TALLINN UNIVERSITY OF TECHNOLOGY

School of Business and Governance

Institute of Business Administration

Ekaterina Vasileva

ESTONIAN CONSUMERS' PERCEPTION OF 3D PRINTING TECHNOLOGY USE IN THE FASHION INDUSTRY

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Supervisor:

Ekaterina Demiankova

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I hereby declare that I have prepared the Bachelor's thesis independently and

I have referred to all used in compiling the work

works, important views and data of other authors,

and has not previously submitted the same work for credits.

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summary.

Ekaterina Vasileva.................................

(signature, date)

Student code: 194433TVTB

Student e-mail address: vekaterina691@gmail.com

Supervisor: Ekaterina Demiankova,

The work meets the applicable requirements

....

(signature, date)

Chairman of the Defense Committee:

Allowed for protection

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(name, signature, date)

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ABSTRACT

The aim of this study is to examine the Estonian buyers' perception of 3D printed technology in the fashion industry, as well as the factors influencing the Estonian buyers' perception of 3D printed technology in the fashion industry, using a modernized model of the Theory of planned behavior by Ajzen (1991) and Simona Naspetti et al. (2021).I have examined the following theory-based factors: Perceived risk, Perceived benefits, Subjective norm, Attitude towards technology, Moral norm and Perceived control over behavior. Based on the model used, an online data collection questionnaire was created and administered to 182 Estonian respondents. The results of the survey revealed that only 2 out of the 5 initial factors were found to be influencing the purchase/wearing intention of Estonian buyers of 3D printed fashion products. They were Subjective norm. and Attitude towards technology. It is these two factors that had the greatest influence on the subsequent intention, and consequently the perception of the Estonian buyers of 3D printing technology in the fashion industry, since the intention to buy is a direct evidence of perception either negative (if customers do not have intention to buy/wear) or a positive one (if customers have intention to buy/wear).The other factors, however, proved to have a low influence or lack of significance, for use in this concept.

Key words: 3D printing, fashion industry, production, consumer behavior

INTRODUCTION

3D printing is "an automated additive manufacturing process that builds a product by depositing material into successive layers until it is complete" (Vanderploeg et al., 2017) Its applications range from medicine to rocket engines (Shahrubudin et al., 2019). It may seem new, but it is worth saying that the commercial use of 3D printing began back in 1980. (Holzmann, 2017) As it is applied in many areas, fashion is not an exception. 3D printing technology has been utilized in manufacturing jewelry for some time now, but in the case of fashion, the technology is not as widespread. (Tess 2017) One of the best-known examples of the implementation of 3D printing in fashion would be the haute couture dresses created by Iris Van Harpen. Notably, at this stage, 3D-printed products are not limited to haute couture. Jewelry (Shapeways 2018) and shoes (HILOS 2020) are now also being produced using this technology. This suggests that 3D printed garments are becoming more widely available.

There are a huge number of advantages to using 3D printing in the production of fashion garments. For example, the fabrication of smart textiles (Yang et al. 2016), faster production times, decreasing costs by reducing packaging and supply chain costs. (Dilberoglu et al. 2017) An important advantage of 3D printing in production is that consumer demand will have a greater influence on manufacturing. Customers will be able to influence the product by making it more customized. (Rajan et al. 2016) More significantly, the use of 3D printing in the production is also more environmentally friendly (Mellor et al. 2014), as the fashion industry is now having a very negative impact on an already bad environmental situation, it could help to reduce the negative effect of fashion sector on the ecology. Now the fashion sector is in a flourishing state, its negative impact on the environment does not go unnoticed either. Not only does the fashion sector currently pollute and dehumidify water resources, but it also produces 10 percent of total human carbon dioxide emissions. And ultimately, 85 percent of the textiles produced each year end up in garbage dumps. (UNECE 2018)

Besides obvious benefits in the use of 3D printing in more high-volume apparel production, it is worth considering customer behavior regarding this innovation. One possible problem in applying this technology on a larger scale may be its limitations. "Compared to the revolution in other technologies (e.g., the Internet), the industry and

consumers are concerned that 3D printing may not make significant progress in the fashion industry because of its limited applicability to mass-market products (Gilpin 2014)".

However, consumers' perceptions of this technology should be investigated as well. If this technology is perceived negatively, its expansion and launch into mass production would not make sense or have the desired results. By identifying the buyers' perception of the technology, it will become clear to producers whether the technology should be used in mass production, which age group should be targeted due to their positive perception of the technology and, consequently, the willingness to purchase it later. «The extant 3D printing-related research in the context of fashion is focused on material and technology applications, which neglects consumers' perspective (Han et al. 2014).»

The primary focus of my research is therefore to identify the perception of Estonian customers regarding the use of 3D printing technology in the fashion industry through the theory of planned behavior by Ajzen. Understanding if consumers see this technology as something they would use on a daily basis or they would not be interested in buying such items for various reasons (doubts about quality/comfortability etc.) is initial for the study. The aim of this research is to understand consumer perception of 3D printing in the fashion industry. Research questions guiding the study are:

 1.How Estonian consumers perceive usage of 3D printing technology in the fashion industry?

2.What factors influence a consumer's perception of using 3d printing technology in the fashion industry?

The first section of the diploma presents the theoretical framework, the basic concepts, and provisions on which the study is based. This part explains the assumptions used for further research and the rationale for their choice. It includes a description of 3D printing technology in the fashion industry, as well as the theory of planned behavior, which explains buyers' perceptions of certain factors and their subsequent influence on intention. The second chapter covers the methodology: the data collection and its further analysis as well as the tools applied to it. The work then includes the interpretation of the results and discussion. The final part is the conclusion, which brings together and summarizes all the information obtained from the study.

The findings of this study will enable manufacturers to determine consumer behavior towards this innovation to decide on further manufacturing development. The current research aims to provide a comprehensive study of Estonian buyers' behavior towards the use of 3D printing in the fashion industry for clothing using theory of planned behavior by Ajzen. "Personal values are a fundamental source of human behavior, are closely linked to human needs and can be the best indicators of consumer behavior" (Schwartz 1994; Steenkamp et al. 1999).

1.THEORETICAL FOUNDATION AND FRAMEWORK

1.1 3D printing technology in fashion industry

To begin with, I would introduce 3D printing technology itself and its applications in the fashion industry.3D printing technology consists of producing various geometric shapes layer by layer, based on 3D modeling information. (Lee et al. 2019).

Turning to the rise of 3D printing, its contribution to the third industrial revolution has been most active since 1984. (Sun & Zhao 2017) The application of 3D printing extends to many industries: food (Nachal, Moses, Karthik, & Anandharamakrishnan 2019) medicine (Ventola 2014), automotive (Ganesh Sarvankar & Yewale 2019) and construction (Sakin & Kiroglu 2017), as well as fashion and textiles (Spahiu et al. 2020).

The application of 3D printing in the fashion industry has been attracting interest for the past few years. (Beecroft 2016). This has happened for a reason. 3D printing in the fashion field, or more specifically personalisation it enables, will facilitate the expansion and development of new applications. (Tenhunen et al. 2018) Moreover, 3D printing in combination with conventional, traditional textiles (knitwear) has been found to be advantageous. (Grimmelsmann, Martens, Schäl, Meissner, & Ehrmann 2016)

By depositing functional materials on textiles, 3D printing allows the creation of new 'smart textiles'. (Ahrendt & Romero Karam, 2020; Eutionnat-Diffo et al. 2019) A wide range of printing materials such as ceramics, glass, wax, polymers, resins, metal, composts and natural or synthetic fibers in their various forms (liquid, solid form - powder or filament, gas) are available for 3D printing. (Vanderploeg et al. 2017)

Despite the differences in 3D printers, the extrusion process is the same. Extrusion printing, or Freeform Fabrication (FFF), is the most used printing method at the present time. The filament, which is rolled on a spool, passes through the extrusion head, and is heated there, the heating temperature being adjusted according to the material and type of filament itself, after which the melted material is transferred to a special platform for further construction of the desired object. The construction process involves layer-by-layer application as the platform moves. The product is bonded as the process progresses. Eventually the resulting product solidifies. (Formlabs 2018)

Speaking of the types of filaments used in this process, there are quite a few, but they all have different properties for different purposes. (Pei et al. 2015)

3D printing technology has numerous applications in fashion production. With the ability to create models and all kinds of designs, it leads to manufacturers being able to test their products before full-scale production, which ultimately leads to improved product quality overall. Furthermore, it helps reduce the cost of materials and labor for the manufacturer. 3D printing allows for a fully printed fashion item that will result in a product that is customizable to the consumer's own parameters. This technology will guarantee the freedom to customize the size and shape, according to individual needs. 3D printing in the fashion industry also ensures flexibility, strength, ductility, and resilience compared to traditional fashion industry products. (Chakraborty et al. 2020) Discussing in more detail the application of 3D printing technology in the fashion industry, the production of not only clothing and accessories has an impact, but also shoes. Shoes produced with 3D printing technology will also have a significant impact on the fashion industry. Due to the fact that the materials used in 3D printing are quite lightweight, this application is actively considered. In addition, the customization allowed by 3D printing technology will not only provide customers with a more comfortable product, but also a product with individual design and style. (Black 2012). Geometric freedom is virtually unlimited for AM, something no other single process offers. (Campbell et al. 2011).

There are considerable advantages for production using 3D printing. The technical tools used in 3D printing make it possible for the design process to create more advanced prototypes and models, as well as complex models with a plethora of design possibilities. (Melnikova et al. 2014; Yap & Yeong 2014) This is available due to the ability of 3D printing to create different configurations down to 0.01 mm in size (Grothe et al. 2020). This technology minimizes possible waste as it differs from simple machining. (Tekinalp et al. 2014) The utilization of 3D printing technology in the fashion industry also eliminates traditional manufacturing processes such as: fiber preparation, spinning, weaving, dyeing, finishing, cutting, sewing. These speeds up the process of making the product, although it is believed that the printing speed of commercial 3D printers is rather slow compared to traditional textile manufacturing, due to the fact that the length of the production chain of the textile process is significantly reduced, this ensures that the low printing speed of the commercial 3D printers which are currently accessible is

compensated for. (Partsch et al. 2015) Transport costs are also reduced, as a result of the factors described above. In addition, the time taken from the direct creation of the idea to the final product is also reduced, and the amount of the energy consumed by the production process is minimized. (Partsch et al. 2015).

The traditional fashion industry has a certain number of limitations in the form of expensive equipment for the various stages of production, rather complex and time-consuming workflow, high labor costs, high percentage of waste from resources and materials used. However, the use of 3D printing in the fashion industry entails a significant reduction in these limitations, which are quite common in traditional fashion production. Thus, the use of 3D printing in fashion production is quite impressive. (Sun & Lu 2015)

It is worth noting that due to the possibility of freedom of design (Singh et al. 2020), production of flexible materials from solid raw materials (Goncu-Berk 2019), minimization of waste during product manufacturing, possibility of customization of both the manufactured product as a whole and part (Spahiu et al. 2020), 3D printing technology acquires a large number of advantages over traditional manufacturing in the fashion industry.

However, an influential argument in favor of the use of 3D printing in the fashion industry is also the fact that designers have a new impetus to develop and create innovative solutions and products with new features and functionalities. (Kuhn & Minuzzi 2015) This is the result of the fact that production steps such as inventory, warehousing, packaging, and transportation are omitted when 3D printing is used in production, as opposed to traditional production in the fashion industry. Moreover, these factors also contribute to making the production process more cost-effective. (Spahiu et al. 2020; Vanderploeg et al. 2017).

Consequently, 3D printing technology in fashion manufacturing provides an alternative to the need for the high labor intensity, time-consuming creating steps and level of hazard present in the traditional manufacturing method. (Jordan 2019)

While talking more about the benefits of 3D printing in the fashion industry, there is a huge challenge for the textile industry in terms of sustainability. The textile industry is

among the most polluting industries in the world. (Fibre2Fashion 2015) The use of 3D printing in the fashion industry to make production more sustainable is not only a good prospect but is already happening. Julia Daviy has created the Liberation Collection, a collection of nine dresses made using 3D printing technology with the idea of reducing the fashion industry's ecological footprint. According to her, the dresses are not only produced with zero-waste, but are also flexible, comfortable, and suitable for everyday wear. Moreover, by using this production method, the designer hopes to solve the problem of exploitation of female workers in mass production. She received the 2019 Eluxe Award for her design (Vermaak et al. 2021)

Despite the obvious benefits of using 3D printing in the fashion industry, it must be remembered that for it to be used in masse, consumers need to have a positive view of the use of the technology and its products accordingly. It is the producers who may or may not use the technology, and the buyers express their attitude towards it, thus determining whether the producers will implement the technology or not. (Naspetti et al. 2021)

1.2 Consumer perception: Theory of planned behavior

There are various theories that examine and evaluate consumer perception, in particular their attitudes towards new products/new technologies. For example, the Theory of Reasoned Action (TRA), introduced by Fishbein & Ajzen (1977). This theory is based on the assumption that norms, attitudes, which are individual motivational factors, determine the likelihood of a particular behavior occurring. (Ajzen and Fishbein 1980) Nonetheless, in my work I will use the equally common and well-known model, the Theory of Planned Behavior (TPB) which is an extension of the theory of reasoned action, presented by the same author as the model mentioned above by Ajzen (1991). I chose this model for a number of reasons. Firstly, the author has proven how behavior can be predicted and based on those components. Secondly, it is worth highlighting that the theory was selected by me due to the fact that its elements enable us to see what influences buyers' choices. Choice is a reflection of buyers' perception of the technology. The factors presented in this theory represent the buyers' perception of a particular aspect in relation to 3D printing technology (in the case of my research), which ultimately leads to a certain behavior - which choice will be made by them, based on the perception of the technology. Thirdly, when researching various published works, I came across a piece of work examining the attitudes of buyers towards the use of sustainable practices in dairy production. I made an analogy -

sustainable production in the dairy industry has just as many obvious advantages as 3D printing in the fashion industry, but this does not exclude the fact that buyers may have a different view of the use of the technology and its products, which may cause the technology not to be applied in mass production, as there would not be enough demand due to a negative perception towards it because of a lack of acceptance of the innovation, caused by prejudice or cognitive dissonance. (Almli et al. 2011) Through this analogy and the exploration of this paper, I identified that the model used in this paper would be the best fit for my research, revealing the most important aspects and answering the research questions I posed.

This theory consists of certain elements, central to which is 'intention', the intention to perform a certain action. In the particular context of this study, the buyer's intention. It follows from motivational factors, reflecting a person's (the buyer in the given paper context) eagerness to perform an action or exert effort to perform a certain behavior. The theory holds that the stronger the intention to perform the behavior, the more likely it is that the behavior will be performed. It is also worth noting that behavioral intention will only be manifested in a behavior if the behavior is under volitional control. Although some behaviors can indeed be performed on this basis, the performance of most behaviors depends in part, if not entirely, on non-motivational factors represented by the means or opportunities to perform them - money, time, skills, acquaintances, etc.

The combination of these factors constitutes the actual control of a person over his/her behavior. A person who has the necessary components (resources/opportunities) and the intention to implement the behavior must achieve success in its execution. An assumption that the combination of intention and ability is necessary for a behavior to occur is not innate. It has already been applied to various issues.

Perceived behavioral control is also a component of the theory. It corresponds to a generalized expectation that varies in different situations and actions. This leads the individual to believe that, in general, outcomes are influenced and determined by their behavior, but at the same time they may understand the small probability that a particular outcome will translate into reality. In this model, the concept of perceived behavioral control is most comparable to Bandura's concept of perceived self-efficacy, as stated by the

author. It is about the vision a person has about how well they can perform certain actions - whether or not they are confident that they can easily perform a particular action.

The second independent determinant of intention in this theory is attitudes towards behavior. This represents the level of favorable or unfavorable evaluation of the behavior in question. That is, how favoring or unfavouring the behavior is or has been assessed by the individual. The third factor is represented by the subjective norm. It is a social factor, determined by social pressure to do or not to do a given act. Depending on the situation, the influence of these factors may vary. Sometimes all three factors have a contribution, and sometimes only some of them.

This model is quite common in use for various studies, but in this research, it is used to assess Estonian consumers' perceptions of the use of 3D technology in the fashion industry. Therefore, it is worth noting that in the study I have found this model has been modified. In my work, I also use the modified model to obtain more accurate results and a more convenient way of assessing motives of buyers to buy / wear products of the fashion industry with the use of 3D printing technology.

However, it is worth underlining that in the work I found the model was modified and used its version updated by Bredahl (2001) In my work, I also use the modified model to obtain more accurate results and more convenient way of assessing motives of buyers to purchase / wear products of the fashion industry with the use of 3D printing technology.

This modified model has been applied many times in the food sector to make decisions about new technologies. But it fits in with my theme because I also would like to find out how consumers perceive the use of new technology (3D printing technology) in the fashion industry. An addition to help me learn more about buyers' attitudes towards the use of technology is the 2 factors that precede 'attitude towards behavior' (attitude towards technology in the modified model I use) - overall perception of the new technology. Beyond that, one of my research questions is what factors influence a consumer's perception of using 3d printing technology in the fashion industry. Following that it is important for me to identify the factors that will influence consumers' while choosing to wear/purchasing products made with 3D printing technology.

The model I discovered and used also addresses this issue. It is supplemented with an element; the "moral norm". The main factors in the model remain unchanged: intention and attitude. However, the attitude towards the accepted use of 3D printing technology in the fashion industry now contains new criteria: risks and benefits. And the 'norms', which are now 2, represent factors that predict intention, independent of attitude and perceived behavioral control. (Naspetti et al. 2021) The visual representation can be found below in Figure 1.

I have developed the following hypotheses guided by the theoretical material and each of which corresponds to one factor from the model I used:

H1 - The perceived risk associated with the use of 3D printing in the fashion industry has a negative impact on the intention to buy/wear fashion products made with 3D printing technology.

H2 - The perceived benefits associated with the use of 3D printing in the fashion industry have a positive effect on the intention to buy/wear fashion products made with 3D printing technology.

H3 - Consumers' attitudes towards 3D printing technology use in the fashion industry is positively related to their intention to buy/wear the product.

H4 - The more the consumer perceives the influence of society and experts as a positive one towards the innovation, the higher their intention to buy/wear the fashion industry product produced using 3D printing.

H5 - The more customers perceive use of 3 printing in the fashion industry as an action that is consistent with their moral norm, the higher their intention to buy/wear the fashion industry product produced using 3D printing.

H6-There is a strong positive correlation between consumers' perception of behavioral control and their intention to buy/wear fashion products made with 3D printing technology.
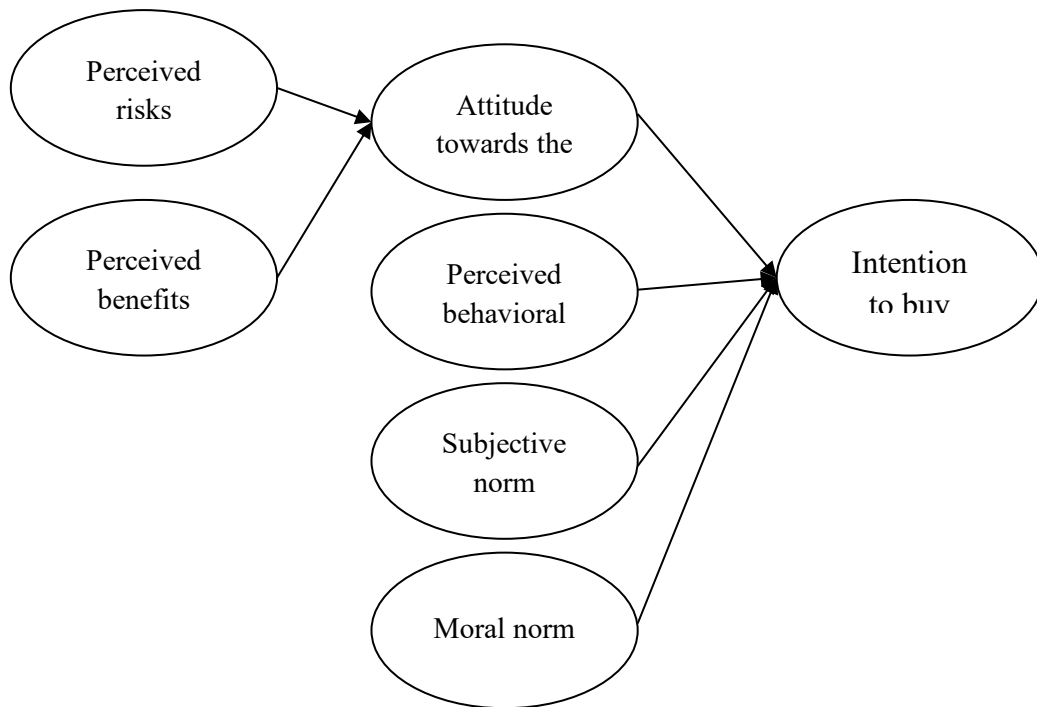
Figure 1.

Source: Naspetti et al. 2021 'Consumer perception of sustainable practices in dairy production'

2.RESEARCH METHODOLOGY

2.1 Research approach

The research design is characterized by a set of methods and procedures describing how, when and where data was collected and analyzed. (Churchill, Brown and Suter, 2013) There are a variety of types and sub-types of research models. Looking at research design in general, it can be divided into two major broad groups - qualitative research and quantitative research. However, I focused on a quantitative method for this study.

As part of the quantitative strand, this study uses a survey type of research. Survey research is the acquisition of information through a sample of the population by responding to questions. (Check and Schutt 2012) Acquiring and capturing information promptly and descriptively from a large sample of people of interest is a key objective of survey research. (Ponto, 2015)

As I mentioned previously, in order to use the current research model, I conducted a detailed literature analysis and examination from a number of sources such as springer open, research gate, science direct, Google Scholar, EBSCO. Examining the literature, I came to the conclusion that very few studies have explored the buyers' perception of 3D printing technology in the fashion industry. In addition, my research explores the vision of Estonian buyers specifically, thus revealing a particular market.

Therefore, the main objective of the study was to examine Estonian buyers' perceptions of the use of 3D technology in the fashion industry on the basis of a widely accepted theory of planned behavior. In particular, the goal of this study was to examine the potential factors influencing the perception of Estonian buyers towards the use of 3D printing technology in the fashion industry (Perceived behavioral control, attitudes towards behavior, subjective norm, perceived risks and perceived benefits of the new technology, moral norm) and what perception Estonian buyers have towards the use of 3D printing technology in the fashion industry as described in my research questions.

2.2 Data collection

For this study, an online questionnaire was developed to obtain the necessary information as well as to test the hypotheses of the study. A reason for my use of this method is that by applying the online questionnaire, the required number of people, regardless of time or location at the time, will be reached. Moreover, it is worth emphasizing that the target group for this study consisted of people who did not require any special skills or knowledge to complete the questionnaire.

This type of information collection also makes it easier and more convenient to retrieve the data from the questionnaire. The process of interpreting the data is also facilitated by the fact that the data is standardized via quantitative analysis (Saunders et al. 2009). I used the Google Form platform to design and administer the questionnaire. The questions were of the closed type, representing a certain number of options from which you can choose the most appropriate one on a scale. At the beginning of the questionnaire, I provided introductory information to the respondents - the purpose of the survey, as well as brief information about 3D printing technology, which allowed respondents to familiarize themselves with the concept if they were unfamiliar with it before. I did this to minimize sampling error and response bias.

The statements for the questionnaire were based on the information I received and the previous study - Consumer perception of sustainable practices in dairy production by Naspetti et al. 2021 and were adapted from the underlying research and theme. The questionnaire consisted of multiple sections. The first part was introductory, presenting examples of fashion products produced using 3D printing and background text for respondents who had not heard of the technology and its application to the fashion industry before the questionnaire. Next, I asked two demographic questions to determine the target group of my sample

For the analysis of the data obtained from the online questionnaire, I used the following programs: SPSS version 27.0 for analysis (a program used for various tests and statistical analysis of data) and EXCEL.

Demographic data in this study was not relevant for hypothesis testing and answering the questions posed. In the sampling method I used, Respondents were selected according to the following mandatory criteria: residency in Estonia.

Social media (Instagram, Facebook) were used to gather information, containing the conditions of the questionnaire and its description. The questionnaire was in two languages: Russian and English for more convenience of respondents. A total of 182 responses were received using the online questionnaire. To measure the six factors (Perceived behavioral control, attitudes towards behavior, subjective norm, perceived risks and perceived benefits of the new technology, moral norm), I used a 5-point Likert scale ranging from (1) strongly disagree to (5) strongly agree. This method of evaluation was applied by me as it allows me to assess the spectacle of the respondent agreeing or disagreeing with this or that statement, which provides an estimate of the respondents' perception.

In the table below you can see the sections (variables) with the corresponding statements that I used in my questionnaire. Table 1 is provided to illustrate the construct I used for the questionnaire and the associated resources and links. It represents the statements used in online-questionnaire. The construct and statements were fully based on the implied theory and the following study - Consumer perception of sustainable practices in dairy production by Naspetti et al. 2021

Table 1.Applied constructs and measures
Source: made by the author

Factor	Code	Measures
Perceived risk	Risk1	Overall, applying this innovation to fashion industry will prove harmful to the environment, the animals, myself, and other people that are important to me.

	Risk 2	If this innovation is used, it will prove to be disadvantageous to the environment, the animals, myself, and other people that are important to me.
	Risk 3	Using this innovation to fashion industry involves considerable risk to the environment, the animals, myself, and other people that are important to me.
Perceived behavioral control	PBC1	If fashion industry products made using 3D technology were available in shops, nothing would deter me from buying them.
	PBC2	I believe in having complete control over the process when it comes to buying/selecting fashion products created using 3D printing
	PBC3	Whether I would buy clothing items produced using 3d printing technology—if available in the stores—is entirely up to me
Moral norm	MN1	Buying fashion products manufactured using 3D printing technology seems the morally right thing to do.
	MN2	Buying fashion products manufactured using 3D printing technology goes against my basic principles
	MN3	Buying fashion products manufactured using 3D printing technology would make me feel like a better person
Subjective control	SC1	Most people important to me would approve of me buying clothing items using 3D printing technology

	SC2	Most people who I value think that it would be a good idea to buy fashion items made with 3D printed technology if they were available in the shops.
	SC3	My family and friends would encourage me to buy fashion products manufactured using 3D printing technology
Perceived benefits	PB1	Overall, the application of this innovation in the fashion industry will prove beneficial to the environment, animals, me, and others important to me
	PB2	Overall, applying this innovation to the fashion industry will be of great benefit to the environment, animals, me, and other people important to me.
	PB3	In general, applying this innovation to the fashion industry will benefit the environment, animals, me, and other people important to me.
Attitude	A1	The introduction of such innovation in the fashion supply chain would be acceptable for me
	A2	All things considered introducing such an innovation in the fashion supply chain is a good idea.
	A3	Applying such an innovation to the fashion industry's supply chain would make sense.
Intention to purchase/wear	ITP1	Considering the above, if 3D printed clothing items were available in shops, I would buy/wear them.

3. RESULTS AND ANALYSIS

3.1 Sample description

The first question was the gender of the respondent. From the responses I received, I found that 56% (102 respondents) were male and 44% (80 respondents) were female. Speaking about the age distribution among the respondents the following results can be reported: 41% (75 respondents) respondents were 18 to 28 years old.34% (61 respondents) respondents were 29 to 39 years old respectively. Of the 182 respondents, 25% (46 respondents) were 40-50+ years old. Therefore, most of the Estonian buyers who took my survey were in the age category of 18 to 28 /years old.

This was followed by a question about pre-survey knowledge of the technology with three options: "Have not heard of it", "Have heard of it, but know very little or nothing about it», «Know enough about it that I could explain it to a friend". This is how I obtained data about the awareness of Estonian buyers in general about 3D printing technology in the fashion industry. Thus, I received data that 39% (70 respondents) of the Estonian buyers I surveyed chose the answer "Have not heard of it" - which means that before this survey they have never heard of 3D printing technology in fashion and learned about it from the information I provided in the questionnaire. However, even though this group of respondents had never heard of the use of 3D printing technology in the fashion industry, they do not become unreliable because they received information about the technology at the beginning of the questionnaire, which allowed them to become familiar with the technology and its application. Moreover, the point of the question was to obtain information about whether respondents were aware of this technology BEFORE they read the information in the questionnaire.

46% (84 respondents) chose the answer "Have heard of it but know very little or nothing about it". This indicates the fact that most Estonian buyers I surveyed have already been exposed to the technology, but their knowledge is relatively low.

Out of 182 respondents I interviewed, 15% (28 respondents) answered "Know enough about it that I could explain it to a friend". From the data obtained, it can be concluded that there is even a sufficient number of respondents who have knowledge about 3D printing

technology in the fashion industry. For greater clarity, you can refer to Figure 2, containing the results of the answers in graphical way. Grey color on the diagram - "Have not heard of it"; Orange color on the diagram- "Have heard of it, but know very little or nothing about it"; Blue color on the diagram - "Know enough about it that I could explain it to a friend"
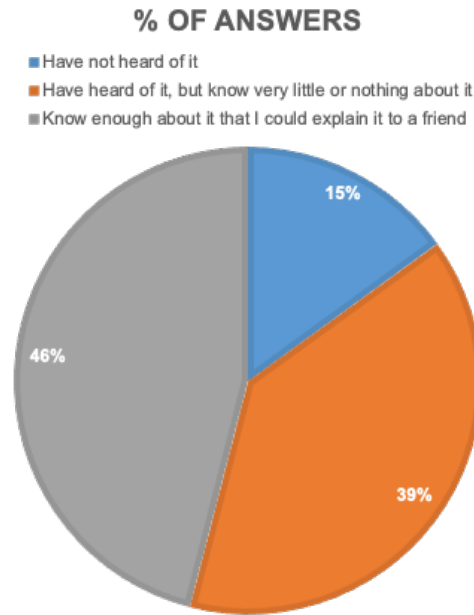

Figure 2. Answers to the question "Have you heard about 3D printing technology in the fashion industry, before reading the information in the questionnaire?"
Source: made by the author

3.2 Received answers

The descriptive statistics of the 19 questions in the questionnaire are outlined in Table 2 before conducting a further analysis of the data from the survey to give a general idea of the data collected. From Table2 we can understand how each statement was rated by respondents on a Likert scale from 1(strongly disagree) to 5(strongly agree).

Table 2. Frequency Table

N=182	1	2	3	4	5
PR1(perceived risk)	21(11%)	48(26%)	59(32%)	36(20%)	18(10%)
PR2	20(11%)	48(26%)	64(35%)	34(19%)	16(9%)
PR3	22(12%)	54(30%)	53(29%)	42(23%0	11(6%)

N=182	1	2	3	4	5
PR1(perceived risk)	21(11%)	48(26%)	59(32%)	36(20%)	18(10%)
PR2	20(11%)	48(26%)	64(35%)	34(19%)	16(9%)
PR3	22(12%)	54(30%)	53(29%)	42(23%0	11(6%)
PB1(perceived benefits)	12(7%)	41(23%)	58(32%)	50(27%)	21(12%)
PB2	11(6%)	42(23%)	60(33%)	48(26%)	21(12%)
PB3	15(8%)	32(18%)	62(34%)	47(26%)	26(14%)
SN1(subjective norm)	9(5%)	22(12%)	63(35%)	48(26%)	40(22%)
SN2	12(7%)	17(9%)	67(37%)	55(30%)	31(17%)
SN3	11(6%)	22(12%)	75(41%)	44(24%)	30(16%)
MN1(moral norm)	4(2%)	18(10%)	66(36%)	60(33%)	34(19%)
MN2	21(12%)	19(10%)	40(22%)	35(19%)	67(37%)
MN3	26(14%)	32(18%)	68(37%)	39(21%)	17(9%)
PBC1(Perceived behavioral control)	18(10%)	24(13%)	54(30%)	41(23%)	45(25%)
PBC2	6(3%)	18(10%)	31(17%)	64(35%)	63(35%)
PBC3	3(2%)	11(6%)	30(16%)	61(34%)	77(42%)
A1(Attitude towards technology)	6(3%)	12(7%)	53(29%)	53(29%)	58(32%)

A2	15(8%)	20(11%)	57(31%)	47(26%)	43(24%)
A3	7(4%)	13(7%)	41(23%)	58(32%)	63(35%)
ITP1	7(4%)	24(13%)	50(27%)	52(29%)	49(27%)

Source: made by the author

3.3 Analysis and results

In order to assess the appropriateness of the data, several statistical tests have to be carried out. The first test performed was to check the factoriality of the correlation matrix. The result provided evidence that none of the correlations exceeded 0.8. This demonstrated that there was no multicollinearity, a linear relationship between the variables.

To ensure that there was no common method bias in my study, I conducted a one-factor Harman analysis. The essence of this is that if the variance extracted by one factor is greater than 50%, then there is general method bias in the study. The result of my test is 33.594%, indicating that my data does not bias the general order, as the number obtained is less than 50%.

In order to test the reliability of the constructed measures in more detail, all factors were analyzed on the basis of internal consistency of reliability. This measure tests correlations between different items of the same test and shows their consistency with the designed model. (Nunnally and Bernstein 1994; Devon et al. 2007) I used Cronbach's Alpha approach for this test. Cronbach's alpha shows that we can categorize these questions into the same group. In most cases, if the calculated Cronbach's Alpha is greater than 0.7, it is considered acceptable. (Allen & Bennett 2012) Referring further to Table 4 indicating that all factors except for Perceived behavioral control and Moral norm (having alpha 0,357 and 0,272 respectively) have a Cronbach's Alpha value above 0.7, which proves the strong internal coherence of the scales used.

Table 4. Reliability statistics-Cronbach's Alpha

FACTOR NAMES	NUMBER OF ITEMS	CRONBACH'S ALPHA
Perceived risk	3	0,905
Perceived benefits	3	0,959
Subjective norm	3	0,823
Attitude towards technology	3	0,974

Source: made by the author

Table 5 shows the correlation between the dependent variable (Intention of Estonian customers to purchase/wear fashion items made with 3D printing technology) and the factors affecting it (Perceived risk, Perceived benefits, Subjective norm, Attitude towards technology)
I have retained only the factors that proved to be relevant after checking Cronbach's alpha (Moral norm and Perceived control over behavior were excluded)

Table 5. Pearson's Correlation

FACTOR NAME	CORRELATION WITH Intention to purchase/wear
Perceived risk	-0,24
Perceived benefits	0,22
Subjective norm	0,631

Attitude towards technology	0,614

Source: made by the author

The first factor - Perceived risk has a reversed correlation with the dependent variable. However, a value of -0.24 is low enough to indicate a weak correlation between Perceived risk and Intention of Estonian customers to purchase/wear fashion items made with 3D printing technology. It can be concluded that perceived risk has a not significant impact with reverse correlation on the intention of Estonian people to purchase/wear fashion items made with 3D printing technology.

The second factor used in my model is Perceived benefits. The correlation value between this factor and Intention of Estonian customers to purchase/wear fashion items made with 3D printing technology is 0.22. This indicates a low positive correlation between these variables. It can be concluded that the Perceived benefits of 3D printing technology in the fashion industry also have a weak effect on the Intention of Estonian customers to purchase/wear fashion items made with 3D printing technology.

The third examined factor is the Subjective norm. This factor has a correlation of 0.631 with the intention of Estonian customers to purchase/wear fashion items made with 3D printing technology. This correlation between these two variables can be called moderate. A Subjective norm that is expressed through the opinion of people who are important to the respondents about their purchase and use of fashion items made with 3D printing technology has an impact on the further Intention of Estonian customers to purchase/wear fashion items made with 3D printing technology. The more confident the respondents were that they would be endorsed by the people whose opinion is important to them, the more likely they would eventually be willing to buy/wear fashion items made using 3D printing technology.

The fourth and last remaining factor applied in my model is Attitude towards technology. The correlation between this factor and intention of Estonian customers to purchase/wear fashion items made with 3D printing technology is 0.614. This value indicates a moderate correlation between these two variables. We can conclude that the better the respondent's

perception and, consequently, attitude towards this technology, the more willing they were to buy/wear fashion items made with 3D printing technology.

4. DISCUSSION

In this chapter, the results obtained from the analysis in the previous chapter will be interpreted and discussed. My research provides insight into Estonian buyers' perceptions of the use of 3D printing technology in the fashion industry. It reveals the factors that influence customers' subsequent intention to wear/buy products made using 3D printing technology. My analyses revealed the most significant perception factors in relation to 3D printing technology used in the fashion industry.

4.1 Hypothesis testing outcome

Based on the analyses I conducted, the values of which are given in the last chapter, the following results on hypothesis testing can be deduced:

H1 -"The perceived risk associated with the use of 3D printing in the fashion industry has a negative impact on the intention to buy/wear fashion products made with 3D printing technology." can be confirmed only partially, as after correlation analysis it became clear that it has an inverse correlation with the dependent variable (intention to buy/wear), but this correlation is weak. Thus, perceived risks do negatively influence Estonian buyers' intention to wear/buy 3D printed fashion products, but this influence is very weak and almost insignificant.

H2 - "The perceived benefits associated with the use of 3D printing in the fashion industry have a positive effect on the intention to buy/wear fashion products made with 3D printing technology." can also only be partially confirmed. As the correlation between perceived benefits and intention to buy/wear 3D-printed fashion products do exist and it is direct, however, its value is very low, which indicates that perceived benefits have almost no influence on the subsequent intention to wear/buy 3D-printed fashion products by Estonian buyers.

H3 - "Consumers' attitudes towards 3D printing technology use in the fashion industry is positively related to their intention to buy/wear the product." was confirmed by me. After tests and correlation analysis, the variable "attitude towards technology" did indeed show sufficient influence on Estonian customers' further intention to wear/purchase fashion

products created with 3D printing technology, due to the fact that the correlation between these variables is direct and moderate. Therefore, I can say that the more positive attitudes customers had towards this technology, the more likely they were to subsequently indicate that they would wear/buy 3D printed fashion products, thereby expressing their positive perceptions of the use of 3D printing technology in the fashion industry.

H4 - "The more the consumer perceives the influence of society and experts as a positive one towards the innovation, the higher their intention to buy/wear the fashion industry product produced using 3D printing." was also confirmed by me. The variable "subjective norm" after passing the tests and correlation analysis proved its direct moderate correlation with the further intention of Estonian buyers to wear/purchase fashion products created with This is evidence that the more confident the respondents were that they would receive approval when buying/wearing 3D printed fashion products from people who were important to them, the more likely they were to subsequently indicate that they would buy/wear 3D printed fashion products. We can also conclude the following: The more Estonian buyers felt certain that they would get approval by people they consider significant to wear/purchase fashion products produced using 3D printing technology, the better their perception of the use of this technology expressed through their intention to buy/wear products produced using this technology.

H5 - "The more customers perceive use of 3 printing in the fashion industry as an action that is consistent with their moral norm, the higher their intention to buy/wear the fashion industry product produced using 3D printing." The hypothesis cannot be confirmed by me because the variable 'moral norm' proved to be insufficiently significant in the concept I applied, its Cronbach's alpha value being too low to be considered significant and assessed further. Hence, it follows that the moral norm has no proper influence on the subsequent willingness of Estonian consumers to buy/wear 3D printed fashion products, thereby also having no proper influence on their perception of the use of this technology in the fashion industry.

H6 - "There is a strong positive correlation between consumers' perception of behavioral control and their intention to buy/wear fashion products made with 3D printing technology." also cannot be confirmed by me. Because the Cronbach's alpha value is too low, which indicates that this variable cannot be considered valuable for the model I used.

4.2 Findings

An essential consideration is that the use of 3D printing technology not only makes the experience of using a product more user friendly, but it also provides more economical production of fashion products, in addition shortening the product chain. This benefits not only customers, but also creators and designers. Bringing more freedom in creating designs and more unique models tailored to each person's parameters.

While the adoption of 3DP has its own limitations, fashion designers have a number of advantages in using the technology. The ability to 3D scans the body for clothing designers can lead to the elimination of prototyping, as the scanning allows the exact measurements of the person to be entered into the program. A garment or an accessory can then be created exactly to the shape of the body, unaltered, and printed exactly to size (Sun and Lu 2015)

After conducting various analyses and collecting information, it is reasonable to assert that: Estonian buyers mostly showed a positive perception of the use of 3D printing technology in the fashion industry, which was expressed through their intention to buy/wear the fashion industry products produced with 3D printing technology. Speaking about the factors influencing this choice, it can be said that the approval from the people important to the respondents (Subjective norm) and the general attitude towards the use of this technology, influence the decision. Only these 2 factors out of the whole model proved to be relevant in this study. It is reasonable to suggest that the use of 3D printing technology in the fashion industry may be in demand among Estonian buyers, as demonstrated by the results of this study.

According to the results of a recent European Innovation Rating Agency, for the third year in a row, Estonia remains among the strongest innovators, but at the same time has made the biggest leap forward in the last seven years. (Kadi Kolk 2021) Due to this fact and the result of the study, it can be assumed that the use of this technology can gain success in the Estonian market. Buyers' intention to buy fashion products made with 3D printing technology, together with the general trend towards inventiveness in Estonia, may serve as a favorable environment for further large-scale advancement and application of this technology in Estonia, as one of the most innovative countries. This could also serve as an

impetus to promote the technology on the global stage, as was the case with Skype, for example.

CONCLUSION

The results obtained in the study can be applied both theoretically and practically. I studied the influence of different socio-psychological constructs on consumers' perception and intentions for subsequent purchase/wear of fashion industry products produced by 3D printing. In this paper, I studied Ajzen's (1991) Theory of Planned Behavior, which reveals the factors that influence consumer behavior. However, for a more accurate analysis I used a modernized model by Simona Naspetti et al. (2021). The additional factors added to the model made it more detailed. By applying this model in my study, it was possible to determine the factors influencing the subsequent intention to buy/wear 3D printed clothing by Estonian shoppers. According to the results obtained, the following conclusions can be drawn in the course of the study:

1.3D printing technology in the fashion industry is attracting a lot of attention (Brooke 2013), as it has many advantages, such as the elimination of the necessity for customers to struggle with finding the right size clothes and the ability to fit models to their body type at home, prototyping and the ability to develop a variety of designs and models, reduced production chain, reduced production, transportation costs and storage costs.(Chabaud 2015; Kilbert 2016).

2. Buyers' perceptions of the use of this technology have been studied very little, as most researchers focus on application and technological aspects. (Jewon Lyu et al. 2018)

3.Using a modified Theory of planned behavior model to conduct a survey among Estonian buyers about their visions and intentions to buy/wear 3D printed fashion products, I have found through tests and hypothesis analysis that hypotheses H3 and H4 have been confirmed. I found out that Subjective norm, which manifests itself through the approval of significant people to the respondent and Attitude towards technology, implying general acceptance of the use of technology and fashion industry are factors which have a significant influence on the perception and intention to buy / wear fashion products made with 3D printing.

4. An unexpected result was that in hypothesis analysis it turned out that hypotheses H1 and H2 could not be confirmed to the full extent, as the perceived risks and bonuses from

technology did not prove to be influential in the vision of Estonian buyers and intention to buy/wear fashion products made with 3D printing.

5. Hypotheses H5 and H6, responsible for Perceived of behavioral control and Moral norm were also not confirmed, due to the low value of Cronbach's alpha, making further analyses and tests impossible due to the low values of these variables.

6. The majority of Estonian buyers appeared to be ready to wear/buy fashion products made with 3D printing technology when it is presented in the stores, thus expressing their positive vision of this technology. After all, the intention to wear and buy is a direct proof of the positive attitude of buyers to the use of 3D printing technology in the fashion industry.

Despite the results obtained in this study, it has limitations that further research can deal with. First, the relatively small number of respondents to the survey. The higher the sample size, the more accurate the results will be. It would be worthwhile to gather more respondents for follow-up studies, to get a more accurate and detailed result. Secondly, my research is limited to Estonian buyers. For future studies it will be possible to consider more extensive data collected from different European countries. This will make it possible to see a more general trend in Europe. Moreover, due to the novelty of this technology, and the fact that many respondents have heard about it for the first time when taking the questionnaire, it would be valuable for later investigators to conduct a similar study when this technology becomes better known and more widespread in order to compare the results and identify the changes that have occurred.

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APPENDICES

Appendix 1. Questionnaire

This questionnaire is aimed for research on usage of 3D printing technology in fashion.

About 3D printing in fashion: 3D printing technology consists of producing various geometric shapes layer by layer, based on 3D modeling information. This technology is used in a various aspects of manufacturing clothing: creating prototypes, heating fabrics (smart textile) and new forms or designs of things we are used to (like accessorize, jewelry, clothing). It does not require as much water as conventional production, making production more sustainable. It also enables to do more customized product. You can get familiar with examples of 3D printed garments below

1.How old are you
      18-28 years
      29-39 years
      40-50+ years

2.What is your gender?
      Female
      Male

3.Have you heard of 3D printed clothing before reading information in the questionnaire?
      Have not heard of it
      Have heard of it, but know very little or nothing about it
      Know enough about it that I could explain it to a friend

Choose a point from 1(strongly disagree) to 5(strongly agree) according to each statement:

1.Overall, applying this innovation to fashion industry will prove harmful to the environment, the animals, myself, and other people that are important to me.

<center>1 2 3 4 5</center>

2.If this innovation is used, it will prove to be disadvantageous to the environment, the animals, myself, and other people that are important to me.

<center>1 2 3 4 5</center>

3.Using this innovation to fashion industry involves considerable risk to the environment, the animals, myself, and other people that are important to me.

<center>1 2 3 4 5</center>

4.If fashion industry products made using 3D technology were available in shops, nothing would deter me from buying them.

<center>1 2 3 4 5</center>

5.I believe in having complete control over the process when it comes to buying/selecting fashion products created using 3D printing.

<center>1 2 3 4 5</center>

6.Whether I would buy clothing items produced using 3d printing technology—if available in the stores—is entirely up to me.

<center>1 2 3 4 5</center>

7.Buying fashion products manufactured using 3D printing technology seems the morally right thing to do.

<center>1 2 3 4 5</center>

8.Buying fashion products manufactured using 3D printing technology goes against my basic principles.

<center>1 2 3 4 5</center>

9.Buying fashion products manufactured using 3D printing technology would make me feel like a better person.

<center>1 2 3 4 5</center>

10.Most people important to me would approve of me buying clothing items using 3D printing technology.

<center>1 2 3 4 5</center>

11.Most people who I value think that it would be a good idea to buy fashion items made with 3D printed technology if they were available in the shops.

1 2 3 4 5

12.My family and friends would encourage me to buy fashion products manufactured using 3D printing technology.

1 2 3 4 5

13.Overall, the application of this innovation in the fashion industry will prove beneficial to the environment, animals, me, and others important to me.

1 2 3 4 5

14.Overall, applying this innovation to the fashion industry will be of great benefit to the environment, animals, me, and other people important to me.

1 2 3 4 5

15.In general, applying this innovation to the fashion industry will benefit the environment, animals, me, and other people important to me.

1 2 3 4 5

16.The introduction of such innovation in the fashion supply chain would be acceptable for me.

1 2 3 4 5

17.All things considered introducing such an innovation in the fashion supply chain is a good idea.

1 2 3 4 5

18.Applying such an innovation to the fashion industry's supply chain would make sense.

1 2 3 4 5

19.Considering the above, if 3D printed clothing items were available in shops, I would buy/wear them.

1 2 3 4 5

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