YAŞAR UNIVERSITY

GRADUATE SCHOOL

MASTER THESIS

THE RISE OF DIGITAL CULTURE, CONNECTIVITY, AND INTERACTIVITY THROUGH SMART GARMENTS IN THE AREAS OF FUNCTIONAL CLOTHING, HAUTE COUTURE AND CONCEPTUAL FASHION

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COMMUNICATION

PRESENTATION DATE: OCTOBER 2020, IZMIR.

BORNOVA /IZMIR

OCTOBER 2020

BORNOVA / İZMİR
MONTH 20XX

ABSTRACT

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October, 2020

The adoption of a digital culture is widely spread in the society today. The global use of technology has played a huge role in the creation of a digital community whose members have adopted this culture. The members of this community have replaced old forms of media and technology with new media like YouTube instead of television and podcasts instead of the radio. This thesis explains that these new forms of technology have also been brought into the clothing industry thereby extending the digital culture into the clothing industry. Traditional forms of clothing have been modified with technology to form wearable technology and smart clothing. This thesis analyses three different areas of smart clothing which are i. Functional Smart Clothing ii. Fashionable Smart Clothing and Haute Couture iii. Conceptual Smart Clothing. The thesis also analyses how these smart clothing promote the concept of digital connectivity through several ways like digital storytelling and functional technology.

Key Words: digital culture, functional smart clothing, fashionable smart clothing, conceptual smart clothing, wearable technology, connectivity, haute couture, interactivity, global village.

ÖZ

TÜRKÇE BAŞLIK

Soyad, İsim
Yüksek Lisans / Doktora Tezi, Bölümün Adı
Danışman: Dr.Öğrt.Üyesi/Doç./Prof. Dr. Xxx YYY
Yardımcı Danışman: Dr.Öğrt.Üyesi/Doç./Prof. Dr. Xxx YYY
Ay 20XX

Üretim ve servis sistemlerinde kullanılan rassal modellerin analitik çözümleri genellikle benzetim çalışmalarıyla doğrulanmaktadır. Bu çalışma benzetimin ontolojik açıdan doğruluğunu sorgulamaktadır. Paradoksal görünümüne rağmen benzetimin neden ve hangi durumlarda başarılı olduğu ve hangi durumlarda da bir geçerleme yöntemi olarak yetersiz olduğu saptanmıştır.

Anahtar Kelimeler: benzetim, servis sistemleri, üretim sistemleri, rassal modeller, sistem bakışı

ACKNOWLEDGEMENTS

First of all, I would like to thank my supervisor Gizem Kiztunali for her guidance and patience during this study.

I would like to express my enduring love to my parents, who are always supportive, loving and caring to me in every possible way in my life.

Lawal Hauwa

İzmir, 2020

TEXT OF OATH

I declare and honestly confirm that my study, titled "THE RISE OF DIGITAL CULTURE, CONNECTIVITY, AND INTERACTIVITY THROUGH SMART GARMENTS IN THE AREAS OF FUNCTIONAL CLOTHING, HAUTE COUTURE AND CONCEPTUAL FASHION" and presented as a Master's Thesis, has been written without applying to any assistance inconsistent with scientific ethics and traditions. I declare, to the best of my knowledge and belief, that all content and ideas drawn directly or indirectly from external sources are indicated in the text and listed in the list of references.

LAWAL HAUWA

Signature

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November 2, 2020

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

The merger of technology and wearable brings a new definition to the idea of clothing. As Kirstein et al. (2005) describe, clothing is an environment that we need and use every day (pp. 177-197). Clothing is special because it is personal, comfortable, close to the body, and used almost anywhere at any time. The societal idea of clothing has taken a new direction leaving behind the idea of clothing as only a simple piece of fabric used to protect the body from external elements and headed towards the addition of extra functionalities to clothing.

In previous years, technology in the clothing industry focused mainly on the production and manufacturing aspects of the garment. Tyler (2009) writes that "technology is employed primarily to do things that cannot be done on basic machinery but to reduce cost and improve quality and to reduce the requirement for human skill" (p. 2). Tyler (2009) continues to write that fashion trends are rarely technology-led which means that technology started and stopped with the production process (p. 2). Fashion trends had nothing to do with technology. However, the relationship between clothing and technology has transcended beyond the manufacturing process and is present in design and user experience. The result of the merger of technology and clothing has emerged to form "Wearable Technology" or as McCann and Bryson (2009) call it, "Wearable Computing". For the purpose of this thesis, I will address this term as 'Wearable Technology'.

McCann and Bryson (2009) define a wearable technology as a "computing device assembled in a way which allows it to be worn or carried on the body while still having the user interface ready for use at all times" (p. 4). Mann (1996) postulates that wearable technology will enhance our "capabilities without requiring any conscious thought or effort" (p. 23). Beloff and Seymour (2008) write that wearable technology "will take the interface into the real world both literally and metaphorically, as our bodies become the interface" (pp. 131-140). The history of

wearable technology shows that the concept underwent several stages and forms and struggled with the concept of "wearability" before it finally evolved into a seamless merger of technology and everyday clothing. According to McCann and Bryson (2009), one of the earlier examples of wearable technology was bulky camera equipment that could be worn on the body but this wearable technology remained physically restricting (pp. 6-7).

Feasible and unobstructed wearability of technology only emerges when wearable computers are merged with smart textiles to form "Smart Clothing". According to Mann (1997), smart clothing is the combination of wearable multimedia computing, personal imaging, and wireless communications, into a rig that is comfortably worn in an active "always ready" mode (p.164). Cho (2009) describes smart clothing as a "smart system" capable of sensing and communicating with the environment and the wearer's conditions and stimuli (p. 2).

Although smart clothing is a form of wearable computers, the two are not the same. The factors that distinguish smart clothing from wearable computers are comfort, wearability and to a certain extent, aesthetics. The emphasis of these factors in smart clothing is what is missing in wearable computers. Although the two possess sensing and communication capabilities, Bartfield et al, (2001) state that smart clothing emphasizes the important features of clothing like wearability. McCann and Bryson (2009) suggest that for a clothing to be regarded as smart or intelligent, the addition of technological hardware must not alter the traditional features of the clothing (p. 5). Adding to that, Cho (2009) quotes Kirstein et al. where they state that people prefer to wear textiles since they are more flexible, comfortable, lightweight, robust, and washable (p. 2). To make smart clothing comfortable, it is necessary to embed electronic functions in textiles so that both electronic functionality and textile characteristics are retained. Smart clothing should be easy to use, maintain, and should be washable like ordinary textiles. Therefore, combining wearable technology and clothing/textile science is essential to achieve smart clothing for real wearability. Hence, smart clothing takes all the features of the traditional idea of clothing and embeds sensors and intelligence to make the clothing more responsive. Instead of a dormant body, smart clothing uses the body as an interface and a mode of communication between the wearer and the environment. In the thesis, I will refer to

the more modern form of wearable technology as 'smart clothing'. I will also use the term smart clothing as a general term throughout the course of this thesis.

Through technology, smart clothing appears to have extended the "Digital Culture" into the fashion industry. Technology is changing the way we interact as human beings. It is changing the way that we behave, think, and communicate within the society. In the context of this thesis, I aim to explore how technology is changing the clothing industry by building a digital culture through smart clothing. Prior to the emergence of smart clothing in the industry, technology was only present during the production process of clothing (Godley, 1997) but with the entry of smart clothing, technology has reached the wearer. Digital culture has been extended into the fashion industry and clothing has taken on other functionalities other than the protection of the body.

As Deuze (2006) writes, although digital culture has been referred to by many names; "cyberculture" (L´evy 2001), "interface culture" (Johnson 1997), or "virtual culture in cyber society" (Jones 1998), Manovich (2002) conceptualized it as "an information culture as manifested in the convergence of media content and form, of national and cultural traditions, characters, and sensibilities, as well as a mixing of culture and computers" (np).

As digital tools have brought in new forms of interaction, smart clothing is also doing the same in the clothing industry thereby furthering a digital culture. Digital tools like the internet and social media platforms have altered the way in which people interact and connect with each other and similarly, smart clothing has forged several ways in which people can interact with each other through their clothes. A specific feature of digital culture is "remediation": the blending of the old and the new to form a new digital culture (Deuze, 2006, pp. 63-75). To illustrate, traditional journalism has adopted digital features and transformed into online journalism. Social networking sites like YouTube use the concept of television but made it mobile to facilitate constant connection to the rest of the world. In his concept of the "Global Village", McLuhan (1989) posits that through the internet, the world is linked and we are able to connect and have conversations with people thousands of miles away, even faster than we hear the news from the people that live with us in the same home. McLuhan argues that it is the speed of these electronic

media that allow us to act and react to global issues at the same speed as normal face-to-face verbal communication. As McLuhan (1967) states, "'Time' has ceased, 'space' has vanished. We now live in a global village. A simultaneous happening" (p. 63). McLuhan (1964) explains that in the electric age, when our central nervous system is technologically extended to involve the whole of mankind and to incorporate the whole of mankind in us, we necessarily participate in the consequences of our every action (p. 4).

Remediation exists in the area of smart clothing where the concept of clothing has been re-defined to involve technology that connects the wearer to the rest of the world. I hope to examine how smart clothing in fashion has brought changes to the general digital culture and how this culture extends into the clothing industry. With this thesis, I hope to break down and explore the various aspects of smart clothing in various fields and how they have been utilized by various designers. The thesis breaks smart clothing into three aspects; fashionable smart clothing, functional smart clothing, and conceptual smart clothing. These aspects will act as the main research of my chapters as I explore the different purposes they serve and how they further strengthen a digital culture in the clothing industry. This thesis will also highlight the concept of "connectivity" and how the various aspects of smart clothing explored in thesis aim to connect people across the digital space.

In the first chapter of this thesis, I explore and research the area of "Functional Smart Clothing". In the context of this thesis, functional smart clothing refers to the garments produced majorly to perform specific functions that serve to aid the wearer. The functions could be related to sporting activities, healthcare, or even military purposes. Functionality has been introduced into clothing where the main purpose of the garment goes beyond sheltering the body and garments are produced to cater to specific functions rather than for aesthetic purposes. In many cases, the primary concept of clothing which is comfort and wearability has been merged with functional purposes to make these functional smart clothing comfortable on the body of the wearer. One of the functions of this form of smart clothing is connectivity. I explore how people are connected to each other and to their own bodies through the use of functional smart clothing.

The second chapter of the thesis will cover "Fashionable Smart Clothing" which refers to garments made with the intention of being fashionable yet are created with the use of smart materials. I aim to explore how these designs merge *haute couture* and fashion with smart clothing. In her designs, Iris Van Herpen employs the use of smart textiles and 3D printing which makes the garments smart yet fashionable. I explore how these techniques by Van Herpen serve to connect and influence other designs within the fashion industry and ultimately further the digital culture within the clothing industry. Connectivity through this form of smart clothing may not be as obvious as the connectivity achieved with functional smart clothing but in this chapter, I explore how connectivity is achieved among some designers and consumers of fashionable smart clothing.

The last chapter of this thesis will explore "Conceptual Smart Clothing" and the designs by Hussein Chalayan. In the context of this thesis, I explain conceptual smart clothing as garments made with smart materials but are also created to explain or define a concept. The designs by Chalayan carry a strong message that is usually passed during the presentation of his designs. Through his conceptual fashion shows, Chalayan harnesses the power of technology, architecture, aerodynamics, and bodily form to bring a narrative to the audience. With the use of digital tools, Chalayan also tells stories through his designs. This could be referred to as "Digital Storytelling", the art of telling stories with a variety of emergent new forms of digital narratives such as web-based stories, interactive stories, hypertexts, narrative computer games, etc. Hillary McLellan (2006) explains that "digital storytelling offers a powerful framework for incorporating media, in combination with stories, into educational practice" (p. 26). Chalayan uses his conceptual smart clothing to feed his audience personal stories. In this thesis, I will explore many designs by Chalayan that strengthen digital culture in the clothing industry and how Chalayan has used the concept of storytelling to achieve connectivity among people.

In addition to the various aspects of smart clothing, I will discuss how connectivity has contributed to the digital culture in fashion. Connectivity is of great importance in the digital space. As new forms of technology emerge, people are bridged together and brought even closer to each other. The internet and digital tools connecting us are everywhere from the streets, offices, to our own homes. The

presence of digital tools has brought an increase in connectivity among humans from various parts of the world. Although some forms of connectivity were achieved through the use of traditional media like radio and telephone wires, the level of connectivity has increased exponentially with the advent of new media also known as digital media. Logan (2010) describes new media as "those digital media that are interactive, incorporate two-way communication and involve some form of computing" (np). He continues to write that new media is "very easily processed, stored, transformed, retrieved, hyperlinked and, perhaps most radical of all, easily searched for and accessed" (np). This definition given by Logan describes the various forms of digital media available today.

With the presence of new media, the level of connectivity among people has risen and digital connectivity has brought people closer than ever before. The virtual communities that have formed and developed since the advent of the internet are firmly embedded in the idea of connectivity among people from various parts of the globe. It is the power of connectivity that brings and keeps people together further solidifying the digital community.

According to McLuhan (1964), the internet has succeeded in extending connectivity beyond ourselves to the outside world and all over the internet making the world into a global village (p. 3). Should the concept of connectivity be taken out, virtual societies may crumble and disband. In the introduction to McLuhan's *Understanding Media* he writes:

> Today, after more than a century of electric technology, we have extended our central nervous system in a global embrace, abolishing both space and time as far as our planet is concerned (1964: p. 3).

In this era, the subject of digital connectivity is immediately and inherently linked to social networking platforms. In his book, *The Culture of Connectivity: A Critical History of Social Media*, Van Dijck (2013) writes that a new infrastructure for online sociality has emerged to drive connectivity and merge the offline world with the one online (p. 4). Van Dijck (2011) continues to give a more general idea of the culture of connectivity when he writes that;

> It is a culture where perspectives, expressions, experiences, and productions are increasingly mediated by social media sites. The culture of connectivity manifests itself particularly through platforms such as YouTube, MySpace, Facebook, Twitter, and others (p. 402).

While it is true that the internet has built a digital community and fostered connectivity among millions of people around the world, I argue that digital culture is gradually being extended into the fashion industry and this culture is formed and strengthened through the use of technology in the designs. Several researchers like Van Dijck (2013) have written about the rise of digital connectivity through the use of social media and how the need for connectivity drives people to these sites in millions (p.4). Although the use of the internet, social networking platforms, digital video games, and other forms of digital tools has contributed to this rise in digital connectivity, other forms of technology have furthered this digital connectivity. With this thesis, I aim to explore the extension of digital connectivity through the use of smart clothing. Some of the aspects I aim to explore are how connectivity is achieved through functional smart clothing, fashionable smart clothing, and conceptual smart clothing.

In this thesis, I will discuss the use of smart clothing in various sectors within the clothing industry and how they contribute to various forms of digital connectivity. This thesis shall explain the roles functional smart clothes, fashionable smart clothes, and conceptual smart clothes play in fostering connectivity.

'Functional smart clothes' are required to go beyond the general purpose of sheltering the body. In an article titled *What are smart clothes*, Stephenson (2020) defined smart clothes as "high tech clothing, smart garments, smart wear, electronic textiles, smart textiles, e-textiles, monitor clothing, or smart fabrics, are clothing items that have been enhanced with technology to add functionality beyond that of the traditional use" (np). These smart clothing could be referred to as functional because they do not only protect the body from external elements but also add extra functionality to clothes. By analysing functional smart clothing, I hope to explore how these clothes contribute to connectivity and the development of a digital culture in the fashion industry.

Fashionable smart clothing may not be as functional as the functional smart clothing mentioned above but through fashionable smart clothing, digital connectivity is achieved in a different way. The use of technology in the fashion industry has gone beyond the production and manufacture of clothes, there is a shift from the use of technology during production to the presence of technology in the user experience of clothing. With the use of 3D printing to produce fashionable smart clothing, the producers and consumers of the fashion industry are digitally connected. In subsequent chapters, I will explain 3D printed collections, especially those presented by Iris Van Herpen and the role that 3D printing has come to play in building connectivity and a digital culture within the fashion industry. Through 3D printing, Van Herpen has contributed to this connectivity.

With conceptual smart clothing, Chalayan uses connectivity through his designs in ways that can be functional yet personal. Chalayan is renowned for his 'intellectual' and conceptual approach to fashion and fashion shows (Anderson, 2000, p. 229-230). The designer fuses fashion with arts, technology, and culture. His conceptual fashion shows are known to tell stories, either about the body, or emotions, or culture. Evans et. al (2005) and Violette (2011) agree that Chalayan is also a politically engaged designer who combines modernist themes such as technological process with reflections on migration, cultural identity, religion, social changes, and war (np). Chalayan's designs introduce a digital culture that fosters connectivity in the fashion industry and through this; it is worthy to note that Chalayan is one of the designers building a digital culture in fashion.

With this thesis, I aim to fill the gap that has failed to be understood in academia which is to understand the gradual transformation of wearable technology from unconventional and complex clothing pieces into: 1. functional smart clothing 2. fashionable smart clothing 3. conceptual smart clothing. I hope to understand the role digital connectivity within the clothing industry. This thesis serves to explore and understand how clothing has influenced digital connectivity and the part that smart clothing has played in the development of a digital culture in the fashion industry. Bearing all of this in mind, I hope to answer the following questions;

Research Questions

1. How has smart clothing contributed significantly to a digital culture in fashion and the clothing industry?

2. Will smart clothing come to be seen as more every day wear within the rising digital culture in fashion and the clothing industry?

3. How does wearable technology in fashion and the clothing industry contribute to connectivity and interaction amongst people in this digital age?

Research Methodology

For the purpose of this research, the qualitative research method will be employed. Qualitative research is inductive in nature, and the researcher generally explores meanings and insights in a given situation (Strauss & Corbin, 2008; Levitt et al., 2017). As outlined by Stakes (2010), a qualitative study is appropriate when the goal of research is to explain a phenomenon by relying on the perception of a person's experience in a given situation (np). Polkinghorne (2005) explains that qualitative research help to understand the social world in which we live, and why things are the way they are (np). Due to these reasons, a qualitative method of analysis may be the most appropriate method to be used in the analysis of the various aspects of smart clothing and connectivity among users of digital technology.

Qualitative study was performed using the case study theory methodology. This research explores multiple case studies in order to answer the research questions posed in this thesis. According to Sturman (1997), "a case study is a general term for the exploration of an individual, group or phenomenon" (pp. 61-66). Creswell (2009) defines case study as an in-depth exploration of a program, an event, an activity, a process, or one or more individuals (np). Case studies are considered as quantitative or qualitative research depending on the researcher but in this thesis, the cases studies are comprehensively analysed using the qualitative method of research.

Several case studies were used in this research to answer the research questions listed above. In this thesis, several aspects of smart clothing are analysed. Firstly, functional smart clothing is explored along with its link to connectivity

within the digital space. Several examples of functional smart clothing is given and analysed to determine the connectivity aspect. The wearable and comfortable aspect of these functional smart clothing are also analysed and compared to wearable technology in the past. The study critically looks at some of these functional smart garments and how they further connectivity and contribute to a digital culture within the clothing industry.

In the aspect of fashionable smart clothing, the case of designer, Iris Van Herpen, is studied. Van Herpen harnesses the use of 3D printing and smart textiles to create fashionable smart clothing. According to the research, Van Herpen's designs may not be functional but they are regarded as fashionable smart pieces. Through this, Van Herpen has succeeded in contributing to the digital culture in the clothing industry. Van Herpen's use of 3D printing technology has also led to connectivity with other designers, influencing them to create designs with the use of smart textiles. Danit Peleg is one of the designers heavily influenced by Van Herpen's use of 3D printing.

The last case analysed in the process of this research is Hussein Chalayan's conceptual smart clothing and his use of storytelling. The research showed that Chalayan uses the concept of storytelling in the creation of his smart garments. A few of his creations were analysed in the research and Chalayan was found to contribute to digital storytelling within the fashion industry as he uses digital tools to tell his stories.

While conducting this research, online observation and library research were the only factors considered. This research does not include interviews from the designers or consumers of smart clothing. The content of the research was mainly sourced from secondary interviews and the observation of the digital space and the effects of smart clothing on the digital space.

A Brief Introduction Of Connectivity Through Today's Functional Smart Clothing.

Photographer, Steve Mann (1996) revealed that when he first experimented with smart clothing in the early 1980s, the combination of human and machine looked quite strange and socially awkward (p. 23). However today, sensors and

hardware have been carefully embedded into clothing such that the clothes are comfortable and wearable while carrying out smart functions.

Although smart accessories like smart watches and smart glasses are popular and widely used, technology has begun to show up in fashionable items of clothing. Some brands have collaborated with technology companies to come out with their own version of functional smart clothes. One of such brands is *Levis* and Google in the creation of a smart jacket. In 2020, *Lifewire* published the latest forms of functional smart clothing currently available to the public. The *Commuter x Jacquard* is part of a collaboration between *Levi's* and Google. This non-stretch denim jacket connects to your smartphone via Bluetooth and can screen phone calls, control music volume, and even get you directions by tapping or brushing the sleeve (Lifewire, 2020). With this Jacket, there is a connection between the body and the jacket that goes beyond the sort of connectivity a traditional jacket will provide. The jacket assists the wearer with screening calls thereby controlling the connectivity of the wearer with the world. According to Lifewire (2020), a brush of the sleeve assists the user with directions. This simply shows the connectivity that the jacket has fostered using technology and the body of the wearer.

Another example of functional smart clothing is the NadiX yoga pant. Lifewire (2020) writes that the NadiX yoga pant is high tech clothing that can sense when your yoga pose needs refining and use haptic feedback to create small vibrations on the body part you need to adjust (p. 1). The pants connect to the Nadi X iOS app which offers instructions on how to optimize each pose in addition to proper yoga flows which can be used to curate your own personal yoga class (Lifewire, 2020). Unlike the Levi Jacket explained above, these pants do not seek to connect the wearer with the external world but with the body of the wearer itself. It fosters a form of connectivity between the body of the wearer and the wearer itself that goes beyond traditional forms of clothing. The yoga pants in collaboration with an iOS app tells the wearer which part of the body needs to be adjusted, informing the wearer about her own body. This is a form of connection that could not be achieved with regular forms of clothing.

A Brief Introduction Of The Use Of 3D Printing By Iris Van Herpen

Iris Van Herpen is one of the fashion designers spearheading the birth of digital culture in fashion and *haute couture*. The designs from Van Herpen suggest that she is forging a path that is seldom explored in the fashion industry. Van Herpen uses a combination of unique materials in the process of her designs. She finds new unfamiliar materials and discovers her own unique structures and shapes through them. As mentioned by Hemmings (2019), Van Herpen's earlier works often relied on low tech solutions with the sheer simplicity of their creation as part of their wonder. *Chemical Crows* (2008) for example, makes use of cow leather and the metal ribs of children's umbrellas to create a garment that looks like it should be worn by a Samurai warrior (p. 288). Gradually, Van Herpen started to incorporate more sophisticated technology into her designs through the use of 3D printing. Her first wearable 3D printed dress dubbed The *Black Drape Dress*. Kuhn & Minuzzi (2015) state that Iris Van Herpen was the first designer to bring 3D printed pieces to the runway (p. 5). They continue to state that at the Amsterdam Fashion Week in 2010, Van Herpen presented her *Crystallization* collection which also had 3D printed pieces as part of the collection (p. 5). Although Van Herpen uses technology in her designs, they can still be regarded as *haute couture* because the designer also uses her hands in the production of her pieces as *haute couture* demands. The *Crystallization* collection, as Hemmings (2019) writes was inspired by 'the bathtub', a nickname given to the extension of Amsterdam's Stedelijk Museum. While working on the *Crystallization* collection, Hemmings continues to state that Van Herpen's initial attempt to use digital printing to make a realistic splash of water was eventually solved by hand, taking a hot air gun and pliers to PET (thermoplastic resin from the polyester family) to create a dramatic collar for the collection (p. 289). This shows that although Van Herpen relies on technology to print her pieces, the designer still uses her hands in the production of her pieces. Hence, her designs retain their status as *haute couture*.

As the first designer to bring 3D printing to the runway, Van Herpen successfully bridged the creative gap between fashion and technology. Van Herpen broke away from the use of traditional fabrics and explored new perspectives in the creation of print and textiles and by so doing, set a trend for future designers who plan to tow the path of 3D printing. Iris Van Herpen seeks to create a digital culture in fashion and to further the idea of connectivity within the digital space. After the

presentation of her 3D printed collection, more designers have experimented with 3D printing and presented pieces on the runway. Tania (2017) argues that Van Herpen has inspired designers like Francis Bitonti, Karl Lagerfeld, and Danit Peleg (p. 49). She continues to state that Israeli fashion designer, Danit Peleg used a home printer to create five garments for her graduation collection and Danit Peleg became the first designer to showcase an entire collection with 3D printing (p. 49).

A Brief Introduction Of Digital Connectivity With The Use Of Storytelling

Although the concept of connectivity requires a community of people, the concept is also deeply personal. To achieve connection, something must be shared on a personal level. Social networking sites are teeming with people who are connected from all parts of the world however, within the networking sites, there are various niches and people do not establish a connection unless there is a common ground. For example, YouTube users will follow a cooking channel because they are interested in cooking shows or recipes. Similarly, Twitter users will follow their city's Mayor on Twitter because they need quick updates on policies. In the process, a connection is formed furthering connectivity in the digital space.

According to the University of Wollongong, digital storytelling can be described as a "multimedia presentation combining a variety of digital elements within a narrative structure" (np). Hussein Chalayan is a designer that fuses storytelling with technology to achieve digital storytelling which eventually fosters connectivity. Chalayan brings this combination of technology and storytelling alive when he presented his spring/summer 2007 collection titled *One Hundred and Eleven* (Fig 1.4). The garments in this collection appear to transform through time and these transformations by Chalayan take the audience through times and tells the story of how fashion has evolved and changed through the years.

Anderson (2000) writes that Chalayan is a designer renowned for his 'intellectual' and conceptual approach to fashion and fashion shows (pp. 229–230). This reinforces the argument that Chalayan creates conceptual smart clothing within the fashion industry.

Chalayan's designs also heavily reflect emotion through the use of technology embedded in the garments. Through emotional designs, Chalayan manages to provoke responses by creating a relationship between the garment and the wearer. With the use of technology, the wearer becomes a part of the experience. In collaboration with Intel, UK-based fashion designer Chalayan has produced a series of wearable devices that detect emotions and project them externally for anyone to see. With his collection titled *Room Tone*, Chalayan is able to use the smart accessories to connect with the body of the wearer to detect their stress levels.

Similarly, the designer also explored the use of connectivity through technology in his *Remote Control Dress* which was the first wireless device to be presented as a fully functioning fashion garment (Quinn 2002, p. 365). Explaining the *Remote Control Dress*, Quinn (2002) quotes Hussein Chalayan stating that;

> If you alter the way the body comes across in the space around it, then the body alters everything in the space that affects it. The dress can also be transformed invisibly by the environment. The idea was a technological force between the environment and the person. (p. 365-366)

Chalayan's use of technology, culture, emotions, storytelling and vivid concepts in his design shows a form of connectivity that goes beyond just the digital. Hussein Chalayan's designs connect and communicate on a more personal level with the use of technology. In this highly digitalized world, Van Dijck (2013) believes people are constantly craving a sort of connection and this dives them to social media sites. (p. 4) Van Dijck (2013) continues to explain that "the widespread presence of platforms drives people to move many of their social, cultural, and professional activities to these online environments" (p. 4). With his designs, Chalayan is bringing digital connectivity to people through the clothes they wear. In the introduction to McLuhan's *Understanding Media* he writes, "Today, after more than a century of electric technology, we have extended our central nervous system in a global embrace, abolishing both space and time as far as our planet is concerned" (1964: p.

3). McLuhan was referring to digital media in form of radio, television and the internet. The underlying concept of McLuhan's view of electronic technology is that it has become an extension of our senses, particularly those of sight and sound. The telephone and the radio become a long distance ear, as the television and computer extend the eye by projecting further than our biological range of vision and hearing. Similarly, with the use of technology in his designs, Chalayan has furthered connectivity simply through the use of clothes. Van Dijck (2013) explains that people seek out social media to establish connectivity (p. 4) but with Chalayan's designs, connectivity is already made through the clothes. His designs are the medium as well as the message. Chalayan's collection *Room Tone*, which measures the stress level of the wearer fits into this media theory. In this case, the garment, which is the medium can also double as the message. The message in this case is connectivity and the garment is able to achieve that by itself. Through his medium, which is the conceptual smart clothing, Chalayan also tells stories.

The technology used by Chalayan in his designs establish a digital connection and the use of storytelling establishes and emotional and personal connection among people. Hence, Chalayan is able to establish both digital and personal connectivity through the conceptual smart clothing.

CHAPTER 1: THE EVOLUTION OF FASHION INTO FUNTIONAL SMART CLOTHING AND ITS LINK WITH CONNECTIVITY: INTRODUCTION

Technology is present and useful in many aspects of the human life today. In the 21st century, human beings are surrounded by various forms of technology and it appears to take on more functions as times goes on. Before the internet, people had to walk to the newspaper stand or wait for the newspaper to arrive to read the news but today, news is right at our fingertips through the use of a smartphone and the internet. Although technology is embedded in different parts of our daily lives through our smart gadgets that take on several functions, technology has been taken a step further and is now being embedded in the clothes that we wear. Temessek (2020) writes that as the barriers between technology and humans become thinner, innovation becomes embedded in our everyday life not through an external computer

but on our wrist or even embedded in our clothes (p. 2). In this chapter of the thesis, I hope to explain the relationship between technology and clothing and how clothing has come to take on several functions which transcends clothing of the body. The functions will be thoroughly explained in this chapter with examples. This chapter also aims to explain how digital connectivity is achieved through these functional clothing and how this has contributed to the digital culture.

Clothing takes on several roles and functions but the first function of clothing is to protect the body of the wearer. Ross (2008) writes that the Germans describe the function of clothing as a means of protection. Clothing serves as a means of protection against elements like weather (p. 6). As weather and climate change, clothes need to adapt to the change to protect the body of the wearer. Ross (2008) continues to explain clothing as a form of modesty and how relative the concept could be in different societies (p. 6). Although the first function of clothing is to protect the body from the external environment, it is also used as a tool for modesty and adornment as seen in various religions and cultures. According to Ross (2008), in some societies, modesty could mean only the coverage of the private area and in others, especially religious societies; it may translate into the full coverage of the body (p. 6). In the last aspect which relates clothing to ornament, Ross (2008) explains that although it differs throughout centuries and societies, clothing has always been a form of adornment of the body (p. 7).

In various cultures and societies, clothing is seen as a means of adorning the body. In many cases, clothes are being made specifically to adorn the body of the wearer. Cordwell and Schwarz (2011) support this argument when they describe clothing as a means of adorning the body. They write that it complements the body as well as attach a sense of worth to the wearer (p. 9). The Veblen Effect is one of the theories that prove this. According to the Financial Express (2020), The Veblen Effect simply means spending of money on luxury goods and services to display financial power (np). Sometimes, clothes are bought and worn to show off a display of wealth and higher social standing.

Other than a means of protection, adornment and modesty, clothing has also been used as a tool of communication and connectivity. In many social gatherings, clothing can communicate the social status of the wearer and how other people

approach them. Cordwell and Schwarz (2011) also write that clothing is functional in communication and informing people of the social status of the wearer (p. 9).

1.1 The Merger Of Clothing And Technology

Although technology has come to be embedded in clothing, the role of technology in the clothing industry started in basic production. Godley (1997) writes that the first role technology had to play in clothing was through the production and manufacturing (p. 7). Godley (1997) describes fabrics used for clothing as limp and light (p. 6). This shows the malleability of clothing. Even today, many of the clothes we wear could be tossed into the machine and spun several times without affecting the texture of the clothes. Godley (1997) linked early clothing to soft, wearable material but this may not be said about early wearable technology.

While describing early "Wearable Technology" in the late 1970s and early 1980s, Mann (1997) writes that they consisted of a backpack-based, tether less computer system together with wireless communications. (pp. 21-27). In a previously published article, Mann (1996) stated that wearables were physically and socially awkward due to the obvious presence of hardware on the body (p. 23).

Mann's explanation is in stark contrast to the descriptions of clothing by Godley. Godley (1997) describes clothing as limp and malleable (p. 6) but Mann (1996) describes the combination of clothing and technology to form wearable technology as physically restricting, rigid and awkward. (p. 23). Mann (1996) writes that;

> When I first experimented with wearable computing and wireless communications, people thought some of the apparatus I wore looked quite strange, so I didn't wear it much; it was both physically and socially awkward. People were shocked by the visceral combination of human and machine. (p. 23)

Wearable technology which is the unique combination of technology and clothing is said by Smitheram et al. (2017) to be an "interdisciplinary domain drawing from areas including engineering, material science, physiology, textile

design, and human-computer interaction design (HCI)" (p.1). Dr Lamontagne (2017) also described wearable technology as "electromechanically enhanced garments with the ability to process and receive information, sense the body or environment, and thus create effects" (p. 8).

As already described by Mann (1996), technology is linked to hardware. The presence of a bunch of cables, antennas, and inflexible material makes it look obvious when worn on the body. In many cases, technological gadgets cannot be washed and hung to dry like the clothes; instead another method of cleaning is used.

Adding to the differences between clothing and technology, early technological devices like the computer or radio could not be linked to the skin, instead, they served as separate entities. As stated earlier, the function of clothing was to protect and adorn while the function of early technological inventions like radio or the internet was to communicate and connect. Technological devices served a purpose that was not directly related to the skin as clothing was.

While a key function of clothing which is to protect the skin from extreme conditions may change as the weather changes, technological devices do not. For example, a gadget may not lose its functionality due to the weather. A person may have to trade their bikinis for a trench coat as summer turns to winter but a radio works just fine throughout the seasons.

Over the years, heavy bulky wearable computers have been integrated into clothing to make it seem as unobtrusive as possible. Mann (1997) supports this statement when he writes that wearable technology has been transformed from an awkward burden into a completely unobtrusive internet-connected multimedia computer built into ordinary clothing. (p. 21). Steve Mann distinguishes between smart clothing and wearable technology when he explains that the wearable technology has transformed from bulky and heavy clothing into smart clothing which is lightweight, comfortable, and wearable. Mann (1997) describes this as "Smart Clothing" and further explains that smart clothing allows technology to be constantly worn creating a new form of social interaction and connectivity. (pp. 21-27).

Comparing smart garments to wearable technology, Dunne et al. (2005) state that wearable technology are "body mounted devices traditionally more focused on assuming the kind of information processing tasks performed by desktop or portable computers" while smart clothing are "garments integrated with devices that augment

functionality of the clothing or which impart information processing functionality to a garment" (p. 8). This definition of smart clothing by Dunne et al. (2005) clearly incorporates the importance of clothing and unlike wearable technology that simply mounts the device on top of the clothing and is assumed to be separable, smart clothing is a concept that embeds the technology in the clothing.

The function of clothing as a means to protect the body mentioned by Godley (1997) is met. The clothing retains its primary function to protect the body and the technology only serves to improve functionality of the clothing. According to Dunne et al (2005), smart clothing has been made more flexible with emphasis on the clothing to prevent the technology from being too obvious or awkward on the body of the wearer. (pp. 1-11). According to Mann (1997), wearable computing posed a problem in its early stages because it had no attributes of comfort and wearability attached to it, it was simply too rigid to be maneuverer, however, this problem has been solved with the introduction of smart clothing which he describes as a form of 'existential media' (pp. 21-27). While the industry has overcome this challenge of how to wear technology, the next challenge according to Tomico et al. (2017) is to proffer solutions on how to enhance "social adoption and cultural relevance" (pp. 1-6).

1.2 McLuhan, Technology And Connectivity

What the world lacks in terms of physical connections, it has made up for in the sphere of digital and social connection. The invention of the internet and digital tools has led to an interconnectivity that has become a social norm. Like McLuhan predicted in his book, *Understanding Media: The Extensions of Man* (1994), the world has become a global village with the media abolishing the concept of time and space.

McLuhan (1964) suggests that news is coming to us at a much faster rate through the use of media. Gone are the days when news was not quite immediate and had to travel over long distances before reaching a group of people. With electronic media, news is disseminated across the world reaching millions of people in a blink. McLuhan (1964) writes "as electrically contracted, the globe is no more than a village. Electric speed at bringing all social and political functions together in a sudden implosion has heightened human awareness of responsibility to an intense degree" (p. 5).

Yet another concept McLuhan explored in his theory is how electronic technology has become an extension of ourselves. McLuhan (1964) writes "today, after more than a century of electric technology, we have extended our central nervous system in a global embrace, abolishing both space and time as far as our planet is concerned" (p. 3). The telephone is an extension of the ear, the television an extension of the eyes, the internet, an extension of the self and in the case of smart clothing, an extension of the body and its functions.

McLuhan explores the concept of connectivity when he claims that the internet has abolished the idea of individualism and instead focuses on a community of connected members. McLuhan (1962) states that "electric technology… would seem to render individualism obsolete and… incorporate independence mandatory" (p. 1) McLuhan states that media like telephone, radio, television, computers and especially the internet has made it possible for the world to be interconnected on a global scale. In our highly digitized world, sending and receiving messages through new media has redefined connectivity. It is common to see that even while living in the same space, people would rather connect via media than physically communicate.

Although McLuhan was not around to witness the emergence of wearable technology and the developments that have been made in the area of smart clothing, most of his theories apply to the smart garments being designed and produced today. These concepts by McLuhan are quite visible in the mechanically engineered clothing being integrated into daily use. These smart clothing are pushing for social acceptance and awareness, combining fashion-ability and functionality to bring about interconnectivity within the digital space. In the following sections, I will provide a detailed explanation of how these functional garments have gained social acceptance and how they provide interconnectivity across the digital space. In the following chapters, I will break categorize these functional clothing into three; Healthcare and fitness, military and other forms of functional clothing.

1.3 Connectivity Through Fashion Via Technology: Healthcare And Functional Smart Clothing

In this section, I will discuss functional smart clothing in healthcare and fitness. This section of the thesis has grouped healthcare and fitness because some available smart clothing in the market today simultaneously caters to the healthcare and fitness of the wearer. Furthermore, this section will expand on functional smart clothing and how they affect and change the healthcare and fitness sector. Clothing embedded with sensors and technological intelligence is being produced for industries such as sports, medicine, and even the military. Functional smart clothing has started to take the centre stage in health care due to the ease of use that accompanies it.

The healthcare sector is one that is quite delicate due to the vital role it plays in the improvement of the quality of lives of the general population but more importantly, the lives of the older generation. Healthcare professionals are required to maintain and provide close monitoring of patients to ensure the well-being of patients. As the population gets older, there is the need for high quality medical healthcare which may be expensive. Other than the high cost of medical healthcare in many countries, there is the need to physically walk into hospitals each time a person has to be checked. Hospitals cater to the population and sometimes, are overwhelmed by the amount of patients that come in every day. The recent spread of the coronavirus has shown how full hospitals can get and how exhausted medical professionals are when this happens. There is an increasing need to provide avenues through which patients can be monitored from outside the hospitals. Through these avenues, healthcare professionals do not have to physically be around the patients at all times. Simultaneously, this method has to be both cost-effective and retain the same level of quality provided in hospitals. By providing avenues through which patients can monitor their own health, there will be lesser dependence on hospitals and people will learn how to personally monitor their own health, which may lead to a longer lifespan.

Functional smart clothing being produced for the healthcare sector is one of the answers to this problem. While explaining the benefits of smart clothing in healthcare, Axisa et. al (2005) states that “intelligent biomedical clothes and wearable ambulatory health-monitoring systems can act as a key enabler for lifelong continuous health monitoring for all individuals” (pp. 325-336). The non-invasive sensors that gather data from the body of the wearer have the potential to detect certain illnesses easily potentially prevent diseases and even provide

diagnosis. Axisa et. al (2005) continues by writing that "integration of such sensors into clothing can, therefore, enhance home healthcare, citizen medicine, and disease prevention" (p. 325).

"Citizen Medicine", according to Axisa et al. (2005) is the ability of a patient to monitor his own health wherever he is, either from home or outside the home. The system is to allow the person the freedom to choose if they want to come into the hospital and also to teach people how to better manage their health from outside of the healthcare centre (pp. 325-336). The system provides comfort and saves time and money for the patient.

Functional smart clothing could also be available to people who are relatively healthier and are not riddled with any ailment. The system will simply assist in the monitoring of day-to-day activities, help users adopt a healthier way of life, and generally provide better living. As most 'healthy' adults are living through daily stress from work, family, and peers, functional smart garments could help to lower that stress and provide solutions on how to better manage the stress, prescribe effects of the stress on their health and detect early symptoms if the wearer is at risk of a health consequence. The intelligent system could as well monitor drug treatment and administration for the user instead of taking a trip down to the hospital. Axisa et al. (2005) describes intelligent biomedical clothes and wearable ambulatory health-monitoring systems that act as health monitors for individuals. According to Axisa et al. (2005) to monitor pain, "Baxter developed a small multi therapy pump for ambulatory applications. It is designed with wireless communication and a user-friendly graphic interface" (p. 325). They continue to state that the integration of such sensors into clothing can enhance home healthcare, citizen medicine, and disease prevention. For people at risk of a disease, Axisa et al. (2015) write that,

> The system will provide adequate information on how to deal with individual risk factors like hypertension, obesity, diabetes, physical inactivity, and stress through personalized training plans, and will provide motivation to change behavior. Early detection through long-term trend analysis will dramatically reduce the potential damage due to severe events. For post event patients, this

system can significantly improve the rehabilitation process, and can detect any complications at an early stage. (p. 325)

Functional smart clothing could also be used for post-operative care or people newly recovering from a disease or ailment. Some people may prefer to recover at home, surrounded by friends and family however, this may not be possible due to the need for close monitoring by healthcare professionals. In situations like this one, smart clothing may be used to monitor the health of the patient from outside the hospital. Axisa et al (2005) write about this category of users when they state that the system could greatly improve and speed up the rehabilitation process, provide comfort to the patients in this stage, improve their knowledge on their own situation, and detect any complications at an early stage. They write that "daily monitoring will enable new forms of personalized drug treatment and the self-administration of drug medication, according to the specific behaviour and circumstances of each individual." (p. 325).

1.4 Functional Smart Clothing On The Market

On the market today, there are many functional smart clothing available to the public for purchase. These functional smart clothing greatly aid in performing functions that traditional clothing may not be able to.

While explaining functional smart clothes that could monitor healthcare, Axisa et al. (2005) mentioned the *Vivometric's Lifeshirt* (Figure 1) which is connected to a specialist monitoring station where vital parameters are analysed. In functional smart clothing, GPS is also used to retrieve the exact location of the patient or wearer to achieve connectivity between the wearer and the healthcare professionals (p. 326). For patients suffering from chronic health conditions, hospitalization or staying as close as possible to healthcare professionals is pertinent. However, even in critical cases, clothing endowed with technologies could still assist patients to understand and manage their condition to prevent occurrences that could lead the condition to worsen. Being away from the hospital and in charge of their own health may improve chances of recovery. Overall, the use of functional smart clothing in health care seeks to revolutionize the healthcare system causing patients to spend less on treatments, free up hospital space for patients that are required to

come into the hospital, save on medical bills, and better educate patients on their own conditions preparing them for future events that may arise and how to prevent it.

According to Verma (2020), smart sensor-embedded clothes are a very patient-friendly way of providing a continuous stream of data to researchers. Quoting Pierre-Alexandre Fournier, the co-founder and CEO of Hexoskin, a Montreal-based start-up designs smart shirts, Verma (2020) writes, "It's much easier to recruit patients if they don't have to visit clinics too often or wear heavy, clunky devices for several days" (np). Researchers around the world are looking into how smart clothing could collect and manage diseases. Although there has not been too many approved smart clothing for medical monitoring, there are a few that have been produced.

Founded in 2006 in Montreal, functional smart clothing production company, Hexoskin, is the leader in non-invasive sensors, smart clothing, software, data science & AI services. In 2013, Hexoskin launched washable smart shirts that capture cardiac, respiratory, and activity body metrics. Hexoskin is an end-to-end system to monitor the user's general health, vital signs, sleep, and activity, using built-in sensors embedded in smart garments. (Hexoskin, 2019).

According to Glatter (2019), *Hexoskin Smart Shirt* (Figure 2) was developed to monitor the breathing by tracking the subtle movements of the chest and abdomen of the user. The shirt expands as the patient breathes and assesses the volume of air they inhale and exhale (np). According to *Forbes* (2019), "data gathered by the shirt–combined with heart rate and movement data— produced quite similar measurements to the face mask and backpack equipment traditionally used to measure lung function" (np).

The results of the smart shirt were compared with traditional bulky equipment used to monitor and measure breathing to detect any lung-related problems and the results were similar showing that the smart shirt draws accurate data from the breathing of the user (Glatter, 2019). Unlike the traditional equipment usually used to measure data like this, the smart shirt is more practical as it could be worn under clothing instead of being as obvious as the traditional bulky equipment. Instead of a face mask and bulky backpack, the smart shirt is conveniently hidden under the garment of the wearer and the shirt is connected to a mobile phone-based app that is

able to record breathing patterns of the lung and inform the wearer of data gathered and any changes in their health that may need to be checked (Glatter, 2019).

Figure 1. The Hexoskin Smart Shirt that is used to monitor health (Mannée et.al, 2020).

Another smart shirt launched by Hexoskin (2019) is able to monitor the activities of the body while asleep to arrive at results on the function of the body of the wearer. The smart shirt that tracks the evolution of the health overtime combines data that was gotten from the wearer (Figure 4.2.A). According to Draper (2018), the smart garment is able to monitor breathing rate and ventilation, it monitors the heart

rate and recovery, activity intensity, peak acceleration, steps, cadence, positions and best sleep tracker (np). Hexoskin (2018) states that these shirts are available for purchase by the general public (np).

Figure 2. The 2019 Hexoskin Smart Shirt used to monitor health (Cobarrubias, 2020).

Similar to the smart shirt from Hexoskin that monitors breathing and any irregularities in the lungs, the *iTBra* is designed to tackle breast cancer and identify any changes that may be tumor-related in the breast (Figure 3). Although women are encouraged to perform self-examinations for signs of breast cancer, the iTBra makes more accurate readings of the breast and "tracks down any irregularities in circadian metabolism related to increased activities in cells which is not very uncommon in breast tumors" (Smart Wearable, 2019, np).

Figure 3 The iTBra is designed to tackle breast cancer (Charara, 2016).

Owlet is a functional smart clothing that offers non-invasive medical monitoring of new born babies. It is a smart sock that can measure a baby's oxygen level and heart rate to alert parents or guardians on how their babies are doing. The technology provides information on the breathing of a baby and vital information on the quality of sleep of the child and any changes that may occur during the night (Owlet, 2017).

Launched in 2017, the *Smart Socks* (Figure 4) take into account the fatigue that new parents have to deal with along with the panic and uncertainty that comes with the experience. The *Smart Sock* provides a level of relief to new parents knowing that the baby is sleeping safely and soundly. It also eradicates the need to visit the hospital, instead new parents know how to monitor the sleep patterns of the infant and if they need to go to the hospital, the smart sock also alerts them (Owlet, 2017). Allison (2017) quotes Owlet co-founder, "From day one, our mission at Owlet has been to revolutionize the way we care for our infants, and that starts with understanding their overall health. We're now helping parents take a more proactive approach to their baby's health by giving them a more complete picture" (np).

Figure 4. The 2017 Owlet smart sock (Metcalf, 2016).

Owlet is an innovative technology that truly encompasses the idea of functional smart clothing technology. It not only monitors the baby's health but also allows parents the ability to learn to monitor their infants and better detect any change in their health. The smart sock allows parents the ability to take healthy proactive measures whenever the need arises.

In the field of maternal healthcare, the monitoring of the foetus is an important aspect during pregnancy. Most women have to go into the hospital for their antenatal care to check the condition and get an overall report of how the fetus is doing. However according to Borges et al (2009), a *Wireless Sensor Belt* (Figure 5) has been developed for pregnant women to monitor their features from any remote area the woman may be. The belt aids in monitoring the fetal movement in the last four weeks of pregnancy. These last four weeks of pregnancy are crucial because the health of the fetus is reported to be prone to sudden change hence, the need for close monitoring. The change in the health can lead to fatal results but the sensor belt allows the mother to record any sudden change and alert the hospital immediately (np). Borges et al. (2009) further write,

> One of the problems responsible for the possible occurrence of pregnancy complications is the failure of the monitoring rules by the pregnant woman. Frequently, the pregnant woman does not account for

the felt movements with the same quality as the health services; or even she does not attend the medical sessions. Therefore, the main reason for the development of these easy to wear prototypes is because sometimes the pregnant woman is not able to give special attention to the monitoring and there is not a harmless device to perform this type of monitoring (p. 1750).

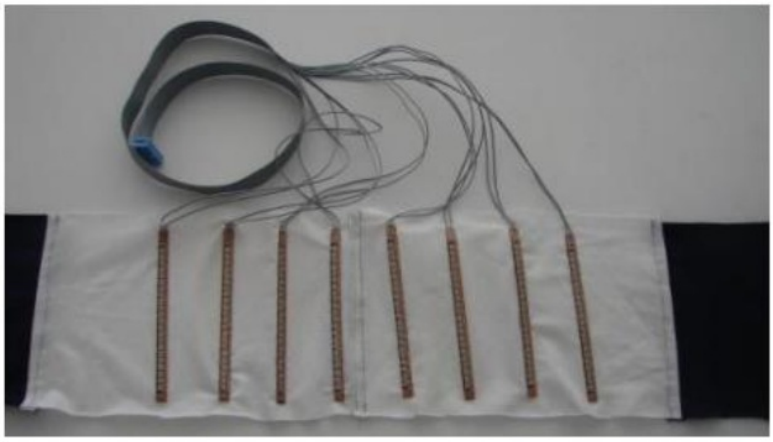

Figure 5. Wireless sensor belt to monitor foetal movement (Borges, 2010).

With independence being a major problem for the ageing population due to fragile healthcare, The University Of Bristol issued a press release in 2014 announcing that it will be pioneering a project that will develop *Smart Trousers* (Figure 6) using artificial muscles in its soft fabric to help old and disabled people to move around freely and unaided (University of Bristol, 2015). As people age, they lose their sense of independence and have to be transferred to a home for old people where they are cared for. However, with robot clothing, the older generation may choose to care for themselves. For example, the clothing has been specially designed for people with conditions such as poor circulation, skin pressure damage or the susceptibility to falls. According to the University of Bristol (2015), old people are less susceptible to injuries while alone with the help of this garment. According to the University of Bristol (2015), "the research project, funded by a £2 million grant

from the Engineering and Physical Sciences Research Council (EPSRC), will enable people with mobility impairments, disabilities and age-related weaknesses to live independently and with dignity" (np). These *Smart Trousers* will aid in the avoidance of falls and support the stamina while walking or going up staircases. By giving people bionic strength, the trousers will continue to aid in activities that were previously impossible. The university also mentioned that robotic clothing will greatly reduce healthcare costs while giving people their independence at the same time. In a world where healthcare is not very affordable, smart clothing has definitely bridged a gap (np).

Figure 6. University of Bristol Smart Trousers (Bar-Cohen, 2011).

The merger of health and wearable technology will only continue to improve the quality of life of the population and put people in charge of their own health. This has several advantages for the population and society in general. With these user friendly designs, people could communicate with their healthcare professionals, submit data that has been gathered by the functional smart clothing, and receive medical advice and prescriptions without being physically present. The digital nature of the functional smart clothing already allows people to communicate through their clothes. Healthcare is a delicate and yet complicated sector but with the production of functional smart clothing that are user friendly and comfortable for the wearer, the sector could gradually become more accessible. The connectivity brought about by smart clothing in the healthcare sector cannot be denied. Not only are patients connected to health care professionals from outside the hospitals, there is also the connection of the person to his own body through the use of functional smart clothing. These clothing prove to be an extension of the body functions, as McLuhan has stated for the media domain.

The use of smart clothing in healthcare only appears to further McLuhan's concept of global village. McLuhan compares the global village to the central nervous system explaining that society is interconnected by the influence of electronic technology (1967). This is vividly seen in the healthcare sector with the use of smart garments that connect the wearer to healthcare professionals over distance and time. The use of smart garments in healthcare seeks to reduce the number of trips patients have to take to the hospital; instead it connects healthcare professionals over time and space. In healthcare, the connectivity does not simply exist between healthcare professionals and the patients but there is a new and much deeper kind of connectivity; the digital connectivity that we share with our bodies. Prior to the entry of smart clothing in healthcare, the connectivity between human beings and their bodies was mediated by health care professionals but with the entry of functional smart clothing in healthcare, people are able to eliminate the middleman in the form of health care professionals. Although functional smart clothing does not completely eliminate the need for healthcare professionals, it reduces the need. With functional smart garments in healthcare, people are more connected to their bodies and are able to monitor their own bodies with the aid of these technologies. McLuhan's concept of the global village just became much more close-knit. While describing the concept of the global village, McLuhan revealed that instead of waiting days, weeks or months for news from across the world, the use of digital technologies will bring it to you in less than a minute. This applies to healthcare as people have ceased to wait for doctors on certain conditions that can be treated from within the home using functional smart clothing.

The concept of functional smart clothing is already being used in healthcare and this digital technology will only get more intricate as the years go by, further shrinking the size of the global village that McLuhan spoke about. Although healthcare is not cheap in many parts of the world and smart garments in healthcare are not very affordable to average citizens in some parts of the world, the concept is not entirely foreign anymore. Smart garments are slowly achieving societal acceptance. The garments are not similar to large and chunky equipment present in hospitals. In some cases, these smart garments could be worn underneath everyday outfits or even worn as everyday outfits. This answers the one of the questions posed at the beginning of the thesis. The use of functional smart clothing in the healthcare

sector has not only furthered digital connectivity causing people to be closer through healthcare, these garments have also been integrated into the society.

Although the use of digital technology is not new in the health sector, functional smart garments still contribute to the rise of a digital culture through garments. The entry of functional smart garments will not completely eradicate the need for physical hospitals but as more garments are produced, it will reduce that need and improve digital connectivity between people and healthcare professionals. To conclude, McLuhan's prediction of a global village has thoroughly come to pass through in this sector.

1.5 Sports And Functional Smart Clothing

Functional smart clothing is very popular in the field of sports and sporting activities. In an industry as competitive as sports, there is an increasing need to maintain a winning edge hence, the importance of health monitoring, training, and sleep monitoring have taken a centre stage. Coaches and athletes alike are constantly looking for the next wearable to give them an edge. Functional smart clothing is preferred by athletes due to their non-disruptive design and as Halson et al (2016) describe, "they are appealing due to how lightweight they are and the proximity to the body to analyse and transmit information" (p. 705). Functional smart clothing appears to combine comfort with technological features that improves the experience of the wearer.

The technology of functional smart clothing in sports has progressed beyond bracelets that are strapped to the wrist to monitor pulse and smartphone applications that assist in analysis. Sportswear embedded with sensors and digital technologies are being produced to bring easy and accurate analysis into sports and training. To illustrate, in the field of skiing, *Sports Wearable* (2019) reported the availability of heated jackets with reflectors and movement trackers (np). *The AppWear Smart Jacket* (Figure 7) designed by AppWear is complete with LED silicon buttons and heating pads that can be controlled with a smartphone. The jacket is rain and water resistant and it also allows for it to be washed without losing its functionality (np).

The geo-locating feature of the jacket allows the wearer to be accurately located by friends therefore, promoting the concept of digital connectivity. According to *Sports Wearable* (2019), "the mobile application also monitors and analyses your movements enabling you to have a second look at all your activities

and how you can perform them better with higher efficiency" (np). This jacket is the perfect example of how functional smart clothing is equipped with all the technological features a wearer needs to have without compromising on the traditional features of the clothing.

Figure 7. The AppWear smart Jacket (Sport Wearable, 2019)

Smart t-shirts are one of the popular smart clothing used in sporting activities. *Sports Wearable* (2019) states that smart shirts are very popular in fitness and sports. These soft clothing monitor the well-being of the wearer and track fitness activities. Polar is one of the companies known to produce *Smart T-shirts*. The polar *Smart T-shirt* (Figure 8) majorly monitors the heart rate of the wearer and links it to a smartphone app for easy access (np). This connectivity through clothing is one of the major achievements of functional smart clothing in sports. The geo-location feature included in the jacket designed by Appwear is important as the jacket is usually worn during skiing. A number of things could go wrong while skiing on the mountains but this jacket designed by Appwear equips the wearer with the option to communicate with the outside world, if anything goes wrong.

Figure 8. The Polar smart t-shirt (Sport Wearable, 2018).

Like Polar, Sgynal is also a company that also produces *Smart T-shirts* but with more functionalities. According to *Sport Wearable* (2018), although the *Smart T-shirt* (Figure 9) cannot monitor the heart rate of the wearer, it can accurately track the amount of calories burned during workout sessions, monitor the amount of steps a person has taken and the amount of stairs climbed while wearing the shirt (p. 1). An interesting feature that promotes the concept of connectivity is the navigation feature. The shirt is able to steer the wearer in the right direction through a vibration on the shoulder. Without the use of a phone, the shirt will tell you which direction you should be going (np). The *Smart T-shirt* by Sygnal which gives the wearer directions to keep them from getting lost which also translates into connectivity with the world. This feature of connectivity is instrumental in functional smart clothing and the importance cannot be undermined in sportswear.

Figure 9. The Sygnal smart t-shirt (Sport Wearable 2018)

For wearable smart clothing, KYMIRA is another smart garment organization that takes a new approach with overall design and concept. The organization uses its design of smart clothing to develop a safer, cleaner, and more habitable planet. According to *Sport Wearable* (2017), KYMIRA fabrics (Figure 10) increase circulation, tissue oxygen levels, and energy production. The fabric also harnesses wasted energy and converts it into infrared radiation (np). The fabric converts body waste energy into infrared and the infrared penetrates deep into muscle tissue causing changes at a cellular level and vasodilation of the blood vessels, delivering more oxygen to the muscles. The energy is also used to make the fabrics quick drying and thermo-regulatory (Sport Wearable, 2017. np). This smart clothing achieves connectivity by interacting with the body of the wearer and performing actions that make the wearer comfortable.

Figure 10. Kymira sport fabric (Sport Wearable 2017).

In conclusion, the use of functional smart clothing in the sport sector has numerous advantages to the athletes. Sports and trainings may not be described as easy. They require a specific type of clothing to make the process easier. Ideally, a track runner should not be dressed in jeans as sportswear is required for flexibility and ease. However, functional smart clothing brings more ease and comfort into sports and training by providing the wearer with information that aids training and enhances the experience.

The inclusion of technology into sportswear makes it easy for the athlete or wearer to monitor their training and activities without stepping out of the sportswear. Important vitals that contribute to sports training are being monitored on the go, making the process of training and sports activities relatively easier for the athletes. Traditional sporting garments that are not equipped with smart clothing may require the wearer to look to external sources for reports on vitals which may be cumbersome.

Furthermore, these functional smart clothing has brought about a deeper level of connectivity. These examples which this chapter has classified as functional smart clothing not only connect the wearer to the workings of the body but also connect the wearer to the external digital world. In many cases, sports or training require the wearer to go out into the field but functional smart clothing keeps the wearer connected.

1.6 The Military Sector And Functional Smart Clothing

The details of wearable technology in the military sector is not as widely known as it is in fashion or sports simply because the military is known for its confidentiality. According to tech website, Pei-Genesis (2018), smart clothing and body sensors for military use may not sell the same way as smartphones do, but it is still a growing market (np). According to the Massachusetts Institute of Technology (2016), the Institute for Soldier Nanotechnologies (ISN) has over "40,000 square feet of space in facility located in the northeast sector of the MIT campus within Cambridge's Technology Square" (p. 1). In 2016, Massachusetts Institute of Technology revealed that the space was solely dedicated to the research of nanotechnology for soldiers. This facility includes "wet and dry labs, computer clusters, and mechanical testing and other research instrumentation, including equipment for low and high-rate mechanical characterization of the dynamic response of materials, electron microscopy, and femtosecond laser spectroscopy" (p. 1). Uppal (2020) writes that in April 2016, the University of Massachusetts and the Institute of Nanotechnology were granted USD 75 Million by the US Department of Defence, for the development of smart textiles (np).

According to Uppal (2020), smart textiles are the answer to the growing need for supportive and performance enhancing garments in the military sector. Satalkar et al. (2016) describe nanotechnology as "the utilisation of structures with at least one dimension of nanometre size for the construction of materials, devices or systems with novel or significantly improved properties due to their nano-size" (p. 1). This definition shows that textiles could also be manipulated with the use of nanotechnology. Satalkar et. al. (2016) continue to write that the manipulation of matter on a 'nano' scale is considered to be a key enabling technology and has a huge potential in the textile industry (p.1). Nanotextiles are considered to have a

huge potential because nanotechnology provide high durability fabrics that cannot be damaged by laundering (pp. 1-2). According to Russell (2002), Before more companies started to invest in the development and use of nanotechnologies in textiles, the first attempt at nanotechnology in textiles was undertaken by Nano-Tex, a subsidiary of the US-based Burlington Industries (pp. 7-9). Although there are different techniques of applying nanotechnology to fabrics, Cramer et al. (2003) writes that coating is the most common technique used to apply nano-particles onto textiles (p. 2). According to Satakler et al. (2016) through the technique of coating, there are various methods used to apply coating onto fabrics which include spraying, transfer printing, washing, rinsing and padding. Padding being the most common method where a padder adjusted to suitable pressure and speed is used and followed by drying and curing (p. 2).

In this thesis, I shall briefly highlight some of the properties imparted to textiles using nanotechnology. I shall also briefly discuss how these properties are useful in creating functional smart clothing for soldiers and how they are linked to connectivity. These properties include water repellence, antibacterial effects, and UV-protection. For water repellent fabrics, Russell (2013) writes that water repellence is achieved by creating nano-whiskers, which are hydrocarbons and 1/1000 of the size of a typical cotton fibre, that are added to the -fabric to create a peach fuzz effect without lowering the strength of cotton (pp. 7-9). By doing this, Kathiervelu (2003) adds that by doing this, the spaces between the whiskers on the fabric are smaller than the typical drop of water, but still larger than water molecules; water thus remains on the top of the whiskers and above the surface of the fabric (pp. 20-22). Another method of using nanotechnologies to make water resistant fabrics was mentioned in a research by Zhang et. al. (2003) where the fabric is coated with a thin nanoparticulate plasma film to improve its water resistant property (pp. 1473-1481). In this case, the water simply rolls off the fabric.

Another property is the inclusion of antibacterial effects in nanotextiles which is included to make the fabrics anti-bacterial. According to Saito (1993), Metallic ions and metallic compounds are capable of sterilizing (pp. 150-164). According to Satalker et al. (2016), “It is considered that part of the oxygen in the air or water is turned into active oxygen by means of catalysis with the metallic ion, thereby dissolving the organic substance to create a sterilising effect” (p. 4). This sterilization

is necessary when producing functional smart clothing especially for the military since soldiers are often exposed unfamiliar territories.

The use of nano-silver particles is yet another method. Satalkar et al. (2016) write that "nano-silver particles have an extremely large relative surface area, thus increasing their contact with bacteria or fungi, and vastly improving their bactericidal and fungicidal effectiveness" (pp. 1255-1276). Lee et al. (2003) explain that nano-silver is extremely reactive with proteins; this makes it hinder the growth of fungi or bacteria that may cause infection, odour or soreness (pp. 2199-2204). In addition, Lee et al. (2003) write that nano-silver could be applied to healthcare products like dressings for scalds or burns (pp. 2199-2204). Wong et. al (2006) adds that this technology is widely present in socks to prohibit the growth of bacteria, prevent odour, soreness, itch, and general discomfort (pp. 1-8). This property that prohibits the growth of bacteria is an advantage to the military sector as wounds and injuries are not uncommon on the field.

Lastly, there is the use of nanotechnology in fabrics to facilitate ultraviolet (UV) protection. According to Cancer.org (2020) Ultraviolet (UV) radiation is a form of electromagnetic radiation that comes from the sun and man-made sources like tanning beds and welding torches (np). Exposure to UV rays can cause premature aging of the skin and signs of sun damage such as wrinkles, leathery skin, liver spots, actinic keratosis, and solar elastosis. UV rays can also cause eye problems. They can cause the cornea (on the front of the eye) to become inflamed or burned (Cancer.org, 2020). According to Satalkar et al. (2016), Although there are inorganic semiconductor oxides such as titanium dioxide (TiO2) [4, 9-11] and zinc oxide (ZnO) [12, 13], it was determined that nano-sized titanium dioxide and zinc oxide were more efficient at absorbing UV radiation and thus, better able to block UV. (pp. 3-8) Sataklar et al. (2016) continue that "this is due to the fact that nano-particles have a larger surface area per unit mass and volume than the conventional materials, leading to the increase of the effectiveness of blocking UV radiation" (pp. 3-8). As soldiers may be exposed to the sun for an extended amount of time without the option of leaving the area, functional smart clothing equipped with the feature to block UV radiation only protects the wearer.

So far in this section, I have briefly explained the use of nanotechnologies in the creation of smart garments and the application of certain properties like water repellency, antibacterial effects, and UV protection. I shall explain how important

these properties are in the creation of smart garments for the military sector. It is widely known that operation of armed forces personnel are exposed to harsh military tenure for a long period of time. It becomes a necessity for them to seek protection from these hazards. Sometimes, they are sent to various places with diverse or extreme weather and climate. These harsh military terrains may range from mountain areas, deserts with a high amount of heat, or in some cases underwater environments. It is necessary for these people to be armed with garments that could withstand unforeseeable factors. Inadequate protection may lead to mission failure and loss of lives. The use of water repellent textiles in the creation of smart garments for military personnel is highly vital. It prevents the wearer from being weighed down in the rain and sometimes, it may provide ease to wade through a body of water or lay in ambush during the rain. The importance of having water resistant textiles may not seem as important but with soldiers trapped in certain situations for hours or sometimes, days, this property comes in handy. The thesis has mentioned earlier that the use of nano-sized titanium dioxide and zinc oxide in the production of smart garments for protection against UV rays. Military personnel are majorly outdoors and they may be required to stand in high levels of heat and this causes exposure to the sun and harmful radiation. This property helps to reduce the level of damage done to the skin. Lastly, the use of nano-silver particles that hinder the growth of bacteria and fungi is very important in creating garments for the military. Military personnel may not always be exposed to medical care in the line of duty hence prevention should be given utmost importance. The antibacterial property of the fabric makes it difficult for soldiers to be infected and this property saves more time than treating an infection, thus saving more lives.

In the following section, I will discuss how the use of functional smart clothing in the military section seeks to aid connectivity. According to Uppal (2020) functional smart clothing and textiles do not only protect the wearer from harsh weather conditions but also monitor health, establish and maintain communication and connectivity, enhanced mobility, reduction of stress, psychological stress monitoring, sensing of environmental conditions, and the detection of biological and chemical threats (np). It is evident that smart clothing manufactured for the military take on a lot of features which protects the wearer in various ways.

Connectivity is an important feature in functional smart clothing for the military as connectivity plays an important role in this profession. Scataglini et. al.

(2015) describe a BioHarness which is used by soldiers, firemen, and astronauts to measure their stress levels (pp. 53-54). Rae Systems, which is a provider of wireless, gas and radiation detection instruments and systems, produced a *Bioharness* (Figure 11) that is won by soldiers to monitor personal vitals like the heart and breathing rate, body temperature, and even posture. Due to the very active nature of the profession of members of the armed forces, the *Bioharness* is simply strapped around the chest and does not obstruct the movement of activities of the wearer. When connected through wireless technology, the *Bioharness* is also capable of providing information such as the location of the wearer. According to Rae Systems, this proactive measurement can help manage worker safety, prevent heat stress injuries, and make decisions about overwork/stress levels" (np). This technology not only ensures the safety of the wear but is also capable of establishing communication thereby leading to connectivity. Although it is not expected that smart clothing will be made available to the public, smart textiles for the military market is expanding with constant technological inventions, according to Uppal (2020).

Figure 11. Rae Systems BioHarness for soldiers (Ishn,2011).

Another example of functional smart clothing created for the military is one that acts as a first responder in the military field. According to Uppal (2020), BAE Systems plc which is a British multinational defence, security, and aerospace company entered into an exclusive partnership with e-textiles developer Intelligent Textiles Limited (ITL) to create a new wearable technology which can turn clothing into networked technology. The Broadsword Spine (Figure 12) is a vest that is specially created for military personnel. According to Bae Systems,

> Broadsword® Spine® is an e-textile based layer that when added to a user's clothing creates an invisible electronic network and power supply, by using conductive fabrics instead of wires and cables. With the innovative network, users can plug vital electronic devices straight into their vest, jacket or belt and have them instantly hooked into power and data via USB – all delivering an estimated 40 per cent weight saving per user versus alternative solutions (np)

BAE Systems explains that in addition to being a power outlet, the Broadsword spine is designed to be able to survive in the harshest of weather including being resistant to fire, water, humidity, and shock. Paul Burke, Defence Information and Technology Director within Military Air and Information explained that the vest will deliver lightweight, cable free and better alternatives to existing systems (Industrial Safety and Hygiene News, 2011, np). The revolutionary e-textile used will allow power and data to move through the fabric. In addition, the vest could also be used to communicate with anyone from a soldier on the battlefield to a first responder called to an emergency.

Figure 12. BAE Systems Broadsword Spine (Ishn, 2011).

There are several functionalities that have been introduced into the production of functional smart clothing for the military. Scataglini et al. (2015) write that the

Institute for Soldier Nanotechnologies (ISN) of MIT is working on a project that is aimed towards the identification of friendly soldiers in action. Scataglini et al. (2015) explains further stating that when a laser is "shined upon the uniform, it would transmit a friendly signal to the user's own uniform, identifying the suspected soldier as friendly. The absence of a return signal would instantly identify opposition" (pp. 53-54). The use of this smart material in the production of this garment aids connectivity that goes beyond speech which is a feature that comes in handy in the military. The examples given of smart clothing in the military clearly further connectivity in several ways. They enhance connectivity with fellow soldiers in the field and maintain connectivity with people outside the field.

In conclusion, it is obvious that the need for performing enhancing capacities and connectivity are considered important in the production of smart clothing for the military. Due to the nature of the profession, the need for connectivity among people is regarded of great importance. The common feature in many of the examples of smart technology is the feature of connectivity and this is achieved with the use of nanotechnology when creating the textiles. This proves further that one of the goals of smart clothing is digital connectivity over space and time.

Although functional smart clothing is not limited to health, sports, and the military sector as there is many other functional smart clothing in the market, these aspects are the main aspects of this thesis. Hence, the focus is solely on these three aspects.

1.7 Conclusion

The use of wearable technology has entered into our day-to-day lives, from smart watches that monitor the heartbeat to smart socks that measure the number of steps that we take. With functional smart clothing in the sport and fitness sectors taking the lead, more brands are on the move to collaborate with designers and tech companies to produce clothing that seek to keep us more connected.

According to PR News Wire (2019), the smart clothing market is likely to grow from "USD 1.6 billion in 2019 to USD 5.3 billion by 2024" (np). This simply proves that the industry will only get bigger and the digital connectivity that we already enjoy will only improve making us more connected to the external world and ourselves especially with the use of Ultra-smart textiles. According to *PR News*

Wire, "ultra-smart textiles are the third-generation smart textiles that can sense, respond, and adapt themselves to environmental conditions or stimuli" (np).

The rise of smart clothing has brought several changes not only to the clothing industry but to the way people interact with each other through clothing. McLuhan states that the medium is the message and any that any medium is an extension of the human body (Agel, 1996). Before sensors came to be embedded in clothing, we only saw the technologies such as the telephone, radio, and the internet as the message. In this overly digital age, we have become the message. The clothes that we wear are an extension of ourselves and not only do they keep us connected with the world but with ourselves by tracking our fitness levels and communicating the information back to us.

As earlier mentioned, connectivity through functional smart clothing is broken into two. 1. The connectivity with our own bodies 2. Connectivity with the external world.

Functional smart clothing has, no doubt, created a digital era in the clothing industry. Prior to sensors being embedded into clothing, the primary function of clothing was to protect the body from external elements but with functional smart clothing today, we are connected to our own bodies. In some cases, like the wireless sensor belt developed to monitor fetus movement, we are connected to the unborn life inside of us through the aid of smart clothing. This was previously impossible but the integration of technology and clothing has bridged this gap. Connectivity with our bodies was mostly left to healthcare professionals or bulky medical equipment that acted as a connector between us and the functions of our bodies. However, with the practical functional smart clothing, we are able to enjoy that connectivity and interaction with the functionalities of our bodies.

Secondly, the interaction with the external world is also aided by smart clothing and its technologies. Today, our smart phones still champion connectivity and connection to the external world. A large part of the world's population own a smartphone simply for the purposes or connectivity and interaction with people over space and time however, the rise of functional smart clothing now seek to change this. Through the use of the clothes they wear, people are able to improve connectivity and interaction with other people also in the domains we operate. As the technology of smart clothing improves, so does digital connectivity and interaction in the clothing industry. Functional smart clothes are quite functional in daily life as

they establish a digital connection and satisfy the need to be connected to the world. Of all the aspects of functional smart clothing discussed in this thesis, functional smart clothes have largely contributed to "digital culture".

The world is a digital one and people have adapted to a digital culture; from using digital watches to reading the news on digital tools, the world now runs on a digital scale. Many years ago, it would have been strange to have a piece of clothing measure personal vitals like heartbeat rate and the temperate of the wearer but today, this has achieved a form of 'normalcy'. As mentioned in the introduction of the thesis, digital machines were only used in the manufacturing stage of the clothing but with the entrance and spread of smart clothing, digital tools are being embedded in the clothes that we wear leading to a digital culture in the clothing industry.

McLuhan predicted that the world will become a global village with more people seeking out higher levels of connectivity with the rest of the world. The production of functional smart clothes and the level of acceptance the clothes are receiving seek to prove McLuhan's theory. Functional smart clothes lead to a new level of connectivity that people crave and this demand for connectivity will push a supply of functional smart clothes. The supply will further strengthen the "digital culture" that already exists in the world today and extend it into the clothing industry.

CHAPTER 2: THE INTRODUCTION OF 3D TECHNOLOGY INTO HAUTE COUTURE: IRIS VAN HERPEN

2.1 The Emergence Of Haute Couture: A Brief Intro

The industrial revolution in the clothing domain has shown the merger of technology and fashion and how technology was introduced into the fashion industry. In explaining the development of the clothing industry, Godley (1997) states that ready-made clothing first began in the United Kingdom as far back as the seventeenth century when the manufacturing of military uniforms first began (p. 4). Pierre Parissot was the first retailer of ready-made garments from Paris. In 1824, he opened a store that initially sold loosely pre-assembled garments but soon began to diversify into suits (Godley, 1997).

Boultwood and Hindle (2018) state that the industrial revolution in fashion started within the textile industry (p. 109). The earliest practical sewing machines were developed in the 1850s, but the first to be successfully applied on a commercial

basis was not developed until the 1860s (Godley, 1997). According to Bolton (2016), the sewing machine was invented by Barthelemy Thimonnier in 1829, refined by Elias Howe in 1846, and was not perfected until 1851 by Issac Singer. In his article, Godley (1997) explains that machines did not completely take over the clothing industry as there was no machinery that was able to replicate the dexterity of the human hand in manoeuvring cloth through a sewing machine, especially the lighter fabrics (p. 7).

With the technological developments in the clothing industry during the mid-nineteenth century, *haute couture* carved out a niche within the fashion industry. In the face of modern technological advancements, emphasis on the hand-sewn techniques employed in the finishing and embellishments distinguished *haute couture* from other categories in the industry (Bolton, 2016). According to Khurana (2007), *couture* is a french word that describes costume tailoring which is made to the measurement of a particular customer (p. 9). *Couture* clothes are expensive, handcrafted and majorly worn by celebrities. Pret-a-porter is used to describe ready-to-wear garments that are generally produced in bulk. These clothes usually have no altercations and are comparatively less expensive (p. 9).

Bolton (2016) writes that pret-a-porter also grew in the nineteenth century to cater to parts of the society that could not afford *haute couture* so the subtle and refined hand skills remained in *haute couture* (p. 9). Martin and Koda (1995) explain that the uniqueness of hand-made dresses that catered to the needs of individual clients added to the general appeal of *haute couture*. Even though Charles Fedrick Worth is deemed father of *Haute Couture* (Lewis, 1981), it was Poiret who, in 1904, pronounced himself a fashion "designer," claiming the position of style arbitrator (Troy 2003; White 1973; Wilson 1985). Having worked at the House of Worth (1990-1004), Poiret was the first to align his craft with artistic practices such as modern painting and sculpture that were coming to the fore in Paris and Europe at the time. In this climate of economic affluence, rapid social change and artistic dynamism, Poiret cast himself as a fashion innovator, gaining international influence and markets across Europe and America (Troy, 2003).

2.2 Smart Textiles In Haute Couture

Although *haute couture* has emphasis on the hand-sewn techniques, an element of smart technology has been seen in this style of clothing. Carciani and Bagnashino (2018) coined the term "Techcouture" to summarize the integration between *haute couture* and the innovative contributions of technology (pp. 689-731). The term "techcouturism" has become a marketing strategy for designers to stand out in the international community. As Boultwood and Hindle (2018) state, one of the challenges that lie in smart clothing today is its classification in fashion (p. 111).

Beneath the convergence of fashion and technology to create smart and intelligent clothing in *haute couture*, there is a merger between textile and electronics for the development of smart textiles. Stoppa and Chiolerio (2014) define smart textiles as "products such as fibers and filaments, yarns together with woven, knitted or non-woven structures, which can interact with the environment/user" (p. 11957-11992). They opine that these smart textiles are capable of accomplishing a wide spectrum of functions with the added advantage of flexibility. Also according to Stoppa and Chiolerio (2014), there are different types of smart textiles that serve different purposes. These smart textiles are divided into three subgroups:

> Passive smart textiles: only able to sense the environment/user, based on sensors; Active smart textiles: reactive sensing to stimuli from the environment, integrating an actuator function and a sensing device; Very smart textiles: able to sense, react and adapt their behaviour to the given circumstances. (p. 11958)

Further explaining the production of smart textiles, Stoppa and Chiolerio (2014) write that over the past decade, many techniques and materials have been used in order to realize smart textiles. One of the materials that could be used to produce smart textiles are conductive fibres. They exhibit conductivity or serve an electronic or computational function. They can have a variety of functions, like antistatic applications, electromagnetic interference shielding (EMI), electronic applications, infrared absorption or protective clothing in explosive areas (p. 11960). Smart textiles can also be produced by using conductive inks. "These specialized

inks can be printed onto various materials, among them textiles, to create electrically active patterns. Screen printing also makes integration with planar electronics simpler than with conductive yarn systems." (p. 11965). However, the technique that I aim to explore in detail is the aspect of 3D printing in the production of smart textiles which are used in the making of *haute couture* pieces.

As haute couture meets with better technology, it has made it possible for some designers and technological companies to create and experiment with garments and wearables in a variety of novel and expressive forms (Seyed, 2019). The merger of fashion and technology contributed to more connectivity. Daniels and Gregory (2016) write that fashionable smart clothing currently on the market tend towards revealing or externalizing emotions and augmenting or controlling connection (np). One of the first smart clothing in *haute couture* fashion shows was the *Twitter Dress* which displayed fan tweets as the model walked down the runway. Wissinger (2017) explains that the first ever iPhone controlled dress changed colours based on the volume of audience tweets (p. 371). This design, although not entirely functional, merges *haute couture* and fashion with connectivity and fosters a closer knit digital community. The use of a digital social media site in fashion is able to capture the interest of people within the digital space and this leads to a connection across the online space. The *Twitter Dress* now serves as a link between the fashion world and the online digital world.

2.3 3D Printing In The Fashion Industry

3D Printing is one of the methods utilized in the creation of textiles for the production of *haute couture* fashionable smart clothing. According to Kwok et. al. (2017), 3D printing is a unique technology that potentially offers a high degree of freedom for the customization of practical products that incorporate electrical components, such as sensors in wearable applications. (pp. 167-175). Although Liu et. al (2018) argue that 3D printing is an emerging technology to fabricate customized structures of responsive materials in areas as diverse as drug delivery, tissue engineering, soft actuators, and adaptive buildings (p. 1), the concept of 3D printing is not entirely a new technique. Kuhn and Minuzzi (2015) write that 3D printing had its idealization in the 80s, when Doctor Hideo Kodama filed the first patent application for Rapid Prototyping (RP) technology. They also write that the process was initially designed for rapid creation of the prototype of industrially developed products however; the patent was not registered (p. 2). Tania (2017)

writes that the first 3D printer (called a stereo-lithograph) to be registered was developed by Charles W. Hull in 1986. A year later, Carl R. Deckard invented the Selective Laser Sintering (SLS) 3D printer in 1987 (p. 48).

3D Printing technology has been introduced into *haute couture* and a few fashion designers have leveraged on the technology of 3D printing to advance their own designs, successfully merging the world of fashion with technology. According to Pires et al (2012) "technological innovations can represent a large differential factor nowadays; at every moment new products arise, from new technologies or adaptations of existing machines" (p. 172). Khun and Minuzzi (2015) support the argument when they write that "technological advancement has provided new perspectives and applications in fashion design, through the adoption of the most widespread techniques such as, digital printing and laser cutting in textiles and more recently, 3D printing in clothes development" (p. 1).

The process of making 3D objects is extremely gradual. First, a gradual design of the object to be created is made. Then the virtual design is made in a CAD (Computer Aided Design) file by using a 3D modelling program or with the use of a 3D scanner (to copy an existing object). After that step, a 3D scanner makes a 3D digital copy of an object. 3D scanners use different technologies to generate a 3D model such as time-of-flight, structured/modulated light, volumetric scanning and many more. To prepare a digital file for printing, the 3D modelling software 'slices' the final model into hundreds or thousands of horizontal layers. When the sliced file is uploaded in a 3D printer, the object can be created layer by layer. The 3D printer reads every slice (or 2D image) and creates the object, blending each layer with hardly any visible sign of the layers. Finally the three dimensional object is created. (Tania, 2017, p. 48-51)

Many research papers point to various types of 3D printing techniques however these are the main elements involved in 3D printing, according to Tania (2017):

2.3.1 The Light Polymerized

Under this category are i) The Stereo-lithography (SLA) which uses lasers to produce a solid part from a liquid. ii) The Digital Light Processing (DLP) uses a DLP projector to expose light selectively to a container of liquid polymer. ii) The 3D photo grafting uses a laser to trace designs at a micro-level in a block of gel. It has medical and pharmaceutical applications and can be used to grow artificial tissue. iv)

Lastly, The UV inkjet printing approach uses an inkjet printer to apply photopolymer in ultra-thin layers, with each layer cured by UV light (Tania, p. 60).

2.3.2 Extrusion Based

This category is subdivided into i) Fused deposition modelling (FDM) and ii) Fused Filament Fabrication (FFF). In this method, filament is melted and extruded via a heated nozzle in thin strips. Simultaneous printing of objects in different colours and materials is possible through the use of multiple extruder heads (Tania 2017, p. 60).

2.3.3 Granular Material Binding

Granular material binding is subdivided into i) Selective laser sintering (SLS) ii) Direct metal laser sintering (DMLS) iii) Electron beam melting (EBM) iv) Powder bed printing (Tania 2017, p. 60).

SLS and DMLS use lasers to fuse (sinter) powder in layers to build up a part. The un-fused media serves as a support to the item being produced; reducing the need for temporary supports to be integrated into the design and removed during the finishing process. The Electron beam melting (EBM) involves melting metal powder layer by layer with an electron beam in a high vacuum. The powder bed approach uses an inkjet printer to apply a layer of powder (plaster or resin) and inkjet print a binder in the cross-section of the part. This technology allows for the printing of full colour prototypes, as well as elastomer parts (Tania 2017, p. 60).

Today, there are considerably over 100 different 3D printers in fashion commercially available (Gebhardt, 2012). While the industrial scale 3D printers are capable of producing a wider range of materials at a larger scale, many of the desktop printers are small and affordable (Yap and Yeong, 2014).

3D printing has led to limitless possibilities in fashion design. The first wearable piece made through the 3D printing technique was the *Black Drape Dress* (Figure 13) in 2000 (Kuhn and Minuzzi 2015. p. 1-12). It was developed by an industrial engineer, Jiri Evenhuis, in collaboration with the industrial designer, Janne

Kyttänen. The black drape dress was created using SLS technology (selective laser sintering) to melt a fine powder into 3D shapes (Kyttanen, 2015).

Figure 13. The First 3D Printed Black Drape Dress (Kuhn and Minuzzi 2015).

2.4 Iris Van Herpen And Her Use Of 3D Printing: A Brief Introduction

Over the last decade, 3D printing was launched and developed in *haute couture*. Some *haute couture* fashion designers use 3D printing to communicate ways emerging technology can be used for innovative fashion design (Kuhn and Minuzzi, 2015). Dutch designer, Iris Van Herpen was the first designer to bring 3D printing to the runway. Although the designer has worked with various textiles and materials including wood and bones, which were used in her 2012 collection (Vogue 2017), many of her pieces are made with the combination of 3D printing technology and handmade stitches. The first 3D design to walk the runway was a part of her spring/summer *Crystallization* collection (Figure 14) which took place in 2010 at the Amsterdam Fashion Week. (Kuhn and Minuzzi, 2015). As stated on the Iris Van Herpen website, the designers used materials like polyamide, various types of Ecco leather and ECCO leather with oil treatment, crystal-clear PETG, transparent lasered acrylic sheets, silver chain, and fabric in the making of this collection.

Figure 14. Iris Van Herpen 2010 *Crystallization* Collection ((Kuhn and Minuzzi, 2015).

While describing the collection, Van Herpen states that the surfaces are composed of thin wires, as fibers, composing the pieces and giving lightness to provide greater flexibility (Herpen, 2015). Subsequently, the designer has improved on her 3D printed designs to accommodate more flexibility. In her 2013 spring/summer collection, *Voltage*, Van Herpen presented the first flexible printed dress, in collaboration with the MIT Media Lab, where a different texture was developed, incorporating a hard material and soft one, able to assign softness and elasticity. (Herpen, 2015).

The fall/winter *Capriole* collection (Figure 15) presented in 2011/2012 was said to be inspired by the idea of skydiving. The French word *Capriole* translates into 'leap in the air' (Herpen, 2015). According to Van Herpen, the collection is a reflection of the existential extremes between body and mind experienced during a parachute jump (Herpen, 2015). The collection presented five striking outfits that evoke the feeling just before and during a free-fall parachute jump. Even though, Van Herpen is known to use a combination of her handwork and technological 3D printing, her famous Skeleton dress from the fall/winter *Capriole* collection which was made in collaboration with architect Isaïe Bloch was not the product of industrious handwork, but came straight from the computer and the 3-D printer (Herpen, 2015, np).

Figure 15. Iris Van Herpen 2011/2012 *Capriole* collection (Herpen, 2015).

In her *Voltage* Spring/Summer 2013 collection (Figure 16 & 17), Van Herpen played with energy and electricity. Using Tesla coils – high-voltage generators – three million volts was running through a dancers body during the show, performing a choreography of electrical discharges that are visible as impressive strokes of lightning (Vogue, 2013, np). To create the design which was deemed the first flexible 3D-printed dress by *Vogue*, Van Herpen collaborated with artist and Professor Philip Beesley, developing three-dimensional fabrics for several of the monochromatic silhouettes, whose sensitive antennae vibrate to the energy of the body. (Vogue, 2013, np)

She also collaborated with Neri Oxman, architect and professor at the MIT Media Lab, who specializes in digital fabrication and material science, creating a sculptural 3-D printed dress of various flexible materials that were fused while printing (Vogue, 2013, np).

Figure 16. Iris Van Herpen *Voltage* (Spring/Summer 2013) collection (Vogue, 2013).

Figure 17. Iris Van Herpen *Voltage* (Spring/Summer 2013) collection (Vogue, 2013)

In 2013, Van Herpen unveiled her fall/winter *Hybrid Holism* collection (Figure 18) which included dresses and jewellery that combine 3D-printing technology and natural forms. The collars and spiky elements on the dresses were designed in collaboration with architect Isaie Bloch and 3D-printed with additive manufacturing company Materialise. (Herpen, 2015, np)

Speaking about the latest collection Sven Hermans, Account Manager for *Materialise* said:

> For the first time, we have worked with Iris van Herpen to produce a hybrid creation incorporating unique, transparent bone-like structures produced with Mammoth Stereolithography. Thanks to 3D printing the dresses are seamless and made to measure. It is exciting working with Iris van Herpen to bring her complex geometrical designs to life; 3D printing does what no other form of clothing manufacture can do when complex shapes need to be created quickly and as one piece. (Materialize, 2013, p. 2)

Figure 18. Iris Van Herpen *Hybrid Holism* (fall/winter 2013) collection (Herpen, 2015).

In her spring/summer 2015 *Magnetic Motion* collection (Figure 19 & 20), Van Herpen experiments with magnetic forces and the concept of attraction and repulsion. The designer worked with techniques like injection molding and laser cutting on maze-like structures, 3D printing and intricate architectural handwork on dresses, jackets, trousers, skirts, and blouses, giving them dynamic shapes and surfaces that echo the body's movement (Starts Prize, 2016, np). Emphasizing light and shadow play, micro webs of lace both veil and reveal the luminescent glow of crystal forms, while triacetate feathers punctuate the soft drapes and volumes. The controlled structure of the clothes is offset by the chaotic structure of the accessories, where, due to the nature of magnetic growth, no two items are alike. The shoes, belts, necklaces, and clutches were "grown" using magnetic fields. (Starts Prize, 2016 np)

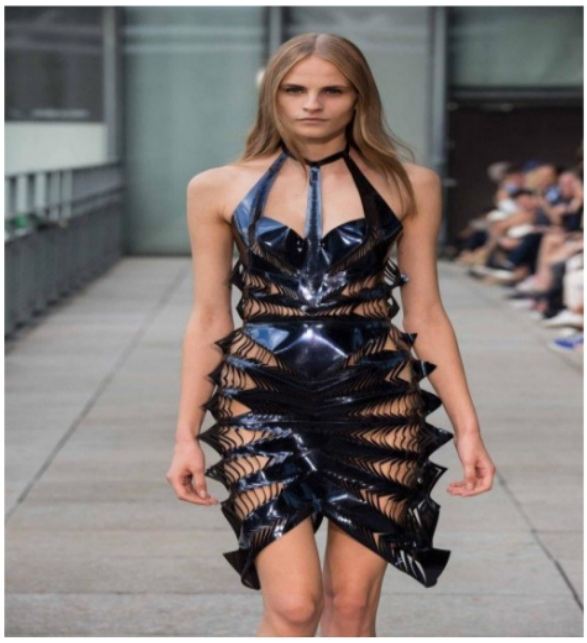

Figure 19. Iris Van Herpen 2014 *Magnetic Motion* collection (Starts Prize, 2016).

Figure 20. Iris Van Herpen 2014 *Magnetic Motion* collection (Starts Prize, 2016).

Van Herpen brought 3D printing novelty to the runway when she featured live 3D printing during her 2016 spring/summer fashion show. Robotic arms combined with 3D printing, laser cutting and weaving create a circular dress live during the show. As explained in *The Verge* (2015), during the show, actress Gwendoline Christie lay on a circular plinth that was surrounded by three robotic arms. These programmed robotic arms formed a garment around her right in the middle of the show as the audience watched. They used various techniques interlacing an architectural mesh which rays out around her. (https://www.youtube.com/watch?v=4uk-P2hY-rA)

According to *Vogue* (2017), Van Herpen played with lasers and blending perspex and polyurethane in creating her *Between The Lines* spring/summer 2017 collection (Figure 21). The designer in collaboration with Berlin artist Esther Stocker studied the imperfections of structures in both the real and digital worlds and created a series of 3D-printed dresses. Several of the 16 creations were permutations of a process whereby hand-casted transparent polyurethane (PU) was hand-painted through injection molding (*Vogue*, 2017).

Figure 21. Iris Van Herpen *Between The Lines* spring/summer 2017 collection (Vogue, 2017).

2.5 Towards Connectivity: Designers Inspired By Iris Van Herpen

Although Iris Van Herpen was the first designer to bring 3D printing to the runway, her designs and techniques have inspired several other designers in the field of 3D printing. Tania (2017) writes that Van Herpen inspired designers like Francis Bitonti, who printed a gown for Dita Von Teese featuring more than 3,000 unique, articulated joints, and Karl Lagerfeld, who adorned iconic tweed Chanel suits with 3D-printed details earlier 2014 (p. 49).

According to Tania (2017), Israeli fashion designer, Danit Peleg used a home printer to create five garments for her graduation collection. The finished collection (Figure 22) which took more than 2,000 hours to print was made with a rubber-like material called FilaFlex. In 2015, Danit Peleg became the first designer to showcase an entire collection with 3D printing (p. 48-51).

Figure 22. Danit Peleg 3D printed collection (Tania, 2017).

In an interview with Ese Osagie for *3D Print* (2019), Ganit Goldstein, a fashion designer who uses 3D printing revealed that her journey with 3D printing started in her room at home. Before her partnership with Startys, America's leading brand in 3D printers, she first tried her hands at printing garments at home. (3D Print, 2019, np) In her Collection *Between The Layers* (Figure 23), she created garments and shoes, inspired by her study of 'IKAT' weaving in Tokyo, Japan (3D Print, 2019).

Figure 23. Ganit Goldstein *Between The Layers* collection (*3D Print*, 2019)

2.6 Conclusion

In fostering connectivity and creating a digital culture in fashion, 3D Printing comes from an entirely new angle. Iris Van Herpen led the charge of 3D printing when she introduced 3D printing to the runway in 2010. From then on, many designers have dabbled in 3D printing using the technique to create garments, jewellery, and shoes. Danit Peleg, who printed her 3D collection in the comfort of her own home, has shown the world that someday consumers will be able to print their own outfits at home. 3D printing has brought a certain level of connectivity into the fashion industry where designers are not only connected through the use of their technique but more connectivity is established between the designers and the consumers. The consumers will come to have more input in the production of their garments. In 2020, when we think of technology in fashion, our minds immediately go towards the use of machines in the productions of clothes, an assembly line, and the use of online stores in ordering the clothes. But our minds rarely go towards making our own customized clothes in the comfort of our own home. With the possibility of printing our own garments at home, consumers are more connected to the designers and the process of producing their own garment. This brings people much closer together, furthering a digital culture in the fashion industry.

For years, designers have created garments - both *haute couture* and *pret a porter* - in their studios or factories. In the production of *haute couture* garments, the client for whom the dress is being made may have little input in the creation but in pret a porter, the consumer is completely out of the production process. 3D printing in this era has made it possible for the consumer to be part of the technological experience.

In *haute couture*, the client will become involved in all aspects of garment making, from the production to the user experience. With the use of 3D printing, clients can not only make decisions on the production of their outfits but may be able to produce it themselves.

This will not completely eradicate the fashion industry as 3D printing requires a lot of effort, time, and knowledge of the techniques involved. However, a future where people will digitally print their own clothes is upon us. According to BQ (2015), Danit Peleg was quoted to have said;

> If technology continues to improve at a significant rate, 3D printing will become the future of the fashion industry; it'll have an enormous impact. This will entail lower transport costs, greater customization and more importantly, the democratization of design: anyone will be able to design their own clothes (p. 17).

3D printing has launched the world of fashion into a digital era. The use of traditional fabrics has become obsolete in this field and digitally printed materials are taking over. In terms of fostering connectivity, the use of 3D printers in the home has become a reality. The digital world will become even more connected when fashion designers can share their designs with their consumers over the web and these consumers can digitally print the designs. Futuristic expectations of 3D printing are limitless. Just as people copy designs from fashion designers online, designs found online could be printed in 3D at home.

As mentioned before, in the early 1960s, McLuhan (1964) coined a term for a new social organization which was called the global village (p. 4). Before the rise of the internet, McLuhan (1996) wrote that the visual, individualistic print culture will soon be brought to an end by what he called “electronic interdependence” (p. 4). Electronic media will bring about a digital connection where, “humankind will move from individualism and fragmentation to a collective identity, with a ‘tribal base’ (p. 304). McLuhan states that the world will be digitally connected with the use of the internet. With 3D printing, this is already a possibility as the fashion industry serves to link the consumer with the designer in the production of fashion pieces.

In an interview with George Garlock and Paul Soles in 1965, Marshall McLuhan emphasized that it is the contents of the filing cabinet that makes it mandatory for people to rush from the home to the office to do a job that could easily be accomplished at home. In the 60s, McLuhan stresses that it is society's obsession with files and folders that forces office workers to make the daily commute from the suburbs to downtown. McLuhan says the stockbroker is the smart one. He learned some time ago that most business may be conducted from anywhere if done by phone. He stated that in the future, people will no longer only gather in classrooms to learn but will also be moved by "electronic circuitry." (https://www.youtube.com/watch?v=qABC3_8ai58).

These predictions by McLuhan have been fulfilled in our world today, there are certain jobs that could be accomplished from the comfort of the home, people hold meeting from various parts of the world through the internet, millions of people are connected via social media networks, and physical presence is deemed unnecessary in many situations where it would have been absolutely needed, decades ago. McLuhan's prediction has also come to pass in various areas including connectivity in *haute couture*. Although digital connectivity is obvious in smart accessories like smart watches that organize your day and smart shirts that monitor your vitals, digital connectivity in *haute couture* is a little more subtle. Before the introduction of 3D printing and smart textiles in *haute couture*, consumers were obliged to visit fashion houses to get their outfits made. In the future, fashion pieces in *haute couture* may be printed from the comfort of the home. An example is how consumers buy furniture pieces from IKEA and assemble it in the comfort of their own home. This process not only connects the consumers to the furniture but connects them with people across the worlds that do the same. This is the future of 3D printing of fashion pieces within the home. With 3D printing and digital connectivity, there will be a closer level of connection between the consumer and the designer and this connectivity will be fostered with the use of technology.

The use of 3D printing has spread from Iris Van Herpen to other designers who have both printed pieces in their work studios and in the comfort of their own home. In the nearest future, I argue that pieces will be printed by the consumers of fashion in the comfort of their own homes. Fashion designers and their clients will be connected through the production of garments. The users will be more involved in the production of their items, and technology will no longer be limited to the fashion designers but spread to the consumers. This will mirror the usage of new media in the fashion domain where the audience is both the producer and consumer of the content. The fashion industry will become a two-way process and instead of the producer to consumer dynamics, the consumer will become involved in the production. This explains the digital connectivity through the use of fashionable smart clothing.

CHAPTER 3: THE USE OF STORYTELLING IN CONCEPTUAL SMART GARMENTS AND CONCEPTUAL SHOWS: HUSSEIN CHALAYAN

3.1. The Evolution Of Storytelling

Oral language is a vital aspect of storytelling as it serves as a medium of communication to the audience. Although there are different languages spoken worldwide and stories are being spread across the globe in various languages, stories have been told before the evolution of oral language. For instance, prehistoric men told their stories with the use of their hands before they developed the art of language and oral communication. In this section, I will address early accounts of storytelling, how it began, and how Hussein Chalayan uses storytelling in his designs.

Early accounts of storytelling could be seen in the form of cavemen drawings, paintings, and hieroglyphics. Mendoza (2015) estimates that the drawings in the Chauvet cave (Figure 24) in France date back as far as 30,000 years (p. 1). The Chauvet cave in the mountains of Southern France has well-detailed drawings of animals like mammoths, lions, rhinos, and bison, that depict daily life in the prehistoric times (p. 2). The paintings depict how the early men survived, the tools they used in hunting, and their way of life. Through these cave paintings, they were able to communicate efficiently without the use of oral language. In general, drawings were an unspoken universal language that communicated across the globe. To date, anyone who sees cave paintings immediately understands that a message is being passed. The medium of storytelling was drawing (p. 3).

Figure 24. Early Drawings on the Chauvet cave walls (Mendoza, 2015).

Drawing as a medium of communication took another form in ancient Egypt. Stories were communicated through the use of hieroglyphs (Figure 25). According to Mendoza (2015), hieroglyphs is a form of writing using pictographic characters as sound and symbols (p. 2). Similar to the drawings in the Chauvet Caves, hieroglyphics was a visual way of storytelling that did not utilize oral language. It was not only used to line tombs, for religious documents, and to pass a message to the future inhabitants (p. 2).

Figure 25. Early forms of Hieroglyphics on walls (Mendoza, 2015).

Mankind has told stories in different ways for centuries. Myths, legends of all kinds, wonder tales, fairy tales, and life stories. The stories spread from generation to generation and as the early men travelled, they took their stories with them, spreading the stories across the several cultures they encountered on their journey. Stories have been told around campfires between working men, stories have been exchanged among midwives, tales have been passed from father to child and legends have gone from one place to another taking different forms.

Eventually, stories evolved to be written and compiled. According to Mendoza (2015), there is evidence that states that written symbols date back to about 9,000 years ago (p. 4). Like the hieroglyphs, writing started out as drawings to represent sounds and symbols but they gradually changed into a script (p. 4). Mendoza (2015) states that the current alphabets were derived from older forms of writing such as the Phoenician alphabet (p. 4). Further, Peter (2018) states that the Greeks were amongst the first known civilizations to develop writing and apply it to storytelling. They used to write poems and their messages were mostly delivered via animals like pigeons (p. 1). Mendoza (2015) writes that some scholars suggest that, ""The Iliad" by Homer is the oldest surviving work in the Greek language that originated from oral tradition" (p. 4).

From oral storytelling came written forms of storytelling and although it is unclear exactly when the first printing press was invented, Gunaratne (2001) writes that "the Chinese began the first printed newspaper, Jing Bao (originally Di Bao), in 713 under the Tang dynasty (618-907); and it continued until the collapse of the Manchu dynasty in 1911" (p.1). Gunarate (2001) continues to state that Gutenberg is celebrated as the inventor of the printing press in Europe when he printed the Bible (p.1).

It is quite obvious to see how the printing press sought to further the art of storytelling. According to History (2018), the Bible which is a literal book of stories was the first book to come out of the Gutenberg Press in 1425 (p. 4).

As time progressed, so did the means and medium of storytelling. Traditional forms of storytelling that were once done via cave paintings, songs and chants, and through books have now evolved into a modern digital form. As Miller (2019) states, "Digital storytelling is humankind's newest way to enjoy narrative entertainment"

(np). Over the centuries, stories have remained. The only change is the medium through which the stories are told.

3.2 The Art Of Digital Storytelling

Stories are a very compelling art. We have always used stories to convey information, experiences, emotions, ideas and cultural values. Since the invention of modern technologies like the internet, blogs, vlogs, podcasts, the computer, and a lot more, they have provided us with new and better ways to tell stories.

Although the practice of storytelling has remained the same over the years, the medium has changed. Traditional forms of storytelling relied on analog means that encouraged very little interactivity. According to Miller (2019), storytelling in the earlier years, were limited to the use of old traditional media which only supported one-way communication (np).

With the invention of digital technology, the forms of storytelling began to change and no longer relied on traditional media. The digitization of storytelling began with the introduction of technologies that broke storytelling into various forms and across several genres. Forms of media like radio and television started to get feedback from the audience. Radios, for example, started to have people call and share their views. Miller (2019) explains that when storytelling became digital, it was no longer linear; it took on different forms that supported interactivity; from games to marketing and branding (np). Miller (2019) described "Digital Storytelling" as "a material that reaches its audience via digital technology and media. One of its unique hallmarks is interactivity- back and forth communication between the audience and the narrative material" (np).

As Miller (2019) states, traditional storytelling was a one-way street where the messages were passed from the sender to the receiver and remained unchallenged (np). Cave painting could only be viewed, nothing could be added to the message by the viewer, books could only be written by the author, and more recent media like the radio and TV also had limited interactivity. Messages were only sent out without any form of feedback, response or interactivity between the parties.

Storytelling in the age of technology is built on interactivity, communication and feedback (Miller, 2019, np). Robert Logan defines new media in his book *Understanding New Media* (2010) where he states that it is "those digital media that are interactive, incorporate two-way communication and involve some form of

computing". In the digital age, new media is a two-way communication between the sender and the receiver. Storytelling with the use of new media follows this pattern. Various forms of storytelling that involve a two-way communication can be seen via online games, virtual reality, social media applications, mobile phones, digital marketing, augmented reality, digital fashion amongst others. The concept of storytelling through the use of new media could be referred to as digital storytelling and it will only continue to expand as new technologies emerge. A few years ago, before the advent of social media, meetings or conferences needed a physical space to happen. People gathered to discuss work and other events but with the wide use of new media, people are able to come together without ever leaving the comfort of their home. Blogs can be written by a member of the internet and edited by another person without ever meeting. With the current Corona Virus pandemic, working has become more remote and this digitization has come to play a significant role.

According to Miller (2019), some scholars have argued that interactivity was present even before storytelling became digital (np). In her book, *Digital Storytelling 4e: A Creator's Guide To Interactive Entertainment*, she explained that early men who sat around campfires telling stories could have changed the course of their stories based on the expressions of their audience (np). This is a form of activity that affects the process of storytelling causing the narrator to shape his story based on the expression of the people listening to him. Despite this, Miller disagrees saying,

> This model never sounded particularly convincing… And even if it were true that ancient storytellers constructed their tales to fit the interest of the listeners, how much control or participation in the story could these campfire audiences have had? At best, it would have been an extremely weak form of interactivity (np).

Miller (2019) argues that even in the early days of storytelling, there was some level of interactivity between people (np). This goes to show that although digital storytelling sees a lot of interactivity, this form of interactivity has always been there. From her explanation, it is safe to assume that storytelling is one of the arts that require interactivity and

connectivity. Although Miller (2019) suggests that storytelling has always contained a level of interactivity, with the introduction and wide use of new media, the levels of interactivity among people has risen and this has greatly improved storytelling.

3.3 Storytelling In The Media Realm

Interactivity drives digital storytelling. The internet is a global community and that community is a hub of interactivity. As mentioned earlier, digital storytelling relies heavily on interactivity. The most common form of digital storytelling is the creation of short videos by both professionals and amateurs on the internet. These videos tell a story and they are shared across the internet to various community members. The videos are seen by millions of people and they are interpreted in several ways, people give their reactions to the stories, conversations about the stories are started by members of the community, and the link spreads. Although short videos are the most common form of digital storytelling, the concept appears in many forms. Almost everything we do today is impacted by digital storytelling.

Every individual on social media platforms like Facebook, Twitter, Instagram, YouTube, LinkedIn and Whatsapp curates a story with their personal page or feed to communicate their personality. Even when a person decides to make their profile private, that in itself, is a story.

Many versions of digital storytelling have been brought into social media, from podcasts which cater to people from different parts of the world by telling them auditory stories to short videos that lean towards visual entertainment. Some of the most popular social media platforms like Facebook, Twitter, Instagram, and Snapchat have a section literally called the *stories* (Figure 26). In this section, photos or videos are uploaded to stay for only 24 hours. These are quick content that could be easily consumed as people swipe through the stories section.

Figure 26. Image of Instagram, a social media platform (Instagram, 2020).

With the use of new media, businesses employ the concept of storytelling in their marketing and brand strategy. Delgado and Sabiote (2016) explain that many brands have discovered the power of storytelling and are currently using digital storytelling as a technique to attract consumers (pp. 151-131). This storytelling sells the image of the brand. Hermansson and Na (2008) explain that in brand storytelling, the initial goal is not to sell a product but to evoke an emotion. Several brands use digital storytelling to directly talk to their consumers online. With storytelling, advertisements and marketing have gone from simply talking to the consumers through a TV screen to talking to each consumer, personally (np).

As Jones & Leverenez (2017) write, "If you want to build a ship, don't drum up people to collect wood and don't assign them tasks and work, but rather teach them to long for the endless immensity of the sea" (p. 67-91). It shows how important storytelling is in branding. Through these stories, the brands not only sell their products but seek to improve brand loyalty (p. 67-91).

Furniture retain company, IKEA is one of such brands using the concept of digital storytelling to improve brand loyalty. IKEA used technology to improve its products and overall retail experience. With the use of new digital technology, IKEA has made the shopping experience even easier as well as connecting people outside of the retail store. According to *TechCrunch* (2017), IKEA launched an augmented reality app (Figure 27) in partnership with Apple to improve consumer experience (np). Within the app, the consumer is able to drop virtual furniture into their own

homes and design it using the augmented reality technology. Within the app store, there are several options of furniture for the consumer to choose from. The app assists the consumer in picking the right furniture and placing it within the home to see how it would look. Using this technology, the consumer is not required to leave the home to design their space using furniture from IKEA. Beneath this technological interior design, this app by IKEA in partnership with APPLE tells a story of brand loyalty. It shoes that you do not need to walk into the IKEA store and picture how furniture will look in your home. This app brings the store into your home further closing the gap between the brand and the consumers. Due to the digital nature of this experience, it could be share among various people across the internet leading to connectivity.

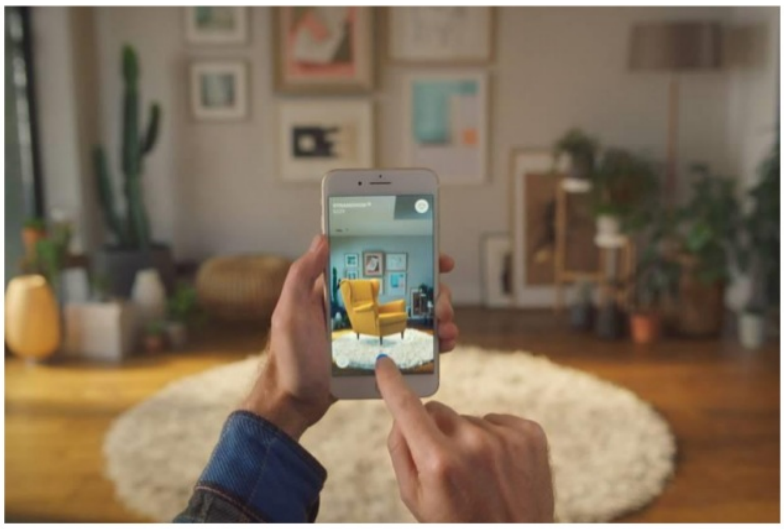

Figure 27. Image of the IKEA app in collaboration with Apple (Klopfer, 2008).

Another brand that uses digital storytelling is Coca-Cola as it is not selling just a drink but an emotion. Over the years, Coca-Cola has always tailored its advertisements to speak to people's emotions rather than push a product. An example is the 'Share a Coke' campaign (Figure 28) which involved printing names on the individual bottles. This campaign by Coca-Cola may not have involved digital tools at first but it gradually became a digital story shared across continents.

Miller (2015) writes that "the media attention of the campaign was extensive and international outlets in every country were reporting" (np). Miller (2015) continues that the campaign was a huge success in Nigeria as the campaign was able to capture the diversity of many cultures and regions of the country. (Miller, January 13, 2015). This sent a spike in sales and the only thing Coca-Cola did was harness the power of digital storytelling (Econsultancy, 2018). Through the campaign, a huge brand like Coca-Cola was able to literally give each consumer a bottle of coke. Coca-Cola was not selling hundreds of bottle anymore; instead it was selling to each person. Printing names of people on the bottle deepened the connection between the brand and the consumers. (Miller, 2015) quoted the Marketing Director of Coca-Cola Nigeria, Patricia Jemibewon, "By swapping our iconic Coca-Cola logo with personal names, we give all our consumers a unique opportunity to connect and share their personalized Coke with the people who matter the most to them—friends, family and loved ones" (np). By personalizing each bottle, Coca-Cola sold the story of consumer importance to the world.

People from every part of the world started to connect via the internet and several internet content were created from this campaign. People over the internet connected with each other after their names appeared on Coca-Cola bottles. So, although the campaign did not start out as a digital one, with the use of new media tools, the campaign quickly turned into a digital story that succeeded in bring people even closer together.

Figure 28. Image of a Coca-Cola bottle during an ad campaign (Cane, 2017).

3.4 Storytelling With The Use Of Digital Tools In Conceptual Fashion Shows: McQueen As The Precursor

In this section, I hope to explain the use of digital tools by certain designers to aid storytelling during their conceptual fashion shows. Duggan (2009) explains that fashion designers have been greatly influenced by storytelling and using it as a concept. In doing so, they eventually brought the art to their runways:

> Drawing on sources of inspiration as varied as political activism, performance art of the 1960s and 1970s, Fluxus and Dada performances, theater and popular culture, many contemporary fashion houses have completely transformed the runway show. What results is a new hybrid of performance art that is almost completely removed from the traditionally commercial aspects of the clothing industry.(p. 244)

Duggan (2009) states that during the mid-1990s, designers like Alexander McQueen and John Galliano became popular for staging fashion shows that boasted

of unique concepts (p. 244). Alexander McQueen experimented with digital storytelling in his Spring/Summer 1999 fashion show which he called *No13* (Figure 29). He used a digital tool to tell a story. Duggan (2001) describes the 1999 fashion show that captured the attention of the spectators and press:

> The finale to McQueen's Spring 1999 show consisted of the model—clad in a white dress resembling a full skirt belted above the breasts—slowly rotating on a circular disc in the floor of the catwalk. As she continued to rotate, two large robotic paint guns violently sprayed her with yellow and black paint (pp. 243-270).

The iconic conceptual show has been interpreted in many ways. *AnotherMag* (2016, October 30) wrote that some of the spectators suggested that the model who was spray painted represented a dying swan and others considered the spraying of the virgin white dress worn by the model was in reference to the sexual climax of a male (np). Like many designers are doing today, McQueen experimented on the relationship between human and machine in the late 90s and the story of the white dress is still being told today.

Figure 29. Alexander McQueen Spring/Summer 1999 collection, *No13* (AnotherMag, 2016).

Following the definition earlier given of conceptual art, more than the garments presented on the runway, it is the concept behind the show that caught the attention of the spectators. With the spraying of the model, McQueen painted a story. This story could be classified as digital due to the use of the digital tools that sprayed the white dress.

3.5 Hussein Chalayan's Use Of Digital Storytelling In Conceptual Shows.

Digital storytelling is the art of storytelling with the use of digital tools and Hussein Chalayan uses this method in his designs and conceptual fashion shows. Hussein Chalayan is one of the designers of conceptual smart clothing who incorporates the art of storytelling into his conceptual shows. The designer not only engages with merging technology and wearable clothing to create functional pieces but he also adds elements of culture, politics, and storytelling into his conceptual designs. There is a seamless integration of innovations in wearable technology and well-detailed storytelling techniques in Chalayan's designs. Quinn (2002) writes that "Chalayan's clothes are minimal in look but maximal in thought" (p. 359). Although his designs may seem simplistic, Chalayan's concepts and fashion shows carry a much deeper meaning. Anderson (2000) supports this statement when he writes that "Chalayan is a designer renowned for his 'intellectual' and conceptual approach to fashion and fashion shows" (pp. 229–230). Evans et. al. (2005) describe Chalayan as a "politically engaged designer who combines modernist themes such as technological progress with reflections on migration, cultural identity, religion, social changes, and war" (np). Chalayan experiments with various concepts in art, architecture, technology, the human body, and fashion. Through the use of digital tools, Chalayan introduces the digital aspect into his designs and fashion shows. He infuses digital technology into his designs and tells a story with them.

In the spring/summer 2007 collection titled *One Hundred and Eleven*, Chalayan used technology and clothing to perform before an audience. Clark (2011) writes that "the history of fashion is acted out, indeed 'performed' through a combination of technology and fashion, was unconventional and innovative at the time" (pp. 126–127). In the collection, Chalayan's models are clad in garments that

change and take on the form of another garment from a different time, which can be watched from: https://www.youtube.com/watch?v=LjnuHmxRbxI .

Cho (2010) narrates how Chalayan uses technology in this collection to transform the garments from styles of the past to those of the present and the future. Cho writes,

> Combining technological materials, including magnets, conductive wires, tiny circuit boards, and micro controllers with traditional textiles such as silk, Chalayan materially merges the old and the new in this collection. Of particular interest is the so-called shape memory material, which, as we will discuss, displays a specific kind of material agency by changing its shape from a temporarily deformed shape back to its programmed original shape (Cho 2010, p. 189).

In this collection, Chalayan uses the integration of technology which is commonly viewed as hardware and the use of soft flexible materials that compliments the body of the wearer. In the same collection, Chalayan uses soft flexible materials embedded with technology which could easily transform without looking rigid. Wearable technology has come a long way in terms of wearability and designers continue to aim to make their smart clothing more wearable to make for what Berzowska termed as 'soft computation'. According to Berzowska (2006), soft computation is "digital and electronic technology that is composed of soft materials (such as textiles and yarns) and based on traditional textile construction methods (such as sewing and knitting)" (np). According to the definition given by Berzowska, soft computation takes on the same meaning as smart clothing today.

In the *One Hundred and Eleven* collection, Chalayan made it almost impossible to guess that his designs were embedded with technology. The dresses seemed quite normal until they started to perform and transform, informing the audience that there was a level of technology involved in the design of the garment. At the end of the show, a model wearing a hat and a light and soft material walked out on the runway and in seconds, her dress started to withdraw into her hat, leaving

her completely naked (Figure 30). The technology was almost oblivious to the viewer until the dress started to withdraw. You can watch it here:

(Chalayan 2006 https://www.youtube.com/watch?v=LjnuHmxRbxI).

Figure 30. Hussein Chalayan spring/summer 2007 collection, *One Hundred and Eleven* (Berzowska, 2006).

In the *One Hundred and Eleven* collection (Figure 31), Chalayan gracefully switches from the past to the present and the future using technology and clothing. The collection appeared to be a mixture of culture, fashion, technology and digital storytelling. In this conceptual collection, storytelling was achieved when the garments on the body of the model continued to change through time showing the audience the history of fashion within minutes. Ryan (2014) explains that the function of the clothing that was displayed on the runway was not simply to transform before the audience but to make a cultural commentary on how fashion has changed from the past and how it will change in the future (p. 156). The simple act of the clothes changing through the decades proves this.

Chalayan's *One Hundred and Eleven* has been analysed to be a collection that works with memory technology in fashion because of how it integrates technology into the fashion culture. Toussaint & Smelik (2017) write that "by changing the shape of the six dresses through wearable technology, a cultural history of fashion emerges before the eyes of the spectator" (p. 91). To explain the changes in the dress through decades of fashion history, Ryan (2014) writes that the collection performs the changes in fashion occurring over the course of a century (p. 156).

Figure 31. Hussein Chalayan spring/summer 2007 collection, *One Hundred and Eleven* (Berzowska, 2006).

Miller (2005) supports the statement when he writes that the "inherent materiality of the technology, the fibre, and the clothes interrelate in an assemblage 'that reconfigures the authority of the past with that of the present" (p. 12).

Chalayan's designs perform before the spectators. In *One Hundred and Eleven*, the designs perform a memory right in front of their eyes. The garments change from garments of the past causing the spectators to go back in time, to a distant memory (Figure 32). Until the garments change and take on the form of modern clothes causing the spectators to come back to the present. It is not only a fashion show but almost like a film as the dresses evolve through time in seconds. Chalayan says in an interview, that he was 'looking at different shapes throughout the eras' and wanted 'to somehow demonstrate the change' with this collection

(Chalayan, 2006). The change witnessed in each dress was unique and served to further the storytelling technique. This collection can be viewed as a form of digital storytelling by Chalayan because of the use of digital tools involved in the storytelling and the dresses in this collection can also be referred to as conceptual smart garments because there is a story behind the garments and they carry out a technological function on the runway.

Figure 32. Hussein Chalayan spring/summer 2007 collection, *One Hundred and Eleven* (Berzowska, 2006).

With the use of digital tools and digital architecture, Chalayan presented the *Remote Control Dress* as a part of his *Before Minus One* collection. According to Quinn (2000), "The dress was based on the Aeroplane dresses series made by means of the composite technology used to construct aircraft, and incorporated the aerodynamics of aeroplane travel into its form and aesthetic" (p. 363).

Quinn (2000) continues to state that the *Remote Control Dress* (Figure 33) which married fashion to technology was the first wireless device to be presented as a fully functioning fashion garment. According to Quinn (2000), the *Remote Control Dress* was made of fiberglass metal and cotton synthetic and the designer used electrical circuitry and automated commands (p. 365). Lee (2010) adds that the dress also furthered the concept of interactivity. During the presentation of The *Remote*

Control Dress, a young boy operated his remote control causing the panel on the model's dress to rise (p. 1963). This contributes to the concept of interactivity in storytelling. Hussein Chalayan has not only embedded digital architecture in this conceptual smart clothing but he has made it interactive as well.

Figure 33. Hussein Chalayan spring/summer 2000 *Before Minus One* collection (Quinn, 2000).

Chalayan's designs also heavily reflect emotion through the use of technology embedded in the garments. For his Chalayan Spring/Summer 2017 collection titled *Room Tone* (Figure 34), Chalayan collaborated with Intel to design smart accessories that are able to sense and manage the stress of the wearer. According to *Forbes* (2016), Chalayan sent models onto the runway wearing intel-powered glasses, monochrome garments and a belt (Fig. 1.4). The glasses were able to monitor brain activity and measure the heart rate. The glasses send the information to the belt via Bluetooth connection and the data was translated into visualizations. These visualizations were displayed on the wall behind the models as they moved. The visuals were able to accurately read the emotions of the models and show their stress levels (p. 4-6). With the use of technology, the wearer becomes a part of the experience. In collaboration with Intel, UK-based fashion designer Chalayan has produced a series of wearable devices that detect emotions and project them externally for anyone to see. The collection, titled *Room Tone*, confronts the idea of repressed emotions whilst simultaneously exploring everyday emotions and anxieties.

Although Chalayan relied heavily on smart accessories instead of smart clothing for this collection, the collection showed how Chalayan uses his designs to makes an emotional connection with the wearer and the audience. In previous collections like the *One Hundred and Eleven* collection, Chalayan was able to tell a story by connecting with the audience's memories and taking them from the past to the future but in the *Room Tone* collection, Chalayan appeals to the mental state of the audience and the wearer. Through the display of the wearer's stress levels, Chalayan serves to prove that smart clothing could teach you more about yourself therefore bringing you closer to yourself and achieving connectivity.

Figure 34. Hussein Chalayan 2016 *Room Tone* collection (Forbes, 2016).

Chalayan's collection *Room Tone*, which measures the stress level of the wearer fits into this media theory. In this case, the garment, which is the medium can also double as the message. The message in this case is connectivity and the garment is able to achieve that by itself. Through his medium, which is conceptual smart clothing, Chalayan also tells stories.

The concept of digital storytelling is one that Hussein Chalayan deeply explores in his fall 2011 art film titled *Kaikoku* (Figure 35) which means "open country" in Japanese. Collaborating with Swarovski, Chalayan designs a golden-painted dress called *The Floating Dress*. The dress is designed with Swarovski crystals and pollen hanging off the dress and the dress is able to move on its own

with the aid of a remote control. During the film, the dress, controlled by the model, moves around and the pollen are released from the dress as they fly into the air.

According to Hussein Chalayan (2016), the dress symbolizes the opening of a country. Kazui and Videen (1982) explain that for a long period, the country of Japan was closed off, limiting foreign nationals from entering japan and common Japanese people were kept from leaving the country (pp. 283-306). Totman (1980) explains the concept of *Kaioku* which is the opening of the country after many years of isolation is referenced by the movement of the dress and the release of the pollen into the air (pp. 1-19). In an interview with Vogue (2016), Chalayan explains that the moving of the dress and release of the petals symbolizes that people could finally leave Japan and move around the globe. Chalayan continues to state that the conceptual smart clothing symbolizes and opening and a new beginning.

According to Fashionista (2011), Hussein Chalayan explains that after the period of isolation which was called *Sakoku* in Japan, the country experienced and openness to Western culture which over the years has influenced the food, fashion, art, architecture and technology while the country has still remained distinctly Japanese (np). Through *The Floating Dress*, Hussein Chalayan uses this concept to tell a story through technology and fashion.

Figure 35. Hussein Chalayan Fall 2011 *The Floating Dress* (Fashionista, 2011).

3.6. Hussein Chalayan's Contribution To A Digital Culture In Fashion

As the gradual shift from traditional clothes to garments embedded with technology continue to happen, a digital culture within the fashion industry is being built. Miller (2019) states that storytelling is quite important in digital life (np). The online games, movies, online advertising, online shopping, social media, podcasts, and augmented reality are all a means to tell a story. These media use stories to catch

the attention of the users and Hussein Chalayan has brought this technique into fashion. Chalayan harnesses the power of digital technology and integrates it with storytelling that resonates with the audience. Through this, he manages to spread a message as well as contribute to the growth of the digital culture in the fashion industry.

As previously explained, digital storytelling is the concept of telling a story with the use of digital tools and Chalayan has achieved this with some of his designs. Through his designs, Chalayan has used the relationship between the body and technology to tell a story. Throughout his designs, the level of technology differs. The level of technology used in creating The *Remote Control dress* cannot be compared to that used in his *One Hundred and Eleven* collection, but one thing that remains constant is the use of digital tools in storytelling. In his *One Hundred and Eleven* collection, Chalayan employs the use of soft, transparent fabric that is somewhat contrary to the rigid nature of technology but in his *Remote Control Dress* and *Floating Dress* he uses rigid hardware. However, with all the designs, Chalayan told a story.

In conclusion, it is not difficult to see that Chalayan has not only used the concept of technology in his garments to revolutionize the fashion industry but has also married the concept of digital storytelling to bring about a digital culture in the industry. With Hussein Chalayan, there is the garment, the technology, and the message. This message is what continues to further the digital culture in the fashion industry.

CHAPTER 4: CONCLUSION AND FURTHER RESEARCH

With this thesis, I have argued that digital culture has entered into the fashion industry in many ways, through functional clothing that merges everyday clothing with technology, through Iris Van Herpen's work with 3D printing that appears to be the future and through Hussein Chalayan's work with storytelling.

The thesis has mainly examined the journey of technology in clothing from wearable technology to functional, fashionable, and conceptual smart clothing. Technology was first seen in the clothing industry in the form of sewing machines used for the production of garments but the function of technology in clothing quickly grew beyond production and was seen in the clothing itself.

Starting with clothing, the thesis examined how technology came to be merged with clothing pointing out that technology first appeared in the clothing industry in the forms of sewing machines used for manufacturing and production purposes. The concept of wearable technology was formed when technology was merged with clothing. The merger of technology and clothing led to bulky and majorly uncomfortable clothing referred to as wearable technology. The thesis progressed to distinguish wearable technology from smart clothing. While wearable technology describes heavy and bulky technology, smart clothing is also the merger of technology with fashion except with the feature of wearability. The main difference between wearable technology and smart clothing is the concept of wearability.

The influences of the three main aspects examined in the thesis were regarded as contributors to the rise of a digital culture and connectivity within the fashion realm. The thesis has highlighted the spread of connectivity and the rise of a digital culture through smart clothing. It listed the aspects of the new digital culture by examining how smart clothing in the fashion industry contributes to connectivity and interaction among people.

The first aspect of the thesis explains the general use of functional smart clothing as a means of fostering connectivity. With the use of functional smart clothing in various aspects of life like sports, fitness, health, and military, people are able to connect with the digital space without the need for an external device. Beyond the digital space, functional smart clothing has made it possible for people to connect with the bodies and care for their health with the use of this technology.

This chapter also explores the concept of digital culture in functional clothing. This is perhaps the most obvious example of how smart clothing is influencing digital culture in the fashion industry and how connectivity is furthered. Functional smart garments remain the most popular and easily accessible kind of smart clothing in the market further encouraging people to stay connected. These functional smart clothing resembles everyday clothing such that when they are worn, many people do not realize that they are smart garments. This appears to answer the question that asks if smart clothing will come to be regarded as ‘normal’ clothing. This may not be possible with military smart garments or healthcare but with sports and fitness, it has become a possibility.

In the second chapter of the thesis which addresses fashionable smart clothing, the designs by Iris Van Herpen were examined. The use of 3D printing by Iris Van Herpen was examined to show the role haute couture plays in the development of the digital culture in the fashion industry. As the first designer to bring 3D printing to the runway, it is clear that Van Herpen has inspired other designers to use the technology in the creation of their own pieces. The thesis also predicts that in future, consumers of fashion will print their 3D pieces from the comfort of their own home. This culture of printing within the home is one of the ways digital culture will enter into the fashion industry. Regarding the concept of connectivity, this chapter shows that Van Herpen fosters connectivity in the digital space through her 3D printing techniques and the influence it has on other designers. This thesis suggests that fashion pieces may soon be printed from the home eradicating the trip to the store and this point proves Marshall McLuhan's theory of the global village. With the use of 3D printing at home, the need for a clothing store is reduces and digital connectivity is further solidified. This point buttresses how smart clothing has led to a digital culture. With the use of 3D printing, the worlds of technology and fashion are merged, making the consumers themselves the producers of their own outfit.

Hussein Chalayan conceptual smart clothing was examined in the third and last chapter of the thesis. With his designs, Chalayan showed the role that storytelling and technology plays in furthering the concept of connectivity. As explained, Chalayan connects with his audience digitally and personally. With the use of technology, he furthers the concept of interactivity and connectivity in fashion and through storytelling; he targets a more personal connection. Chalayan fosters connectivity between his designs and the general audience. The role of the designs of Hussein Chalayan in fostering connectivity within a digital culture is examined. Hussein Chalayan combines technology with art and culture. The thesis explored how Hussein Chalayan fosters the concept of connectivity with his clothing. Using digital technology and storytelling, Hussein Chalayan fosters a more personal type of connectivity between the wearer and the body. As in many of his designs, Chalayan tells a story that connects personally with his audience and with the use of technology, Chalayan promotes interactivity. Through his designs, Hussein Chalayan has furthered the concept of connectivity and interactivity within the digital space thereby contributing to the digital culture within the fashion industry.

To conclude, this thesis examined how smart clothing has contributed to the rise of a digital culture and foster connectivity within the digital space. Our participation in the digital culture has gone beyond the use of smart phones or electrically powered cars but the culture has been extended into the clothes that we wear. With the chapters outlined in this thesis, it is clear that this digital culture has become a part of the fashion and clothing industry. The thesis shows that the various forms of smart clothing will only continue to achieve higher levels of connectivity. This thesis proves McLuhan's theory of global village with the use of smart clothing. The concept of digital connectivity through the clothes that we wear shows that the digital space will continue to thrive thereby shrinking the world and turning it into a global village.

Further research could be made in the realms of the function of smart clothing during the coronavirus pandemic of 2019/2020. More in-depth research could be carried out to examine how smart clothing contributed to measuring personal healthcare instead of taking a trip to the hospital and risking an infection. It could also be interesting to find out how connectivity between people and the healthcare centre was achieved through smart clothing. This area of research will further solidify and promote the concept of digital culture in the fashion industry.

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