire). The number of animal figurines outnumbers human figurines.

In the detailed examination process, Soffer et al. (2000:520) could also visually determine that in one case (Venus from Lespugue) the fibre impression was depicting plant fibres. Barber (1991:40; 1994:44-45) has also investigated in detail the stringed skirt of the Venus from Lespugue. These examples of a Upper Palaeolithic advanced plant based textile cultures, including twisting fibres and woven textile referred by Soffer et al (2000), have been discussed by other archaeologists, and some of their comments have been published in connection with the article and with a reply from the research group (in: *Current Anthropology*, 2000 (41), 3:525-535). It is in particular their arguments about the depicted weaving techniques that have been questioned by others. There is a debate around the interpretation of the impressed skirt of Venus from Lespugues; some claiming that it is a woman's plaited hair (so that the legs are interpreted as a stylized head). There is also a controversy on the interpretation of the strange head gear of the Venus from Willendorf. It looks like a hat made by plaited bast fibres, or shells tightly strung in rows or even a plaited hair.

*Quality of the evidence:* The quality of the comparative study by Soffer et al. (2000) on textile impressions around the Gravettian period in Western, Central and Eastern Europe is of highest quality both in relevance and validity for the String Theory. The group of archaeologists from different countries have re-examined the artefactual evidence for textile technologies in Europe around 27,000 years ago. The publication of the study in a scientific journal together with the added section with comments on their article by other well-informed archaeologists is excellent. Hardy's added arguments on the cord-marked pottery are misleading in their substance and hence are of limited value for the theory.

### **Evidence 3. Direct textile findings from the Palaeolithic and Mesolithic periods**

*"Thousands of fragments of twisted bast fibre rope and string and many fragments of nets were found which date to the early part of the tenth millennium BP (Gramsch, 1992)"* (Hardy, 2008:273).

*Arguments for the evidence:* Very few textile artefacts can be found in Palaeolithic contexts due to their perishable nature, yet under very special conditions like dry caves, cold regions and waterlogged sites, some tiny fragments have been found and they are reported as strong arguments for a String Theory. The three oldest textile fragments are charred twisted fibres ca. 2-3 mm long, which were found when the archaeologists were sorting charcoal material from the excavation of Ohala II in Israel. The site where they found these fragments had been under water since it was deposited there, but was exposed in 1989 due to a drastic drop of the water level of the Sea of Galilee (Nadel et al. 1994). They had problems in identifying the

material in the fragments but they could see that it contained vascular bundles probably from a stem or leaf of a plant. They could also determine that it was not a natural twisted plant bundle but probably a manmade cord. This fragment of a cord has been radiocarbon dated to 19,000 BP.

Another, somewhat later rope (17,000 BP) comes from an also accidental finding in the Lascaux cave. The Lascaux rope is considered to be one of the oldest textile finds from Europe and was found while an abbot was copying the famous rock paintings in the cave. However, the rope fragments were taken care of, and later laboratory analysis could not reveal the exact vegetable raw material but well the twisting and plying techniques, as described by Barber in the following way: *“The plied cords, moreover, had each been formed by twisting their component strands in the other direction from that in which they originally been spun. Such opposite twisting keeps the cord from coming apart once finished... an important principle that craftworkers had discovered even at this early date”* (Barber, 1994:52-53).

Hardy also refers to several plant textile findings from the Mesolithic/early Neolithic period (9,000-3,000 BC) in burials, caves and waterlogged sites like the Danish bogs. The references include findings from central, northern and eastern Europe, as a proof of the spread of this textile technologies in Mesolithic times.

*Other arguments:* Previously, findings from excavations in Russia rarely reach a non-Russian-speaking audience, but now more and more publications are in English from these exciting findings. One of these is a recently published article by Kuzmin et al. (2012), with a report of the earliest surviving textile in East Asia radiocarbon dated to around 8,000 BP (European Mesolithic time). In the Chertovy Vorota Cave, they found three different kinds of textiles: ropes and plaits; nets and woven textiles. The textiles were all made of untwisted or hand-twisted blades of sedge grass (Kuzmin et al. 2012:328). The woven textiles were weft-faced plain weave of three types. No traces of spinning or weaving tools were found in the cave.

There are also reports from Catal Hüyük (Burnham, 1965 and Mellars, 1965:85) of an advanced textile technology, but the analysed fibre material seems to be of wool. Is this evidence of a very early animal fibre technology? We know, for example, that camelid/wool has been used in Central Asia for thousands of years, but it would be interesting to see if the Catal Hüyük textiles are in line with this tradition – or perhaps wrongly analysed, so maybe plant fibres were the textile material also in Catal Hüyük at that time.

*Quality of the evidence:* The arguments for this evidence are based on the few fragments of actual textile findings from the Palaeolithic, and some more from Mesolithic periods. It is a reminder of the perishable nature of organically based artefacts in archaeology. However, these direct pieces of evidence are of highest relevance and validity for the prehistoric String Theory.

#### **Evidence 4. Secondary artefacts: Perforated beads and pendants imply a string**

*"Pendants and beads must be tied or sewn somehow and the earliest indirect evidence for string may lie here"* (Hardy, 2008:272).

*Arguments for the evidence:* The arguments for this evidence are backed up by several references, especially by Robert Bednarik's many studies on beads and their symbolic significance for the early cognitive development of humans. Human agency in bead manufacture can be dated back in Europe ca. 300,000 years in findings in Austria (Bednarik, 1995). These early findings in Europe are compared to perforated beads from other parts of the world, e.g. ca. 100,000 to 135,000 y. in western Asia (Israel) and northern Africa (Algeria) (Vanhaeren et al. 2004); ca. 75,000 y. in southern Africa (Henshilwood et al. 2004); ca. 40,000 y. in Eurasia and east Africa (Hardy 2008, Ambrose, 1998, Bednarik 1995), and ca. 34,000 to 28,500 y. in India and Sri Lanka (Mellars 2006, James & Petraglia 2005). All these examples support the claim that manufactured beads have been around us (where humans can be traced) for at least 300,000 years, thus implying that the string has at least the same age. We can summarize the arguments in four distinct parts: 1) pendants and beads presuppose a string of some sort; 2) strings are at least 300,000 years old; 3) string technology is not a *H. sapiens sapiens* invention but much older; 4) pendants and beads have a symbolic value through their function as adornments.

*Other arguments:* Three different examples will be given from the vast literature on these issues: the origin of beads and pendants; examining drilling techniques and fibre rests in the bead hole; taphonomic aspects of stringed beads in Mesolithic graves.

##### a) The origin of beads and pendants

The oldest perforated shell bead (75,000 y.) is from the excavations in the Blomsbo cave reported i.a. in Holden (2004). However, according to Warner & Bednarik (1996) the oldest evidence for a perforated pendant (a wolf incisor) is from Europe, Austria and ca. 300,000 y. old. Vanhaeren et al. (2006:1785) argue for a shell bead trading or gift giving behaviour some 100 to 135 thousand years ago. The same pattern of deliberate relocation of valuable beads can be found from excavations in Mid-Europe (Adovasio et al., 1996).

In Conneller's book *"An archaeology of Materials. Substantial transformation in Early prehistoric Europe"* (2011) the material of beads plays an important role in the introduction of new materials in Europe forty thousand years ago:

*"the gradual adoption of a broader range of lustrous materials for the manufacture of beads can be seen more clearly in sites belonging to a second early radiation (people with an archaic or proto-Aurignacian' tool assemblage), which seems to have gradually moved along the coast of southern Europe, from east to west, between around 40,000 and 35,000 years ago."* (Conneller, 2011:110).

Coming away from the coastal areas a need for other lustrous material for beads lead to what Conneller calls a material revolution. The solution to this new need was solved, again according to Conneller, in three ways: by establishing an exchange relationship with coastal people; by exploiting fossil shells and by replicating the attractive sea shells by other lustrous material like animal teeth. And the archaeological findings of perforated animal teeth in Europe are abundant from this period and onward. The implication for the String Theory is, then, that the use of perforated teeth for necklaces etc. indicates stringing, sewing and knotting techniques from this early period.

b) Drilling/grinding techniques and fibre remains: examination of the hole in the bead

In an unpublished paper from 2000, Robert Bednarik argues that at the latest 300 to 200 thousand years ago, humans had the skills to make and string beads and his description of how this might have been done is also telling us much about the presumed cognitive level of these humans. Bednarik (2000) means that the combination of a purely technological aspect of drilling through an object (here to construct a bead) to a mental aspect of threading a string through the hole, fastened its ends, probably by a knot to achieve a non-utilitarian end product such as an adornment can be described as not only diverse artefacts but as an hierarchy of diverse concepts relating them to each other. Ambrose (1998:388), with a reference to his own study of worked ostrich eggshells from Africa, with a radiocarbon date to ca 40,000 y., also confirms the notion of a contemporary bead manufacture in Africa: *"These beads may mark the dawn of an era of new artefact manufacturing techniques (drilling and grinding) and of personal adornment, but may also mark a far more significant innovation in modern human behaviour."*

The view of a very old technique for drilling and grinding beads and to use them as adornment (symbolic behaviour) in Africa and elsewhere, was contested by many archaeologists at the time of Bednarik's publication of this theory (Bednarik, 1995). By reference to the "material reality" White, among others, (Bednarik, 1995:623) strongly disagrees in a comment to Bednarik's view of a pre-Palaeolithic symbolic behaviour expressed through the use of beads in Africa and Eurasia. And of course Bednarik has a very good answer to this disagreement of the transition between Middle and Upper Palaeolithic arguing that White has a narrow perspective of hominid history- an European view versus the rest of the world. (Bednarik, 1995:628). A summary of this debate is offered by Conneller, 2011:110: *"Some of the new materials and technologies, such as perforated shell beads and simple bone tools<sup>4</sup>, had previously been made by at least some early H. sapiens groups living in Africa and the near East"*.

Returning to the issue of what can be found of materiality inside the perforated bead; it calls for a much more careful archaeological excavation technique, well expressed by Irene Good in her article (2001), which also is referred by Hardy (2008). She found traces of thread or other binding materials (like mixed fibres of bast and silk) still present in some of the holes of the beads (Good, 2001:214).

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<sup>4</sup> Perhaps like the needle (author's remark).

### c) Burials with indications of stringed beads in Mesolithic graves

The Danish archaeologists Albrethsen and Brinch Peterson (1976), also referenced by Hardy, report of a richly adorned woman from an undisturbed Mesolithic grave (Maglemosen, Bøgebakken, grave 8):

*“To her right and partly below the skull was a big heap of pendants – 190 altogether – most of them made of red deer teeth and some front teeth from wild pig. .... Considering the position of the rest of the grave goods it is natural to regard these ornaments as the remains of a dress folded as a pillow for the deceased to rest her head on.”* (Albrethsen & Brinch Peterson, 1976:3).

There are several similar findings from the Mesolithic cultures in Southern Scandinavia (Maglemose, Kongemose and Ertebølle), dated around 5,000 BC, indicating that the use of perforated beads and pendants, stringed and sewn to cloths as adornments, were a common characteristics of the Mesolithic period.

*Quality of the evidence:* The archaeological evidence for the presence of perforated pendants and beads in prehistoric contexts provide us with a strong argument for the existence of an early string technology. However, it does not inform us whether plant fibres or animal sinews were used from the onset, or about the techniques for twisting the fibres. The relevance of this evidence for the theory is high, but for the validity of the string technology more research on fibre remains in beads and pendants would be necessary.

### **Evidence 5. Secondary artefacts: Tools for fishing, gathering and weaving**

*...”there is a range of secondary evidence from Mesolithic sites in the form of nets, net sinkers, traps, harpoons, needles, or bodkins and perforated shell beads”... (Hardy, 2008:273)*

*Arguments for the evidence:* Hardy’s primary argument for the presence of a string technology in the Palaeolithic and Mesolithic is the need of tools like nets and basketry in the fishing and gathering cultures. Her arguments are based on Mesolithic excavations and interpretation of the findings there. Among others, she refers to the Danish archaeologist Grøn, but he says nothing of any fibre technology in the referenced article (Grøn, 1998). As elsewhere in her article, the reference is obviously only made to strengthen the evidence for a gathering culture during Mesolithic and early Neolithic. However, the reference to Soffer (2004) is relevant as an argument for her evidence and it could have been much more explored than just as an enumeration of references. Soffer et al. (2000) discuss the Upper Palaeolithic findings of small needles and the possible use of these, not for sewing hides but for softer textiles. The reference to Kent & Nelson (1976) seems only to be a remark on the difficulties in interpreting tools for textile technologies in an archaeological context. Their one page (!) article discusses whether previously interpreted fishnet weights might be interpreted in a weaving context as warp weights. The value of this argument lies in the fact that many

objects previously interpreted as hunting and food related items, might be reinterpreted as objects used for the manufacture of (now perished) textile items.<sup>5</sup>

*Other arguments:* There are so many other arguments for this evidence; here we will, however, concentrate on one argument, not mentioned in Hardy, namely marks on bones indicating their use for primitive weaving activities.

Two related studies, analysing prehistoric marks on bones, can be used as valid arguments for a Palaeolithic weaving culture, Soffer (2004) and Stone (2009). In both studies analogies to ethnographic data in museums is reported. The methodology in Soffer's pilot study is to compare, after detailed observation of wear of cordage and weaving in prehistoric antlers and rib bones, similarities in wear marks in tools used for production of cordage and textiles in ethnographic records (from hunter-gatherers in both the New and Old worlds). She finds many evidence of wear that can be interpreted as wear by cordage and textile weaving and as a result "*calls for a re-examination of bone and ivory inventories to identify such implements across Europe*" (Soffer, 2004:412).

In Stone's study from 2009 (much inspired by Soffer's research), she observed in detail wears on bones from the Magdalenian culture as part of her ongoing PhD research on prehistoric textile industries. The aim of her dissertation is to identify the technology of manufacturing objects from plant derived material (Stone, 2009). The implication of her study is that a new understanding "*of the role of osseous technology in the preparation of perishable artifacts will contribute to a broader understanding of the entire suite of technologies and activities employed by Ice Age occupants of Western Europe*" (Stone 2009:230). This understanding might be extended to Central, Eastern and Northern Europe as well.

*Quality of the evidence:* The evidence calls for some re-examination and re-interpretation of previously classified archaeological items. It is very possible that an early advanced textile manufacture may have been the corner-stone of Upper Palaeolithic cultures in Europe, thus changing our perspective of their societies. The arguments of the need of fibre based items for fishing and gathering are highly relevant and plausible, although Hardy is not in her article making good use of these argumentations. There are plenty of direct findings from Mesolithic excavations around the world that could prove the argument. The quality of this evidence is high, but not enough explored by Hardy in her article.

### **3.2. Analysis of evidence from ethnographic studies**

Karen Hardy uses evidence from ethnographic studies to further elaborate the string theory by investigating "*...some of the functional, social and economic implications of string manufacture*" (Hardy, 2008:272). She is referring to studies – such as Heider, 1970; Sillitoe, 1988 and Hardy & Sillitoe, 2007 (see Appendix 1b) – of ethnic cultures primarily from the highlands of New Guinea (Dani and Wola ethnic groups) and Papua New Guinea (Telefol). The three ethnic groups are characterized by having a complex material culture based on

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<sup>5</sup> According to Stone, (2009:286) "*many of the UP (Upper Palaeolithic; my note) osseous artifacts interpreted as hunting implements were actually used in the production of textiles*".

stone and fibre technologies. Evidence for fibre technologies in other ethnic groups such as the Tlinigit from Alaska (Emmons, 1991) or Kogi from Colombia (Minar, 2001) appear in her argumentation as supporting arguments. In the analysis, formal and relational analogies<sup>6</sup> are grouped under four distinct headings: existence of string technologies; the role of plant fibres; learning to manufacture strings, and the social context for string manufacture. An overview of presented evidences and references can be seen in figure 1, Appendix 1a.

### **Evidence 6. Existence of different string technologies**

*“String is likely to have been as central to Palaeolithic and Mesolithic life as it is today, and it is probable that the use of string then may have been as significant as it was to the Dani.”* (Hardy, 2008:271).

*Arguments for the evidence:* The analogy (relational) is based on first and secondary hand observations of fibre technologies in the Dani, Wola and Telefol ethnic groups. She argues that *“The fabric of Dani culture is fibre, plain and rolled into string”* (Hardy 2008:271), by numbering some important artefacts of manufactured fibres like skirts and carrying nets (bilums<sup>7</sup>). Another argument is that the range of contexts around the world where textile items have been found, *“suggests the use of twisted fibres to make clothes, nets and ropes”* (Hardy, 2008:277). Yet another argument is that in many cultures (both contemporary and prehistoric) ropes are essential for survival, like lashing a canoe or climbing cliffs for bird nests. She also argues that we have records from prehistory and from ethnographic studies to compare with the long traditions of old textile technologies in e.g. central Asia, or Northern Scandinavia (e.g. nålebinding<sup>8</sup>).

*Other arguments:* The culture of New Guinea as well as other contemporary so called Stone Age cultures have been “discovered” during the last 100 years by many people, both scientists and plain adventurous explorers. Several Swedish explorers travelled to New Guinea and they have written so called travel diaries of their experiences. During the 1950s many of them also gave popular lectures to enlighten ordinary people about what they sometimes called “the happy island” and its from us different population. Most of this narratives are anecdotal, but interesting, in the sense that the observations they made have a naive approach to the observed “Stone Age” culture’s daily life. Since their view is only filtered through a conception of “primitive” and not through a modern research question, as in the case of Hardy’s and Sillitoe’s reported observations (2003), we can find valuable “naive” information about those cultures. Here is an example from the Swedish back-pack traveller John-Erik Elmberg. His voyages brought him to the highlands of New Guinea in the early 1950s. There he encountered the Nimboran people and made the observation that they could not manufacture stone axes but had to make trading travels to Ormu on the Cyclop Island to

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<sup>6</sup> The meaning of using analogy is to find similarities between ethnographic data and archaeological findings through reasoning. A formal analogy is a direct comparison of ethnographic artefacts to archaeological artefacts; a relational analogy is to compare ethnographic data of cluster of synchronously related artefacts or human behaviour/technology to a presumed archaeological context.

<sup>7</sup> Bilum is a carrying net that is still manufactured in the highlands of New Guinea for carrying all sorts of things.

<sup>8</sup> The oldest record of this technology is only about 1500 years; from the younger Iron Age.

get stone axes in retribution of bilums that the people of Ormu could not manufacture (Elmberg, 1953:191).

His observation can be interpreted in the light of a much later traveller and scientist, Jared Diamond, when he makes the following observation of the cultures of New Guinea:

*”In reality, I regularly observe in New Guinea that the native societies there differ greatly from each other in their prevalent outlooks. Just like industrialized Europe or America, traditional New Guinea has conservative societies that resist new ways, living side by side with innovative societies that selectively adopt new ways.”* (Diamond, 2005:252)

Diamond points out how technological innovations come about. Some innovations are local and depending on the abundance of raw material like e.g. copper; others are borrowed from societies near-by or remote depending on possibilities for travel. And Diamond’s thesis is that e.g. plant domestication has at least five independent origins, (Diamond, 2005:254).

These two examples can be seen as arguments for a more careful interpretation of the importance of fibre technologies for hunter-gatherer societies. If the raw material was abundant and much needed for the group (either for their daily life or for trading), then you might talk about a String culture. But they might also show us the importance of string manufactured items for Stone Age cultures.

*Quality of the evidence:* The ethnographic reports have various qualities, from the more anecdotal narratives (Elmberg, 1953) to experimental design for fibre manufacturing (Hardy & Sillitoe, 2003). The overall conclusion is that there is little doubt about an early existence of string technologies, but whether it was a central part of a Stone Age culture as the analogy suggests is not that well documented. The relevance and the validity of the evidence is limited for a prehistoric String Theory.

### **Evidence 7. The use of plant fibres in string making**

*”The use of tree bast to make string and clothing is widespread in the ethnographic records...”* (Hardy, 2008:274).

*Arguments for the evidence:* How do we know that the manufacturing sequence of string making from plant fibres are the same as when it was first developed? Hardy gives two detailed descriptions on how tree bast fibres are prepared in similar ways, from two very different parts of the world: from Mesolithic time until today in Norway (Myking et al. 2005), and among the Telefol from Papua New Guinea (Mackenzie, 1991, see reference in Appendix 1b). According to Myking et al. (2004), the manufacture of lime bast cordage in Northern Europe has an unbroken history from the Mesolithic to the present day. Their argument is that the old way of preparing the lime bast is still in use and that *”Cordage was one of the first and most important tool of Stone Age man as it was crucial for fishing and construction of traps”* (2004:65). They also enumerate several European plants that are useful for cord making, like grasses, birch, hazel, pine and willow, and maintain that the abundance of useful plants in Northern Europe gave good opportunities for a string technology including both fibres from smaller plants and tree bast and bark. In the example from the Telefol culture,

Hardy makes the interesting observation that the raw material might also be traded (Hardy, 2008:274), meaning that not only the finished product but also the fibre material could be carried over distances for textile manufacture by others.

*Other arguments:* The availability of raw material was essential for the hunter-gatherers. The plants that were useful for fibre making were also useful for other things, e.g. trees (bark, bast, branches) for building seasonal habitats, and nettles and wild flax for eating. The initial process to prepare the material for fibre twisting does not give much variation, you have to gather it, you have to soften it, and you have to twist it. However, we already know that there are several different ways to twist and add in new fibres (e.g. with or without a tool), so here is where the similarities in the process might end. An example of modern reconstruction of rope making is still going on by using the bast fibres from linden from the Linderödsåsen in middle Scania (southern part of Sweden). In this highland surrounding several Mesolithic habitat have been found, and the use of bast from the linden tree might be as old as these habitats, see photos of today's Linden bast manufacture in Appendix 3.

The following two examples illustrate the variety of fibres used in Europe; the rope from the Lascaux cave (see also evidence 3) and the equipment of the Ice Man from Ötzi.

From the finding of the Lascaux rope (dated around 17,000 BC) Barber makes following reflection: "*Palaeolithic people did not need to wait for the domestic plants and animals of the next great era, the New Stone Age, or Neolithic, to have fibres to use. For the relatively short length of string necessary for Palaeolithic tasks, an abundance of raw material lay for taking in the wild*" (Barber, 1994: 53). Among the useful available plants she enumerates various bark and bast from trees as well as hemp, nettle and wild flax.

The finding of the completely dressed and equipped Ice man from the Alps (dated to 3,200 BC) also tells us about the prehistoric extensive use of the available fibre raw material. According to the analyses of his four textile artefacts (as reported by Spindler, 2000), three of them were made of twisted and knotted or plaited grass – a net for trapping birds, cords inter-plaited for shoes, and a cape plaited of long grass fibres. Interestingly, Spindler notes that the Ice Man had no woven textiles, although fully dressed. If we look to the contemporary cultures in the Aegean area, a fully developed weaving culture is at hand here. How to explain that this man has no woven textiles is an archaeological problem, which might be explained by the fact that he may have come from quite isolated parts of the Alps, where the dominant dress probably were just made of hides and grass.

*Quality of the evidence:* The use of the available plant material in the habitat of the first humans is not controversial, but to postulate that it was used in the same way (manufacturing sequences), is not proved by the offered arguments. The need for food and shelter by using the plants in the surrounding environment is not controversial, but the added technologies for making new things of fibres (for carrying or as helpers for adornment) must have happened very slowly, probably through both local invention and also by borrowing the technology from other more inventive hunter-gatherers. The relevance and validity of the basic argument of using the raw material at hand is high; however, to compare the process of using it world-wide or even historically for the same region is not totally convincing.

## Evidence 8. Learning how to make strings

*”Telefol women learn string-making and looping at a very early age through the unconscious copying described by Ingols (2000) as the coordination of perception and action” (Hardy, 2008:275).*

*Arguments for the evidence:* Hardy’s main arguments about the importance of the learning process for string making come from the observation of the role of learning in Telefol society and from a study by Minar (2001). In the Telefol case the early introduction, mostly to female children, of the spinning technology, makes the bodily movement innate and automatized at a very early age. The very time-consuming activity can then be performed while doing other things simultaneously, e.g. gathering of plants and cooking food, taking care of children etc. The spinning activities are going on at all times of the day in this society. Minar (2001) studied corded-marked pottery from different cultures around 600 AD in north-central Florida. She observes the variety and conservatism in the final twist of the impressed cord on the pottery. The fact that the pottery changed but not the twisted cord (in certain communities), makes her claim that both a regional conservatism in the cord plaiting technology, and the learning process in itself, played the most important part for the conservation of the final twist direction over time and space (Minar, 2001:386).

*Other arguments:* Let us return to the rope from the Lascaux cave where Barber (1994:53) argues that: *” twisted fibre string and thread were available in the Palaeolithic, and by 15,000 BC people possessed as much skill as anyone could wish for making cordage. After all, they had probably been practising for five or ten thousand years already.”* We have seen in the previous evidence from archaeological excavations and logic deductive reasoning that probably this technological skill is much older, even as old as the first humans 1.8 million years ago (Warner & Bednarik, 1996). The role of the *”community of practice”*<sup>9</sup> is evolutionary important since this is probably the mechanism through which societies and humans evolve in one way or another. The learning of motor skills (like flint knapping, making a fire, preparing plants for food and strings) went from generation to generation and was essential for survival.

*Quality of the evidence:* We cannot *”see”* the learning taking place during Palaeolithic, but looking at evidence for learning activity in flint knapping strengthens the theory of learning from generation to generations. The string making is a time consuming activity and therefore need to be more or less automatized in a society, so to guarantee the necessary strings for carrying, trapping and fishing, as well as ropes for lashing boats and houses. Although the arguments are quite limited in Hardy’s article, other arguments, e.g. from learning theories like Wenger’s (1998) for technological development strongly support the use of technologies in humans that are more or less automatized, like biking or writing in our own societies

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<sup>9</sup> Ett förklarande citat: *”Over time, this collective learning results in practices that reflect both the pursuit of our enterprises and the attendant social relations. These practices are thus the property of a kind of community created over time by the sustained pursuit of shared enterprise. It makes sense, therefore, to call these kinds of communities, **communities of practice**”* (Wenger, 1998:45).

## Evidence 9. String making in a social context

*"In highland New Guinea, women are closely linked to string manufacture."* (Hardy, 2008:276)

*Arguments for the evidence:* The main arguments concern the gender role and labour division in string making in the reported ethnographic studies from New Guinea (Hardy, 2008:276). In these societies women mostly have the main role as string makers, although men can manufacture from strings on equal terms. Examples from other cultures, Kogi from Colombia (Minar, 2001), show no gender difference in manufacture, but in the technological way of spinning. So the analogy to the prehistoric contexts is not straightforward in favour for women to be the string agents.

*Other arguments:* In the study of Lupo & Schmitt (2002), they argue that: *"small-sized fauna and fiber-based hunting technologies are markers of women's hunting efforts"* (Lupo & Schmitt, 2002:170), and thus less dangerous than the male "net- and weapon"-based hunting. The ethnographic analogy in their argument for a prehistoric social pattern comes from their study of foragers in the Congo Basin in Africa. Their study once again proves that twisting plant fibres into cordage and nets were important for hunter-gatherer communities and they enlighten as well the gender roles for food providing.

*Quality of the evidence:* The relevance of this evidence for a String Theory is limited and far-fetched and does not prove whether the technology was upheld by women or men. Nothing about the status and value of textile products or manufacture is mentioned, such as the importance for many later prehistoric contexts like in e.g. Peru. However, in historic contexts it is mostly women who are involved in textile manufacture, and it is therefore probably intriguing to presume that this must also have been the case in the long history of women and men.

## 4. Discussion

In this section, the methodology and results in both Hardy's study from 2008 and the present study is discussed in relation to the study's three research questions.

### 4.1. A substantially grounded theory of early fibre string technologies

*RQ 1. How is it possible to validate a prehistoric String Theory?*

After working for 3 months with Hardy's prehistoric String Theory (Hardy, 2008), it was not until recently that I understood the theoretical concept underlying her (not) formulated theory (see sections 1.3 and 1.4). It was a problem to accept Hardy's variety and diversity of evidence supporting the theory: indirect or direct textile reports, analogies to ethnographic studies, mixed with direct textile findings and secondary artefacts as well as artistic impressions in clay etc. At some point, when starting to analyse the evidence in relation to the references in the article and realizing their uneven quality, both as relevant for her theory and

the scientific methodologies underpinning some of the referred studies, I was convinced that the String Theory was only a provocative title of the author for a scientific paper.

However, after going back to the Philosophy of Science and theory formulation, the solution to the dilemma appeared – Hardy’s theory formulation is a beautiful example of *Theory discovery* within the framework of Grounded Theory as formulated by Glaser & Strauss in the early 1970s in a rejection of the dominance of natural science and positivistic theory construction (Alvesson & Sköldbberg, 2009:127 ff.). A Grounded Theory is close to empirical data (an inductive methodology), it has a low level of abstraction, and it can be tested but not rejected, only be replaced by another, better theory. Methodologically, any group of data can be compared with each other, with the scientific aim to reach a level of complete understanding of the phenomena to be explained. This also means that the theory is under constant revision by the adding of new and different evidence. We can also perceive two kinds, of scientific levels of theory construction: substantial and formal Grounded theory. The substantial Grounded theory is closer to the empirical data about the reality, while the formal theory is based on a conceptual level of the reality and thus has a higher degree of generalisation. The majority of Grounded Theories are of the first kind and thus called small theories<sup>10</sup> (Alvesson & Sköldbberg, 2009:155).

With this starting point, it is easier to see and evaluate the relevance and validity of the evidence as it is formulated by Hardy (2008) and in the present study. As mentioned previously, Hardy has a large number of references to back up her theoretical statement. However, most of these references are not at all focused on fibre string technologies. The most relevant and valid references for a theory of prehistoric textile manufacture are the works of Adovasio et al. (1996), Barber (1994), Bednarik (1995, 2000), Good (2001), Minar (2001), Nadel et al. (1994), Soffer (2004), Soffer et al. (2000, 2001) and Warner & Bednarik (1996) – that is 11 out of 62 references. Her own reference, Hardy, 2007, appeared to be more or less exactly the same as the article from 2008.

In the analysis, an attempt is made to evaluate the quality of the evidence by the author, both through a careful reading of at least one of the references for each evidence, and by adding some other arguments for the evidence, obtained through a systematic literature search for more facts about the claimed evidence for the Theory. In this process, several of the thus sampled references contained nothing of value for the Theory (e.g. Grøn (1998); Kuzmin (2006); Khabir (1987), and yet others had valuable information but was not really used by Hardy (e.g. Soffer et al. 2000).

The answer to *the first research question* can be summarized in the following way: The overall impression of this evaluation is that even if in constructing a substantial Grounded Theory, the scientist has to select the empirical data very carefully and make use of them in a reflective way (see section 2.1).

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<sup>10</sup> Grand Theories are only, so far, to be found in Natural Sciences like the physical laws of nature, e.g. about gravity.

## 4.2. The materiality of the Stone Age: textile technologies

### *RQ 2. What constitutes the textile materiality of the Stone Age?*

To understand the Palaeolithic and Mesolithic communities of hunter-gatherers we must consider the material culture surrounding them. We assume that they under periods lived under quite harsh conditions in Europe, with the shifting and unpredictable landscape, and a nature that also changed due to huge climate changes like the frequent glacial periods, which varied much during this long duration (1.8 million – 3,000 BC). And we can assume that their basic need of shelter and food occupied the major part of their daily activities (Jensen, 2012). However, some of them must have been living under long periods – much longer than our modern time – here in Europe under quite favourable conditions, in the warmer periods with a rich fauna available for hunting. To understand the materiality of fibre plant technologies we have to know what kind of plants were available during the different eras. As described in Appendix 2, the useful wild plants for early textile manufacture are available even under quite harsh conditions, like the nettle that can grow on the slopes of Himalaya as well as on the tundra landscape of Palaeolithic Europe. In the analysis, we have primarily looked at ethnic cultures living in the tropical zones of the world.

There are a number of possible technologies that for hundreds of thousands of years must have required other material than stone artefacts, like some kind of tools and things of organic material, for fishing, gathering seed, carrying belongings and food, building shelters, crossing waters, and for clothes as shelter for the sometimes colder weather.

In section 1.2, different perspectives on how to study materiality is given: a biological/evolutionary approach, a manufacture-driven approach and an object-oriented approach. To approach early Stone Age materiality with an object or agency-oriented approach is a bit difficult, when the majority of artefacts are missing due to their perishable nature. However, we do have secondary artefacts that have a very long history, the perforated beads and pendants (see evidence 4). To make and use necklaces seems to be an almost innate desire in humans since the very beginning. We can see children today in conflict over the most lustrous plastic pearls for making their own necklace or for gifting their parents. The long history of beads and pendants as adornment shows us their important agency for human development. Another more recent example, which is around 30,000 years old, is the stringed and knotted skirt for ritual purposes, which was first discovered impressed in the Gravettian "Venus" figurines, and again on the Egtvedt girl from the early Bronze Age in Denmark (the National Museum of Denmark in Copenhagen), and still as a ritual dress in contemporary Russia as described by Barber (2010) – see also evidence 2. The two other approaches (evolution/biology and chaîne-opératoire) will be discussed in the next section in relation to the technological mentality of early Stone Age humans.

The answer to *the second research question* can be summarized in the following way: Can we hope for more archaeological contexts and artefacts to build a theory for these perishable materials, so to better understand their world? No, we just have to accept that the materiality of Palaeolithic also includes the relation between humans and the technology for gathering, preparing and manufacturing objects with plant fibres.

### 4.3. A Palaeolithic technological mind for stringing

*RQ 3. Do we have evidence for a new Theory of a Palaeolithic technological mind for string manufacture?*

When we try to understand the technology and the technological development and the cognitive transfer between generations, and even between different human species, we have to reflect on human's biology and evolution. Hurcombe (2007) describes three kinds of technologies that might have been forming the human technological development in relation to materiality: to reduce, to compound, and to transform.<sup>11</sup> We will look into these for understanding the long technological development of things around us today.

- To *reduce an object* – to create a new object by knapping/carving/chopping is the basic technology for stone technologies
- To *compound objects* – to create a new object by gluing/tying/knotting/weaving is the basic technology for textiles
- To *transform an object* – to create a new object by fire is the basic technology for pottery

These three basic technological principles can then be combined in different ways. We have examples of the existence of all three technologies since at least the Upper Palaeolithic.

The skills required to use these technologies developed slowly through the many thousand years, where some of them developed faster with the introduction of new materials or refinement of tools. With the industrial revolution (late in humankind's history), the technologies went through a drastic change with the introduction of machines replacing human skills. With the effect that few people today have the motoric skills for flint knapping, wood carving, spinning or weaving or making their own pottery. The know-how and the necessary skill transfer between generations no longer exists – now you have to consult a book, or even a film on YouTube, to understand how to use e.g. a spindle. There is also no longer a need for a community of practice regarding these basic technologies, since the artefacts like pottery or cloth can be made in industries in remote parts of the world.

Can we then, through observing the development of flint knapping (stone artefacts), understand the development of textile manufactures? Yes, to some extent, although we have almost nothing left to observe. Through archaeological experiments we can trace the developmental steps back in time, which is the technology needed for taking the next technological step. As hypotheses for future research, I would like to suggest the following steps in the technological development of twisting fibres and composing textiles under the Palaeolithic/Mesolithic ages:

*Twisting technologies:* First you learn to twist at least two plant fibres into a string, which you can ply to make it stronger. This can be done simply by your hand or fingers. However when you have shorter fibres and want a longer string you can use a stick (a ten) to make it possible

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<sup>11</sup> I am not discussing artistic activities, only technologies used for 'survival'.

to insert new fibres into the string with the help of gravity and your rotation of the ten as active forces to produce the longer and also thinner strings. Now you are using a tool, although quite primitive but still something that can be further modified.

The next step might be to stabilize the rotation of the twisting and that can be done by inserting the stick into a small stone with a hole in the middle (a whorl). Now you have a modern spindle (!), still in use in many cultures around the world. This fantastic tool can also be used as a digging stick if you put the stone at the bottom of the stick. The next technological discovery of twisting fibres takes a long, long time to be invented: the spinning wheel that was introduced in historic time.

*Textile composing technologies:* The first step to compose with strings is to knot or plait them to make a basic object like a cord or a thick rope. You can also plait the strings one by one or in groups of two or three like the rope from Lascaux or as in the string skirt of the Venus from Lepurgues. For these technologies you need no tools except your fingers. You also can loop or knit the strings into e.g. baskets, shoes, head gears and nets without tools. The needle is probably the oldest tool related to string textiles – when you want to attach things like beads or sew textiles or hides together.

A very early weaving method is plain weaving that can be done with the help of a Y-shaped branch. The technological step taken now is to keep the strings in two systems, the warp and the weft, where the warp is steady and the weft continuously introduced. This technology can be done without tools, but is difficult to perform without a stabilising frame. We now have the basic principle of weaving, namely the creation of two independent string systems (!), still in use today but highly developed through looms and heddles.

The answer to *the third research question* can be summarized in the following way: We cannot any longer observe authentic Stone Age behaviour, unless we accept that some still living ethnic group on earth have the same cognitive level and technological skills. We can, however, speculate on good grounds, and with the help of experimental archaeology, about the motoric and symbolic skills needed for fibre preparation and textile manufacture. As soon as the first beads and pendants surfaced from the mist of human's prehistory, they gave us an understanding that today's skills for stringing fibres are similar, although we don't have skilled teachers around us anymore.

## 5. Conclusions

It is very plausible that textile technologies, like simply twisting, knotting and looping, were developed very early in human's evolution, perhaps at least 1.8 million years ago, in line with the documented skills of Homo Erectus to make stone tools. The overall result of the study is in support of a Grounded theory of early string making as discovered by Hardy (2008).

Further, the evidence also supports the assumption that the phenomena of stringing and composing with strings is not an invention of modern man around forty thousand years ago as

claimed by Barber (1994), but must have been around for a very long time before, and that it was a skill that was learned from generation to generation in prehistory as well as in our modern history.

## 6. Summary

The study presented here focuses on the evidence for an archaeological theory of prehistoric fibre string textile technologies. The background for the study is a recently published article by the British archaeologist Karen Hardy with the title *Prehistoric string theory. How twisted fibres helped to shape the world* (2008).

The three formulated research questions (RQ) discuss: (RQ1) the validity and relevance of the evidence for such a theory; (RQ2) the textile materiality of Upper Palaeolithic, and (RQ3) the early presence of a specific technological mind for fibre plant manufacture.

A reflective analysis of indirect and direct evidence for a prehistoric String Theory by Hardy (2008), was undertaken with the aim to evaluate the strength of the arguments for such a theory.

The overall result of the analysis of the archaeological evidences showed an uneven profile, where some evidence such as direct textile artefacts from Upper Palaeolithic and textile impressions in clay have the highest relevance and validity for the theory. Presented evidence, with arguments from ethnographic studies illustrates the role of plant fibre technologies in “modern” Stone Age societies as well as the required technologies and their development and learning in a community of practice. The ethnographic evidence presupposes that humans in Upper Palaeolithic had the same kind of cognitive and social minds for string technologies as modern humans, and are therefore rated as having a much lower relevance and validity for a prehistoric theory of string manufacture.

The answer to the RQ1 can be summarised as a support for the theory due to the high relevance and validity of the archaeological findings and reasoning in the published articles and books which are referenced here. The theory discovered by Hardy (2008), is argued to be a substantial Grounded Theory.

In RQ2 the author discusses tentatively the materiality of the Stone Age with a focus on plant fibre manufactures. The fact that some of the textiles still surround us, like cordage and thread, indicates a very long biography of such items and it is reasonable to suppose that fibre string technologies were at the centre of the Stone Age technologies and societies. This research question calls for further studies into the materiality of the prehistoric hunter-gatherer groups.

The third research question (RQ3) concerns technological developmental processes and the communities of practice. We can make some inferences from recent experimental archaeology (Andersson Strand, 2013; Stone, 2009), which indicate that we need to re-analyse bone artefacts for marks of early weaving technologies as well as look into the bead holes for remains of string material. The archaeological excavations of early Stone Age seasonal settlements have to take into consideration the fact that there might be traces of textile manufacture not visible directly for the eye but appearing in modern laboratory analysis.

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## Appendix 1a. Contribution of some selected evidence from Hardy (2008) to the substance of the String Theory, figure 1.

### Prehistoric Archaeological Evidence

Evidence 1: Stringing and knotting techniques  
Ingold, 2000; Soffer et al, 2001; Warner & Bednarik, 1996

Evidence 2: Textile imprints and impressions in clay  
Adovasio et al, 1996; Barber, 1994; Good, 2001; Khabir, 1987; Kharakwai et al, 2004; Kuzmin, 2006; Soffer, 2004; Soffer et al, 2000

Evidence 3: Direct textile findings  
Gramsch, 1992; Hardy, 2007; Leroi Gourhan, 1982; Nadel et al, 1994

Evidence 4: Perforated beads and pendants  
Ambrose, 1998; Bednarik, 1995, 1997, 2000; Henshilwood et al, 2004; James & Petraglia, 2005; Kuhn et al, 2001; Mellars, 2006; Vanhaeren et al, 2006; Warner & Bednarik, 1996:

Evidence 5: Tools for fishing, gathering and weaving  
Albrethsen & Brinch Peterson, 1976; Gron, 1998; Hardy & Wickham-Jones (in press 2008); Mellars, 1987; Mithen, 2000; Mordant & Mordant, 1992; Parks & Barratt (in press 2008); Soffer, 2004; Kent & Nelson, 1976

### Contemporary Ethnographic Evidence

Evidence 6: String technologies  
Barber, 1994; Howard, 2006; Myking et al, 2005; Sillitoe, 1988

Evidence 7: Use of plant fibers  
Hampton, 1999; Hardy & Sillitoe, 2003; MacKenzie, 1991; Paijmans, 1976; Sillitoe, 1988;

Evidence 8: Skill learning  
Ingold, 2000; Minar, 2001; Pashler, 2000; Ruthruff et al, 2003; Sillitoe, 1988

Evidence 9: A social-cultural context  
Garth Taylor, 1974; Heider, 1970; Lee, 1979

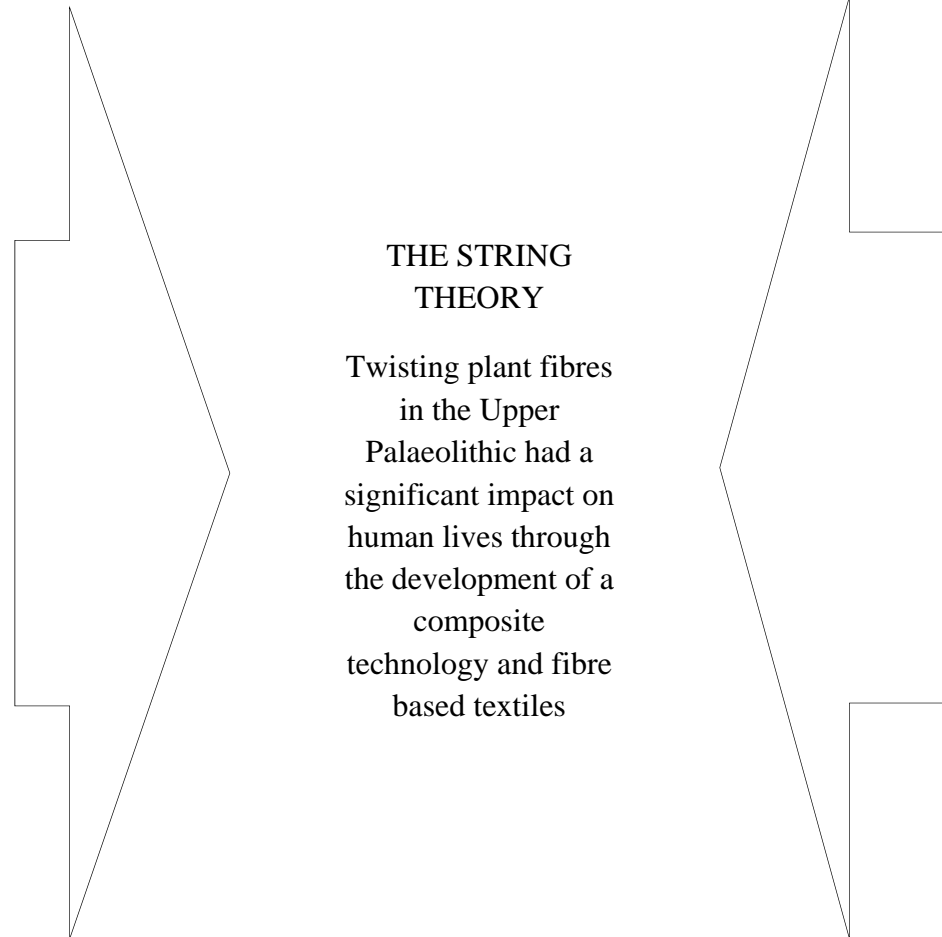


Figure 1. Illustration (by the author) of the direct and indirect evidence for a prehistoric String Theory according to Hardy (2008), see list of references in Appendix 1b.

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## Appendix 2. Textile terminology in archaeology

### What is a textile and what can be found in an archaeological context?

Textiles (from the Latin word *texere* meaning to plait) are made of strings, and they can be so different artefacts as basketry, cordage, shoes, cloths, nets, hammocks, and much more. We are, as were the prehistoric humans, surrounded by textiles to a point that we are unaware of their long history, like for example ropes that certainly were with us very early on for carrying things with us.

Textiles are mostly made of organic materials (from plants and animals), thus perishable in an archaeological context, and they have only been preserved under very special conditions. The fact that they are rarely found in excavations from prehistoric sites does not mean that they have not been there (Hardy, 2008). If they are detected, it is very often by tiny and fragile fragments or by negative impressions in clay, in spite of the fact that excavation and conservation methods have advanced radically during the last decades. However, the awareness of the importance of textiles for the hunter-gatherer groups has led to better excavation techniques, as well as the search for artefacts that might have been used as tools for textile production (like marks on mammoth bones for primitive looms (Soffer, 2004), or indirect evidence like strings for perforated beads or pendants. Techniques for investigation and dating of the textile fragments have also developed through a growing interest in how and when they were made, i.e. the social context for textiles. And several new methods like microscope and other optic devices are non-invasive and do not destroy these fragile archaeological artefacts.

Textile terminology and classification is a science in itself, recently illuminated by the book *Textile terminologies* (Michel & Nosch, 2013), which was published to help textile researchers to a common language. For the present study it is enough to consider the main division in terminology between textile structure and textile production methods. Textile structure classifications (used mostly by archaeologists) target the actual artefact's raw material and how it has been prepared (e.g. retting, dyeing) as well as the structure of the textile. Classification and terminology for textile production methods are mostly applicable to anthropological and ethnographic studies since we have no records of production methods for Palaeolithic societies and few from the Bronze Age and onwards – mostly then in pictures of tools and of actual textile production on pottery, but also in descriptions in text/language based material.

### Fibre material

The raw material for textile is fibres, and they can be classified according to origin or location (Derosier, 2013). The origin of fibre is mainly organic<sup>12</sup>, either from animals or plants. Both animals and plants have been domesticated for their ability to produce useful textile fibres, like wool from sheep, silk from silkworms and flax for linen. However, during the

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<sup>12</sup> When metal comes in use (from Bronze Ages), we can see how e.g. bronze are introduced in cloth, e.g. the skirt of the Egtved girl (Barber, 1994:57)

Palaeolithic Ages the fibre material was from wild animals and plants. From animals the hair was used (like camel or goat lid) as well as the sinew and guts. From the plant mainly the stems was used like bark and bast from trees, or bast from nettles, hemp and flax. To obtain the fibres for string making, the plant had to be softened by retting for some time in running water. The most common plant fibres in prehistory according to Barber (1991: 9 f.) are bast from linden, hemp, flax and nettles; all these materials have been found as impressions or fragments from Upper Palaeolithic excavations. Generally, animal fibres are much shorter than plant fibres, except for fibres from the silkworm which can be many hundred meters. Among the plant fibres, the shortest fibres are from the cotton plant, and the longest fibres are from tree bast fibre. In between comes fibres from flax, hemp and nettles. Bast fibres like nettles, flax, hemp and the inner of the tree bark can vary in coarseness from very soft to very stiff. Different fibres were probably chosen for their usefulness in the fabrication of the desired textile, like tree bast for ropes and nets, and nettles and flax for cloths. The knowledge of finding the right fibre material must have been an equally essential knowledge for Stone Age gatherers as finding the right stone material for the weapons and tools.

### **Techniques and tools for making strings**

The length and stiffness of the fibres are quite important for the choice of twisting/spinning techniques. The simplest method (still in use) is to take some straws of grass and twist them together tightly with the palm of the hand and then to ply the string to make it stronger – and you have a string or a thread. Adding more strings by knotting can provide you with a longer rope or even a nice basket. The use of bast fibres from trees might have been just like this, where the fibres were long enough to provide you with the direct string for use. However, most available plant fibres are not that long and you need a tool, perhaps just a suitable Y-shaped branch, to hold the first twisted fibres while you add in new fibres in the string to be – the first spindle. A tool had to be developed when you had shorter fibres, so it was probably discovered that the fibres twist easier when they are made to twist with the help of a thin branch in free air, due to the law of gravity. The branch which aids the hand to twist is called a ten. By adding a weight on the top or bottom of the ten, the fibres are twisted much more evenly. Now we have a modern spindle, still in use in many cultures around the world. The weight is called a whorl and appears in archaeological findings very often as smooth stone (or clay) products with a small hole in the middle. Similar types of artefacts are weights (sinkers) for fishing nets and weights for weaving in open looms (weft weights). Sinkers and weft weights are normally heavier than whorls.

### **Techniques and tools for composing with strings**

The twisted fibres, the string, could either be used directly with no further elaboration or be composed into useful items (depending on habitat) in the early Stone Age cultures. There are few remaining tool artefacts for textile production since they probably were not made of stone but of bone and wood. The oldest known needle of bone is from the Gravettian culture ca. 30,000 years ago. (Soffer et al. 2000). Needles have been found abundantly in Stone Age seasonal settings and their construction and use is very much the same today, although now needles are made of steel or plastic.

There are a variety of methods to use the fibre strings for manufacture; here only those are mentioned that are relevant for the study.

Sewing pieces of hide together with a needle seems to have been quite an early activity since clothes were necessary as soon as humans entered the cold Northern hemisphere in their global migration. The fibres used were probably mostly sinew or guts but stronger plant fibres might also have been used.

Plying and looping twisted fibres are also probably very early technologies since it can be done without any tools but the fingers. Plying fibres is for making the string stronger and looping fibres is for making basketry and nets. Plaiting fibres is another technique where several independent strings can be plaited together to a strong cordage or even dress.

The weaving of fibres demand two independent string systems (weft and warp) but you do not necessarily need any more tools than the fingers. A rudimentary loom can consist of a Y-shaped branch where you tie the strings in rows (weft) with or without some weights in the other end of the warp. Then the thread (weft) can just be inserted in the warp through an up-and down technique (plain weaving). Another rudimentary loom can be made of long bones or branches, so the warp can be tied to two poles. All these techniques may have been at hand as early as the Upper Palaeolithic in Europe and elsewhere. During the Neolithic phase of the Stone Age there is an assumption that through the farming and domestication of sheep and flax new weaving techniques replaced the older ones through the introduction of more advanced looms and weaving techniques.

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### Appendix 3. Photos of Linden bast manufacture at the Löddeköping Ancient Textile Fair, August 2013



Photo 1. Linden bast rope



Photo 2. Linden bast fibres and a knot



Photo 3. Linden bast basket or hat