Touching the Cloth.
Haptics in Fashion Digital Communication

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Abstract

Clothing ourselves is a communicative experience and a situated, embodied dress practice (Entwistle, 2000; 2015) in which touch, in all its complexity, plays fundamental role. Passive touch sensations convey how dress feels on the skin, and active touch enables the perception and appreciation of its material properties; haptic information - that is, sensory input obtained through touch - informs and enriches consumers' material exploration in physical retail settings. Digitalization has created new venues for fashion consumption and communication, but it has also mediated and de-materialized dress practices. In the digital domain, clothes are visually accessible but cannot be physically touched or tried on; in fashion e-commerce, hand and on-body touch sensations can only be simulated using audio-visual means. This situation potentially leads to misaligned consumer expectations regarding size, fit and feel; it also contributes to the unsustainable phenomena of product returns. By accelerating fashion digitalization, the recent COVID-19 pandemic has underscored the tactility gap which exists between in-presence and online interaction, and spotlighted the need to enrich touch experience in the digital domain. Haptics - the science of manual sensing and manipulation - is a historical field of enquiry concerned with lack of touch interaction in digital environments. In fact, ongoing developments in haptic technology research aiming to enrich mixed reality experiences with touch feedback might help fill the tactile void in digital fashion.

However, touch and haptics have heretofore not been discussed in the specific contexts of digital fashion communication and business studies; the dissertation addresses this gap. The **research questions** it seeks to answer are the following: what is the relevance of touch sensation - or lack thereof - in digital fashion communication and specifically, in fashion e-commerce? (RQ1); what role might haptic technologies play in enriching fashion brands' online sensorium and e-commerce experience? (RQ2). The research approach is pragmatic, and the methodology is qualitative. Drawing from the literature review, a model of the dis-embodied online experience of dress is conceptualized, positing its re-embodiment through touch technology surrogates. The model threads together fashion and embodied cognition theories as well as touch physiology and

haptics literature. Building onto these foundations, the research is designed, and questions addressed, using a variety of methods including content analysis, case study analysis, focus groups and expert interviews. Two haptic devices simulating a fashion e-commerce experience were customized for the study and used as prompts: TanvasTouch, an interactive screen which enables variable friction surface effects, and the WeArt Touchkey, a small device (coupled with an iPad) which delivers force feedback, texture-based vibrations, and thermal cues to the fingertip in sync with visuals.

The dissertation is structured as follows. **Part I (Chapters 1 – 4)** includes the literature review and the conceptual framing of the thesis. Then, two fashion e-commerce phenomena are analyzed which concern RQ1. The first study constructs a semantic framework for the analysis of touch sense communication and applies it to a sample of fashion brands' e-commerce product descriptions, thereby evidencing textual best practices. The second study explores the growth of virtual try-on (VTO) fashion applications through the conceptual lens of platformization (van Dijck et al., 2018) and identifies the potential risks VTOs pose in terms of privacy, social inclusivity, and brand reputation. **Part II (Chapters 6 and 7)** addresses RQ2 and includes two studies which make use of TanvasTouch and of the WeArt Touchkey as prompts. The first, conducted before COVID-19 using focus group methodology, explores young fashion consumers' attitudes towards touch in fashion consumption and their impressions regarding the introduction of haptic effects in a mock e-commerce setting. Findings suggests that for young consumers, providing richer perceptual cues – tactile and visual – adds value to the e-commerce journey, particularly at the information-gathering stage. The second study, conducted immediately after COVID-19 lockdown measures had lifted and consisting of 14 expert interviews, explores fashion and luxury business executives' perceptions regarding lack of touch in e-commerce, and elicits their views on the potential role of haptics in digital fashion. Findings indicate that even though fashion executives consider lack of touch sensation an unsurmountable gap between the physical and the digital experience, leveraging haptic data within the value chain and adopting haptic technologies to enhance the digital customer experience will confer competitive advantage to fashion brands.

In conclusion, this dissertation explores the issue of touch, or lack thereof, in the digital fashion communication domain, and questions the role of haptic technologies as potential surrogates. The thesis conceptualizes dress (dis)embodiment and touch sensation in the context of digital fashion business practices. It investigates, and provides insights, into the relevance of touch in fashion e-commerce; the phenomena its absence engenders; and - using two devices as prompts - the future role haptic technologies may play in consumer experience and industry practices. Thus, the thesis contributes, conceptually and empirically, to the fields of digital fashion studies and ICTs for Communication, providing valuable outcomes to the fashion industry and the haptic technology sectors.

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Embarking on a doctoral journey at (almost) sixty years of age comes with its particular set of challenges and rewards. Overcoming the first, and rejoicing in the second, would not have been possible without the special people who accompanied me and supported me in all these years. To all of them I extend my heartfelt thanks.

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Ardennes and Talisa, my beloved daughters: you are my pride and joy.

And last, but in truth, first:

Thank you Antoinette, Mother, for believing in me from the very first day, always.

To my husband Antonio Borra,

with love and gratitude.

Table of Contents

List of Figures

List of Tables

1. Introduction

1.1 Research context

Digitalization has created new venues for fashion consumption and communication (Kalbaska et al., 2018; Kalbaska et al., 2019; Nobile et al., 2021; Ornati, 2011; Rocamora, 2019) but it has also mediated (Rocamora, 2017) and de-materialized (Shinkle, 2013) the embodied practice of dress (Entwistle, 2000; 2015). In the digital domain, clothes are visually accessible but cannot be inspected and physically tried on; in fashion e-commerce, hand and on-body touch sensations can only be simulated using audio-visual means (Ornati, 2022). The sense of touch is curtailed or removed altogether, with the exception of finger or tool interaction on a screen. This tactile gap between the in-person retail experience and fashion e-commerce was underscored by the recent COVID-19 pandemic, which accelerated the digitalization of business-to-consumer and business-to-business communications and sales (Amed et al., 2020, 2021; Campisi et al., 2021; Noris & Cantoni, 2021). The concurrent growth of fashion and luxury e-commerce has brought to the fore issues regarding size and fit, which are the main cause of costly and unsustainable e-commerce returns (Lieber, 2019; Narvar, 2021; Salerno-Garthwaite, 2022 ; Schiffer, 2019). Efforts to render the online dress experience more realistic and accurate has encouraged the development and adoption of digital embodiment surrogates such as virtual try-on applications (Fortune Business Insights, 2021). These solutions, however, pose potential data privacy risks for consumers and brands (Ornati et al., 2022).

The need to enrich the digital sensorium has spurred investigation in sensory imagery (Elder & Krishna, 2021) and the role interactive visuals may play in evoking touch-related stimuli in apparel e-commerce and online shopping in general (Costes et al., 2019; Lee & Choi, 2022; Orzechowski, 2016; Perry et al., 2013). However, the digital experiences observed in these studies and currently experienced by consumers are mediated (Verbeek, 2005; 2015) by personal computer, tablet and smartphone touchscreen interfaces, which afford a limited range of haptic interaction (Hoggan, 2013). *Haptics*, an interdisciplinary research field focused on touch sensation and its reproduction in human-computer and social interaction, addresses this concern (Prattichizzo, 2021). The term haptics is used within diverse disciplines to imply both the act of sensing and its effects. Haptics is a field of enquiry with a long history (Parisi, 2018). Today, haptic technologies

covering the real to virtual - or extended reality - spectrum are widely used in diverse applications within the automotive, medical, defense, educational and gaming sectors. Although haptic systems are still limited in their ability to reproduce touch (Prattichizzo et al., 2019), in the last decade they have become increasingly wearable, portable, and less expensive. Furthermore, the haptic engineering community is working towards systems interoperability and common guidelines to support haptic design and implementation (Vezzoli et al., 2022). These developments open "great opportunities in the consumer market" (Prattichizzo et al., 2019, p. 228) for diverse applications including interaction in augmented reality (AR), virtual reality (VR) and extended reality (XR). Ultimately, the vision of researchers in the haptic field is one of 'rich touch interactions' with 3D objects in AR, VR and XR applications – 'embodiments of an immersive haptic reality' which 'have the potential to change the way we live, work, learn and leisure' (*Eurohaptics 2020 Conference – September 6-9, 2020, Leiden*, n.d.).

1.2. Research questions

Spurred by the COVID-19 pandemic, which forced traditional marketing and communication activities online, fashion and luxury brands are increasingly interested in digital fashion, from e-commerce to augmented reality to virtual fashion shows, and cognizant of issues connected to touch and dress disembodiment in the digital domain. Thus, haptics - as well as other sensory-enabling technologies (Petit et al, 2019) - are extremely relevant for digital fashion. However, touch - or lack thereof - and the potential which technologies such as haptics may offer as touch surrogates in the digital dress experience, have heretofore not been discussed in the specific contexts of digital fashion communication. Neither have *surface haptics* devices been used in fashion and luxury business studies investigating these issues. The dissertation addresses this gap, providing a substantial contribution to academic and industry practitioners.

This thesis poses the following research questions:

RQ1: *what is the relevance of touch sensation - or lack thereof - in digital fashion communication and specifically, in fashion e-commerce?*

RQ2: *what role might haptic technologies play in enriching fashion brands' online sensorium and e-commerce experience?*

In the next section the theoretical grounding and conceptual model of the thesis is illustrated. Then, the research design and methods section is introduced. This is followed by a brief introduction to haptic technologies and to the haptic devices chosen for the research. Finally, an overview of the thesis structure, contents, and contribution is provided.

1.3. Theoretical grounding and conceptual model

The sense of touch plays a fundamental role in the development of human beings (Bremner & Spence, 2017; Field, 2014) and social interaction (Gallace & Spence, 2010, 2016; Jewitt et al., 2019). Touch is an integral part of the multisensory processes which inform our perception of the world (Linden, 2015; Prescott & Dürr, 2015). Touch affects emotions, thoughts, and actions, including our clothing choices (Peck, 2010; Peck & Childers, 2003a). Touch is the only bi-directional modality: through touch, humans acquire and transmit information (Field, 2014). Given its complexity and significance, touch is investigated within diverse fields of contemporary enquiry, from philosophy (Fulkerson, 2014, 2020; Paterson, 2007) to the social sciences (Classen, 2012; Kearney, 2021) and the natural sciences (Gallace & Spence, 2010). This thesis approaches touch from the perspective of fashion theory (Barnard, 2020; Rocamora & Smelik, 2015) and fashion communication (Cantoni et al., 2020; Kalbaska et al., 2018, 2019; Rocamora, 2017; Sádaba et al., 2021), but also draws from other disciplines and fields of knowledge. In so doing, it constructs a conceptual model - illustrated at the end of this section – of technologically-mediated business and consumer fashion practices which frame the thesis' contributions. The central notion and starting point of the model is *dress embodiment*.

Dress embodiment. As mentioned, this thesis is anchored in fashion studies and specifically, in Joanne Entwistle's theorization of dress as a socially situated, embodied practice (2000; 2015). Her theory provides an entry point to the concept of dress as a bodily experience which fully engages the sense of touch. Subsequently, the role of touch in dress embodiment - and thus, its influence on perception and action - is explored through

the lens of embodied (Miłkowski, 2019), grounded (Barsalou, 2008) and enclothed cognition (Adam & Galinsky, 2012). These theories provide a complementary perspective on the significance of dress as a physically and cognitively engaging experience. Onto these foundations, the thesis builds theoretical contributions regarding the touch sense in consumer behavior and marketing practice. Foremost amongst these are Peck and Childers' seminal studies on the need for touch (2003a, 2003b), the relevance of haptic experience (Peck, 2010), and haptic imagery (Peck et al., 2013); the writings of Klatzky (2010) as well as Krishna (2012) and fellow authors, which bridge marketing, embodiment, and embodied cognition concepts (Krishna et al., 2017; Krishna & Schwarz, 2014); and the multidisciplinary research of Gallace and Spence (2014) which explores touch sensation in both the present and future consumer experience. These studies, which help explain the centrality of touch in the fashion customer journey, and thus, what the lack of it might imply, are extensively discussed in Ch. 1 and particularly in Ch. 2.

Dress dis-embodiment. Subsequently, the thesis adopts a postphenomenological, hermeneutic reading (Veerbek, 2005a, p. 196) of technology's mediating role. Devices commonly used to access the web - computers, tablets, and smartphones - afford rich audio-visual stimuli (still and moving images, text) but limited tactile sensation (vibration, pulses). Thus, the haptic qualities of a garment represented digitally cannot be readily understood as they would be with the garment physically available. In the viewer, however, additional information regarding these qualities may be provided by sensory integration and substitution mechanisms (Bruno and Pavani, 2018) and mental simulation processes (Elder & Krishna, 2012; Papies et al., 2017). Thus, the digital *experience* of dress – the garment's haptic qualities – is *co-determined*, or *mutually constituted*, by both the user and the technology (or rather, its affordances) through which dress is accessed. "Within these human-technology relations, transformations of perception occur" (Verbeek, 2005b, p. 4). Dress is disembodied (it is not worn, nor felt on the body), but its embodiment is understood via *other* means, because "technologies help to shape what counts as 'real'" (Verbeek, 2005b, p. 5). This is the conceptual premise upon which the first two empirical enquiries included in this thesis as Ch. 3 and Ch. 4 are conducted, respectively: touch communication in online texts and virtual try-on (VTO) applications.

Both textual descriptions and VTOs are understood as strategic workarounds which fashion business adopts to address lack of touch interaction in fashion e-commerce. In discussing the implications these phenomena may have for firms and consumers, the thesis engages with theories of datafication and platformization (van Dijck, 2014; van Dijck et al., 2018). The third and fourth studies – Ch. 6 and Ch. 7, respectively - involve fashion consumers as well as fashion industry business managers. Both studies include the use of haptic devices and introduce the possibility of enriching the fashion e-commerce experience with touch feedback. Thus, technology is understood as a means to actively re-intermediate the experience of touch, albeit in a limited way, given surface haptics' technological affordances.

Dress re-embodiment. Finally, the thesis speculates on a future of dress embodiment, where the sense of touch is re-mediated by haptic and other technologies. These experiences will be situated in phygital or hyperreal environments (which blend digital experiences into physical contexts[1]) made possible by the integration of mixed reality technologies (Flavián et al., 2019; Obrist et al., 2017) along the real to virtual reality continuum (Milgram & Colquhoun, 1999); in these spaces, dress might be haptically felt by means of wearable devices and extensions. In fact, dress experience is already situated in the metaverse (Balchandani et al., 2022), where fashion enjoyment and consumption can be expressed and enacted by users' personal avatars. However, these phenomena are new, and their implications for digital fashion marketing practice - and more generally, for consumers and society – are only beginning to be investigated (Dwivedi et al., 2022).

The **model** illustrated in Fig. 1.1 summarizes this thesis. The model conceptualizes the experience of "dress" as situated within Milgram & Colquhoun's (1999) physical to extended reality continuum, represented vertically and from top to bottom. Situated along this axis are *dress embodiment* (the on-body, tactile and kinesthetic experience of the physical world: handling and trying on clothes in a fashion store or at home); *dress dis-embodiment* (the off-body, visually rich but touch-diminished, digital environment

[1] For a very recent development in hyperreal environments see: https://www.outernetglobal.com/

experience of navigating a fashion e-commerce website); and *dress re-embodiment* (the multisensory experience that converging technologies – including haptics - might offer in the future; for ex., donning and feeling virtual garments in the metaverse). In the model, these diverse practices of dress are intersected horizontally, on the one side, by *business* (fashion firms preoccupied with value-creation); and on the other, by *consumers*, who affect, and are affected by, fashion business practices. Since the empirical enquiry of this thesis focuses primarily on the implications of dis-embodiment - lack of touch – in fashion e-commerce, business and consumers intersect the model in its second dimension - that of digital disembodiment. However, the thesis includes a discussion of dress in physical reality - the first conceptual dimension – and extends its investigation, albeit speculatively, to the third.

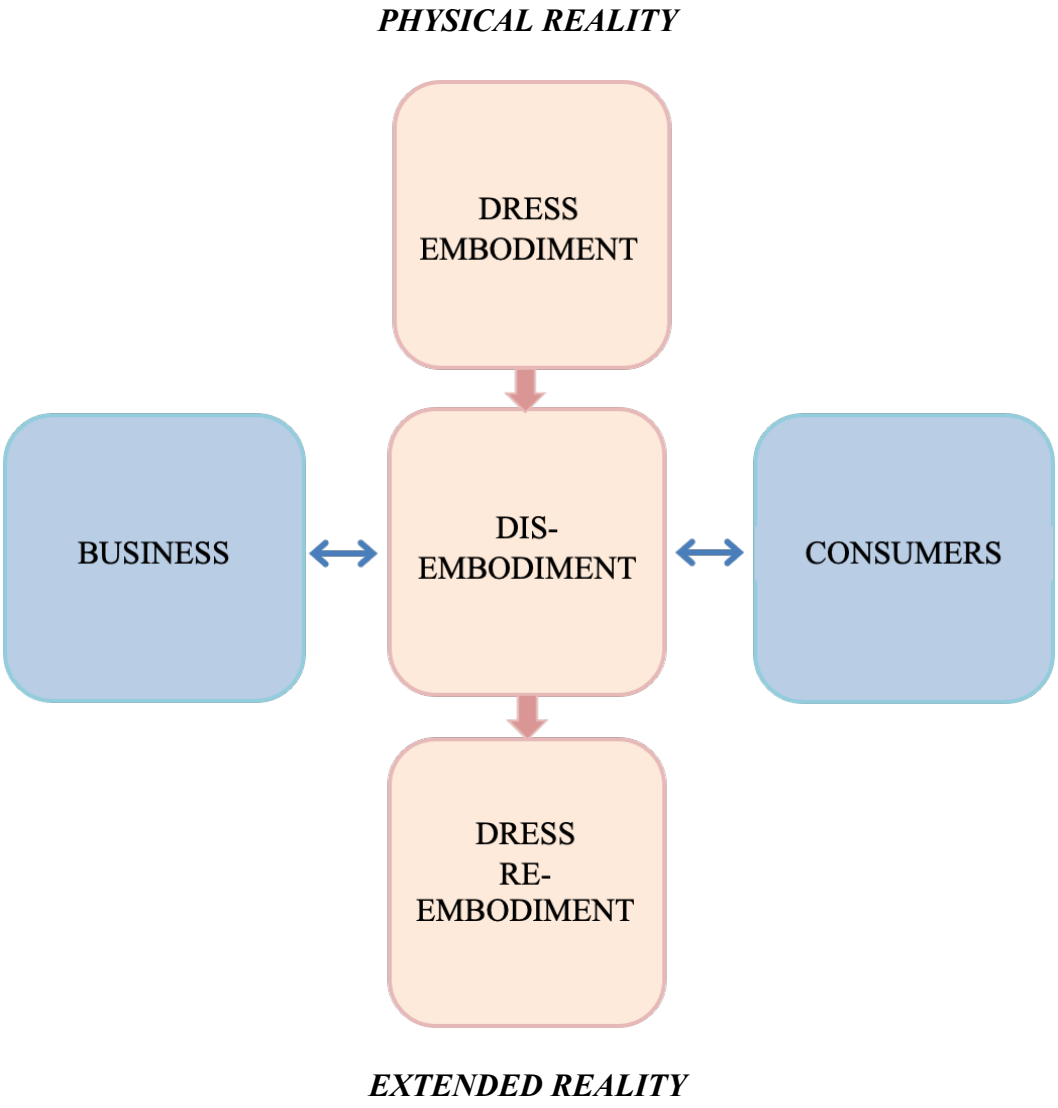

Fig. 1.1. Conceptual model of digital dress (dis)embodiment.

1.4. Research design, method, and timeline

The thesis draws from the diverse disciplinary affiliations and theoretical approaches which are conceptualized in the dress embodiment model and illustrated in section 1.3. However, the focus of the enquiry is the concrete issue of touch in fashion e-commerce and its relevance in current and future digital fashion business and consumer practices. Therefore, the research adopts a *pragmatic qualitative approach,* which is a suitable lens through which to study real-life problems and business issues with methodological flexibility (Savin-Baden & Major, 2012)[2]. As is often the case with pragmatic approaches (Sandelowski, 2000), the methodology chosen for this study is characterized by an overarching *descriptive orientation*. Methods of enquiry included content analysis (Fielding et al., 2017), case study analysis (Yin, 2002), focus groups (Barbour, 2018; Cyr, 2019) and expert interviews (Bogner & Menz, 2009; Meuser & Nagle, 2009; Trinczek, 2009). Special care was taken to describe in detail the haptic devices used in the study and to provide a rationale for choosing them. The research project, starting with the focus group, was approved by the university's Ethical committee.

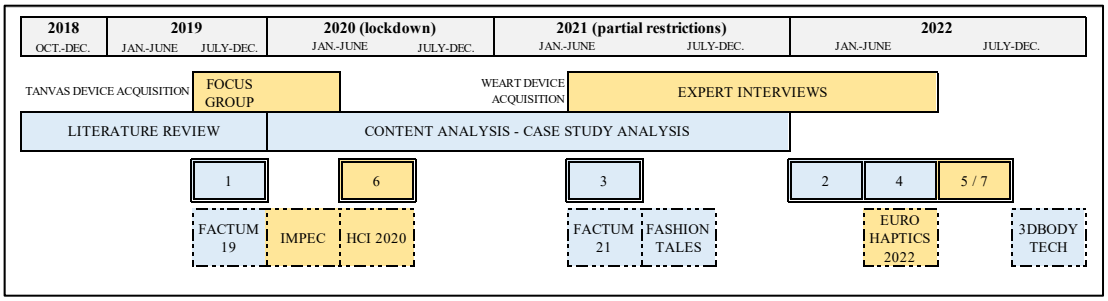

Fig. 1.2. Thesis timeline.

[2] As discussed in section 1.3, postphenomenology informs our understanding of technology's mediating role in the disembodiment of dress. It is important to note, however, that none of the studies adopt a phenomenological methodology.

Timeline. Work for this thesis and the contributions therein (illustrated in section 1.6 and summarized in Table 1.1) was conducted from October 2018 through July 2022. Due to COVID-19, the research design had to be revised, and methods adapted to pandemic restrictions. Fig. 1.2. illustrates the different phases of the research in chronological order. In addition to the literature review, the first part of the study - carried out in large part during lockdown - consisted of primary data collection through content and case-study analysis of fashion e-commerce websites; this work led to publications listed with corresponding chapter numbers 1, 2, 3 and 4. The second part of the research - performed just before and immediately after restrictions had eased - included a focus group and a set of expert interviews carried out using first one, then two haptic devices bought in the interim; this work led to publications listed with corresponding chapter numbers 5, 6 and 7. Several conferences were attended and publications presented either in person or online[3]. Phases of data analysis, writing, and peer-review are not evidenced in the table but were necessarily part of the process.

1.5 Haptic technologies and devices

To clarify the role of haptics in this thesis and in the research design in particular, a brief introduction to haptic technologies and haptic perception is provided, followed by an overview of the surface haptics devices utilized[4].

Haptic technologies. The term "haptics" derives from the Greek word *haptesthai* meaning "of or relating to" the sense of touch (Classen, 2012). Its current meaning as a "science of touch" entered English use in the 19th century (Merriam-Webster, n.d.). Today, the term haptics is used within diverse disciplines to imply the *act* of touching and

[3] Conferences: Factum19, 21-26 July 2019, Ascona, Switzerland; IMPEC, 1-3 July 2019, Lyon, France (online); HCI International, 19-24 July 2020, Copenhagen, Denmark (online); Factum 21, June 28th – July 1st 2021, Pamplona, Spain; FashionTales, 11-13 July 2020, Milan, Italy (online); EuroHaptics, 22-27 May 2022, Hamburg, Germany; 3DBodyTech, 25-26 October 2022, Lugano, Switzerland.

[4] This section is an edited and updated version of the introduction to haptic technologies and haptic devices employed, featured in Ch. 2 and in Ch. 5, 6 and 7, respectively.

its effects (Jones, 2018), as opposed to the non-active experience of being touched (Gibson, 1962). In the context of this thesis, haptics mainly refers to *haptic technologies*. These are defined as integrated mechanical, electronic and computational systems and non-invasive applications enabling human–computer interaction (HCI) by artificially reproducing the sense of touch (Basdogan et al., 2020; Culbertson et al., 2018; Kuchenbecker, 2018; Prattichizzo et al., 2019). By definition, these systems involve 'sensing, processing, and actuating' (Kuchenbecker, 2018, p. 3). Haptic systems can be deployed for interaction in different kinds of environments: the user's physical setting; a tangible but remote environment (e.g., when performing surgery on a patient at a distance); or an immersive, virtual one (Kuchenbecker, 2018). Thus, haptic systems can be found all along the reality-virtuality continuum (Flavián et al., 2019) in devices as diverse as, for example, smartphones, wearables, or virtual reality gaming controls (Parisi, 2018).

Haptic systems can be categorized by type of interaction: *graspable*, *wearable*, *touchable* (Culbertson et al., 2018, pp. 387-8) and *contactless* or mid-air (Rakkolainen et al., 2020). Graspable systems are kinaesthetic devices, typically manoeuvred via a hand-held tool, which enable the user to exert force and feel force or other sensory feedback. Wearable systems are cutaneous devices which are worn on the body – typically the hands – and which convey sensations directly to the skin. Touchable systems are also cutaneous devices, but usually in the form of a surface which changes tactile properties based on the location of the user's fingers during the interaction. Contactless or mid-air haptic systems function by exerting pressure on the skin (via ultrasound, air jet or other technologies); unlike the systems just described, they do not require physical contact with the user.

Haptics systems can also be distinguished in terms of where they are mounted: *grounded* devices[5] are objects attached to a surface; *ungrounded*, or – confusingly – *body-grounded* devices are held in the hand or worn on the body (e.g. thimble-like devices or exoskeletons). *Surface* haptic interfaces are surfaces which may be stationary, such as a computer screen, or portable, as in the case of a smartphone interface; their defining

[5] An open-source database of grounded haptic devices is available online. See: https://haptipedia.org/.

characteristic – with reference to the other types of systems described here – is the fact that tactile feedback is generated via direct interaction with the fingers or a tool, such as a stylus.

In order to function, haptic systems usually incorporate sensors, actuators, or both. *Tactile sensors* are data acquisition devices designed to detect diverse properties of objects upon direct physical contact; these devices approximate human touch sensing and perception capabilities, converting the information acquired so that it can be processed and analyzed within an intelligent system (Martinez-Hernandez, 2015); a sophisticated example of these technologies is the SynTouch Toccare biomimetic sensor (https://syntouchinc.com/technology/). *Actuators* are machine components which control the haptic system or parts of it. Specifically with regards to surface haptics, the three most popular types of actuators are vibrotactile, electrostatic, and ultrasonic (Basdogan et al., 2020). Put simply, actuators can deliver different kinds of *haptic feedback*. In so doing, they trigger *haptic perceptions*, that is, the corresponding perceptual processes which occur in the body.

For the purpose of this discussion, both haptic feedback and the corresponding **haptic perception** modalities (or states) which it actuates can be broadly divided into two categories: *kinesthetic*, and *tactile* or *cutaneous*, as it is called in psychophysics literature (Lederman & Klatzky, 2009). The distinction between the two categories is based on what kind of stimuli a haptic system provides, and on what kind of receptors or nerve endings such stimuli activate in the body. *Kinaesthetic feedback* refers to forces or pressure sensations, either active or passive, which affect joints and body parts. *Tactile feedback* refers to sensations stimulating cutaneous receptors (described in detail in Ch. 2). Tactile or cutaneous feedback can be triggered in one of the following ways: via *vibrations or pulses*; by *stretching* or *displacing* the skin (with or without contact, as in the case of air pressure waves); through *electrostimulation*; or via *temperature* changes (Basdogan et al., 2020; Bayousuf et al. 2019; Culbertson et al., 2018; Vezzoli et al., 2022).

In the context of this thesis, it is important to note that haptic perception guides our understanding of material (surface texture, compliance, and thermal qualities) and

geometric (size and shape) object properties, as well as other characteristics, such as weight (Lederman & Klatzky, 2009, p. 1442). For example, gestures made when inspecting textiles and garments, such as holding cloth in one's hand or assessing fabric by pressing it between thumb and finger, normally activate both kinesthetic and tactile modalities, while stroking a swatch of fabric with one's finger primarily activates the tactile or cutaneous state. Humans have "exquisite sensitivity to mechanical vibrations in the skin" (Fishel & Loeb, 2012, p. 1122). As it happens, cutaneous mechanoreceptors responding to touch and to thermal stimuli are particularly dense in the glabrous skin of the hand and fingers. The latter are also highly innervated and thus, especially sensitive (Jarocka et al., 2021). Tactile acuity, or the ability to perceptually resolve temporal and spatial details in a haptic experience - the fine details in fabric weft, the density of threads used, or the type of weave felt while touching fabric - may vary with age, gender, and practice (Lederman & Klatzky, 2009). Sensory integration (Bruno & Pavani, 2018) also plays a role in haptic perception processes: what we see complements what we haptically perceive.

In fact, visuals and haptic feedback are key features of the two devices used as prompts in this research: TanvasTouch® (www.tanvas.co) and the WeArt Touchkey (www.weart.it). In the next section I shall briefly describe why these technologies were chosen for the research; how they work and how they were customized; and finally, what their limitations are in the context of this thesis.

TanvasTouch and WeArt Touchkey: haptic device selection, customization and limitations. Neither TanvasTouch nor the WeArt Touchkey were developed specifically for the fashion industry. However, both devices offer features suitable for this research, key amongst them the option of layering haptic feedback effects upon images accessible in an interactive environment. Thus, it is possible to simulate the fashion e-commerce user experience with both TanvasTouch and WeArt as it might take place on a computer, tablet, or mobile phone screen, but with haptic effects associated with garment visuals. Furthermore, unlike other haptic technologies on the market, these devices are reasonably low-priced. Based on these considerations, eLab, USI's center for digital technology and support services (https://www.usi.ch/en/university/info/elab), purchased

three TanvasTouch screens in 2019 and one WeArt Touchkey in 2021. Due to the timing of acquisition and to the time period required for customization, the TanvasTouch device was included in both stages of the research design (Ch. 6 and Ch. 7) while the WeArt Touchkey was included in the final part only (Ch. 7).[6]

TanvasTouch. TanvasTouch (Fig. 1.3 below) is a grounded (stationary), capacitive[7], electro adhesion-based surface haptics system which includes an interactive screen and a proprietary software engine.

Fig. 1.3. TanvasTouch device. Source: Tanvas. Reproduced with permission.

[6] Both devices were extensively deployed as prompts in conference workshops, interactive lectures and internal university presentations.

[7] Capacitance sensing is a technology that can detect anything which is conductive. Sensors which incorporate capacitive sensing may, for example, detect pressure, but also position and displacement, as would be the case with TanvasTouch (https://en.wikipedia.org/wiki/Capacitive_sensing).

As explained on the manufacturer's website[8] (emphasis added):

> The touch surface of a TanvasTouch-enabled device has been engineered by Tanvas to enable *precise fingertip tracking* and *simultaneous haptic rendering*. The surface is similar to existing projected capacitance touch sensors in smartphones and tablets, but a few key differences in the manufacturing steps enable us to *change the surface friction programmatically*. Behind the actual touch surface sits custom electronics that track touch locations on the screen. In coordination with the TanvasTouch Engine in software, *the electronics precisely deliver real-time variable friction to each fingertip in contact with the surface*.

TanvasTouch haptic effects are created in programming software such as C++ using bitmapped and grayscale images. Pixels can be programmed within a single image so as to vary in haptic intensity from 0 to 255 per pixel. Thus, by rendering the color photograph of a piece of fabric to grayscale, one can plot varying degrees of haptic feedback based on how the texture presents itself. On the screen, modulated haptic effects will simulate, with some approximation, the uneven surface characteristics perceived while stroking the original flat swatch of material. For the purpose of this thesis, an ad-hoc haptic experience had to be created on the TanvasTouch device. This customization process included several phases described in detail below and in Ch. 6.

The first phase of customization involved acquiring the actual clothes to be used in the study. Five women's and three men's garments (including a knitted cotton top, corduroy pants, a woolen houndstooth skirt and a jeans jacket) were bought new at a local store; the items were purposefully chosen based on diverse material and surface characteristics. Subsequently, the garments were professionally photographed on real models by a photography student at the local art school, and a standard contract signed by

[8] See: https://tanvas.co/resources/tanvastouch-basics

all parties for non-commercial image release. The photos included zoom-in images of each garment.

The next phases involved close collaboration with colleagues at eLab. The zoom-in image of each garment was rendered in black and white and cleaned to visually enhance the differences in surface texture. Then the black and white images were uploaded to the software environment of the TanvasTouch device, where surface texture characteristics were approximated, pixel by pixel, with haptic feedback effects of variable intensity. In the example of the embroidered blouse detail pictured below (Fig. 1.4), the knubs - rendered in black - were mapped with strong effects and perceived like little bumps on the screen's surface, whereas the rest of the surface - the white areas in between – were mapped with lower feedback and thus, felt almost smooth.

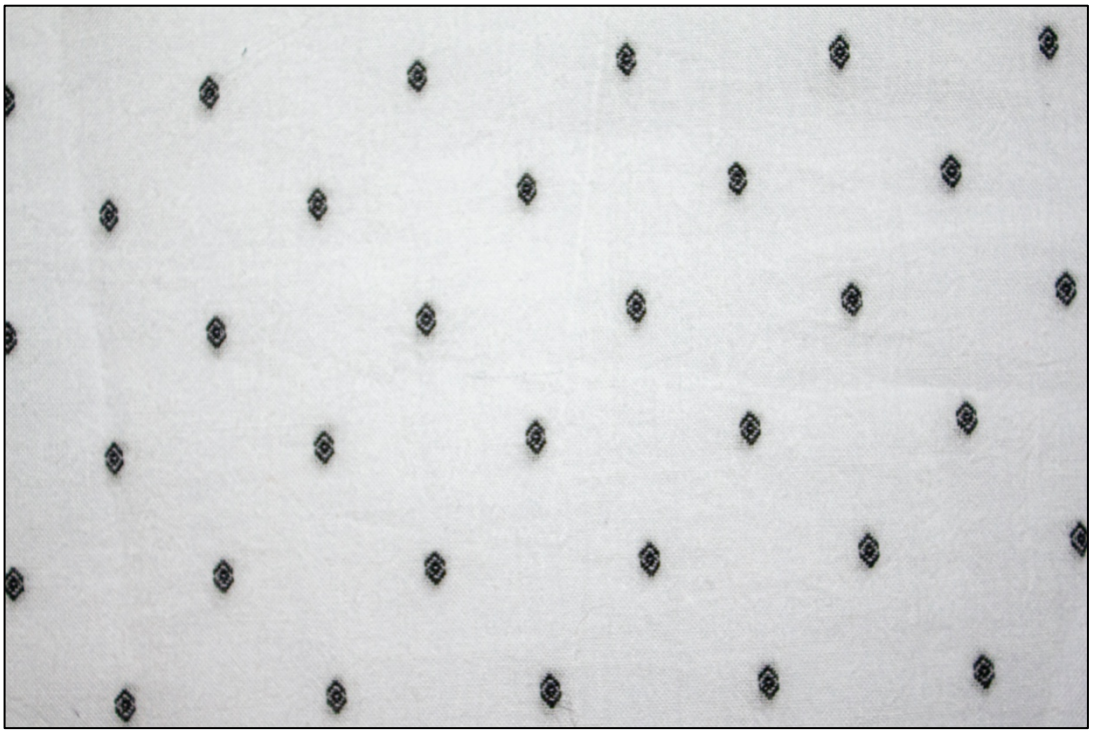

Fig. 1.4. Embroidered blouse detail.

Using an e-commerce storyboard provided as a guide, e-Lab colleagues designed and uploaded the graphic layout of the *FashionTouch* website to the TanvasTouch software environment. This website simulation includes a landing page and several product pages linked to the landing page. The individual product pages feature the garment images with the accompanying product descriptions and the zoom-in images with corresponding haptic renderings. Thus, starting from the landing page, users can select a garment, navigate to the product page (as in Fig. 1.5 below), choose an image, enlarge it, and view a close-up of the material while perceiving diverse surface texture effects in the corresponding area. On the basis of the literature review and to our knowledge, such a detailed, fashion-specific customization of TanvasTouch's features is the first ever to be implemented for use in academic research.

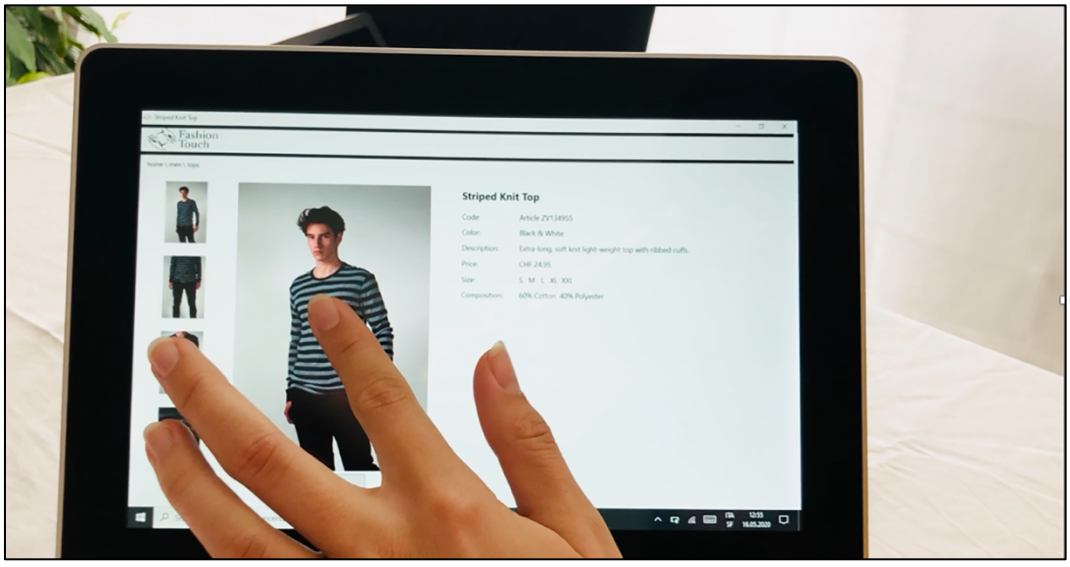

Fig. 1.5. Mock website interaction on TanvasTouch.

WeArt Touchkey. WeArt currently includes a wearable haptic system which reproduces tactile cues on the wearer's skin in virtual reality environments (Gioioso et al., 2019). The WeArt Touchkey (Fig. 1.6) is part of an earlier, non-weareable prototype of this system.

Fig. 1.6. WeArt Touchkey. Source: WeArt. Reproduced with permission.

As mentioned above, the WeArt Touchkey is a small device which must be used coupled with an iPad. Actuators inside the device deliver force feedback and texture-based vibrations; a so-called Peltier device provides thermal cues. These haptic and thermal effects are perceived by the fingertip positioned on a small area in the forward section of the Touchkey (see Fig. 1.7). Unlike TanvasTouch, the haptic feedback effects for the WeArt interaction were created by the WeArt Touchkey developer. Haptic stimuli were recorded directly from the original eight garments (Fig. 1.8) using proprietary sensing technology and editing software (Gioioso et al., 2022; Spagnoletti et al., 2022). Subsequently, the supplier synched the haptic effects recording and corresponding feedback – delivered via the Touchkey - with a video rendition reproducing the original finger gesture.

Fig. 1.7. Interaction on iPad application and WeArt Touchkey.

Fig. 1.8. Texture acquisition in the WeArt labs. Reproduced with permission.

The *FashionTouch* mock website and the interaction simulation for each garment were made accessible on an Apple iPad (using a TestFlight application) and paired to the WeArt Touchkey via bluetooth. Thus, when users place a finger on the Touchkey with one hand and choose a garment on the iPad screen with the other (Fig. 1.9), they simultaneously a) see a pointer moving across the material on the iPad screen, and b) feel the corresponding force-feedback effects under their fingertip.

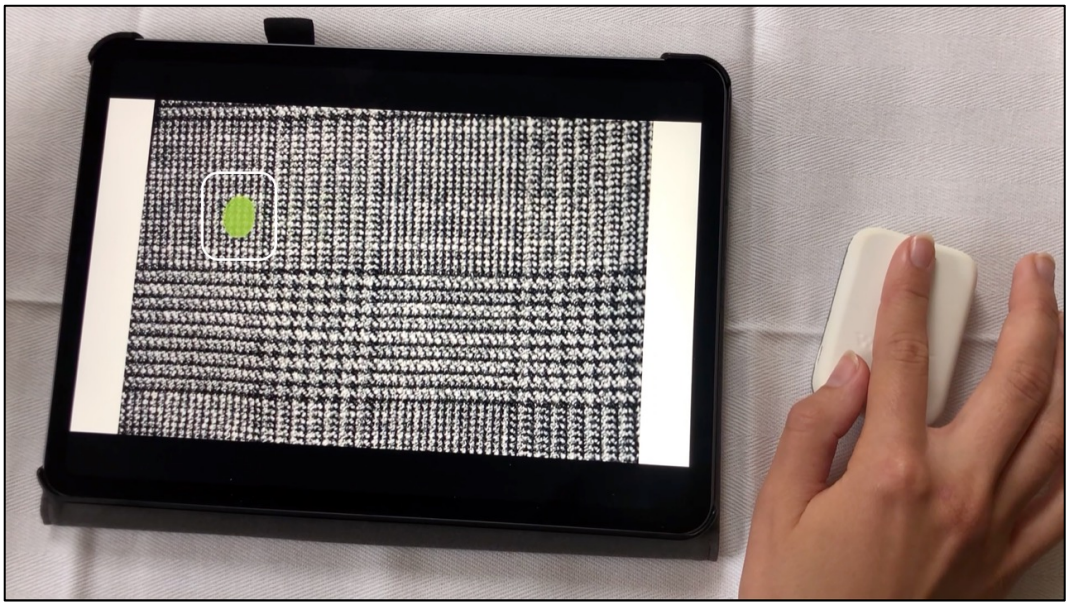

Fig. 1.9. Interaction detail with haptic feedback pointer and WeArt Touchkey. The green pointer is visible in the upper left-hand side of the screen.

Video recordings of device interaction. Two private videos illustrating FashionTouch interaction are accessible online:

- TanvasTouch: https://youtu.be/NEtf1d53eZ8
- WeArt Touchkey: https://youtu.be/_wt_6IG-NU8

Possible device limitations. The TanvasTouch and the WeArt Touchkey are suitable devices with which to investigate touch in the context of fashion e-commerce,

both with regards to their technical features and to their accessibility. However, certain characteristics and specific features affect their use in a fashion research context.

First of all, the degree of haptic feedback afforded by these devices can only approximate the haptic perception phenomena which is normally triggered by the skin's high sensitivity (Fishel & Loeb, 2012) to mechanical vibrations. Stroking a fabric swatch with a finger provides richer perceptual cues than performing the same gesture on the TanvasTouch screen or feeling it through the WeArt Touchkey. This limitation was frequently commented upon, particularly by expert interviewees. Also, both TanvasTouch and the WeArt touchkey are contact-based haptic systems. As such, the intensity of the haptic feedback perceived may vary depending on the user's cutaneous sensitivity as well as the kinesthetic pressure applied with the finger(s) to the surface of the device (Ayyildiz et al., 2018; Sirin et al., 2019). Based on the descriptions of the interaction experience, this proved to be the case with both focus group and expert interview participants alike[9]. And, because of its conductivity, the TanvasTouch device felt unnaturally warm after prolonged stroking. Finally, surface haptics in the form of screens and touchkeys allow reduced gesture interaction: only the fingertip(s) can be used. This is quite unlike the complex hand (Lederman & Klatzky, 1987) and body movements which characterize garment inspection and handling. At every stage of the study, participants freely expressed the perceived limitations of the devices. Where pertinent, these were duly noted in the research results.

These observations notwithstanding, both TanvasTouch and the WeArt Touchkey proved to be important assets in the research design. This is because the devices were used exclusively as prompts: their purpose was to elicit considerations regarding haptic feedback in fashion e-commerce, and this intention was made immediately clear to research participants. As it were, the freedom afforded by not having to test the technologies in terms of fidelity and overall readiness for adoption was fundamental in achieving research objectives.

[9] Haptic perception was most probably also affected by device and hand disinfection, although care was taken to privilege non-greasy, alcohol-based products.

1.6. Structure of the thesis

This thesis explores touch, or lack thereof, in fashion e-commerce, and the potential role haptics - technologies aiming to reproduce the sense of touch - might play in enriching the online fashion sensorium. Thus, as discussed in section 1.2 above, it aims to answer two research questions:

RQ1: *what is the relevance of touch sensation - or lack thereof - in digital fashion communication and specifically, in fashion e-commerce?*

RQ2: *what role might haptic technologies play in enriching fashion brands' online sensorium and e-commerce experience?*

The outcome of the research consists of the seven contributions (and respective publications) presented therein. The thesis is structured in two parts, as explained below and summarized in Table 1.1.

Part I, Chapters 1 – 4. This section includes four contributions. Chapter 1 consists of the position paper for the research. Chapter 2 provides the conceptual capstone of the thesis, including the literature review. Chapter 3 and 4 address RQ1 and focus on distinct fashion e-commerce phenomena. Ch. 3 constructs a semantic framework for the content analysis of touch sense communication and applies it to a sample of fashion brands' e-commerce product descriptions, thereby evidencing textual best practices. Using a case study method, Ch. 4 explores the growth of virtual try-on (VTO) fashion applications through the conceptual lens of platformization and identifies the potential risks VTOs pose in terms of privacy, social inclusivity, and brand reputation (Ch. 4).

Part II, Chapters 5 - 7. This section includes three contributions (highlighted in Table 1.1). Chapter 5 is an overview of the research conducted with haptic technologies devices. Chapter 6 and 7 address RQ2, using the haptic devices described above as prompts. Ch. 6 describes a study (co-authored with Prof. Lorenzo Cantoni) conducted before COVID-19 using focus group methodology. The research explores young fashion consumers' attitudes towards touch in fashion consumption and their impressions regarding the introduction of haptic effects in a mock e-commerce setting. Findings

suggests that for young consumers, providing richer perceptual cues – tactile and visual – adds value to the e-commerce journey, particularly at the information-gathering stage. Ch. 7 details a study (co-authored with Dr. Nadzeya Kalbaska), conducted immediately after COVID-19 lockdown measures had lifted. The research is based upon 14 expert interviews. It explores fashion and luxury business executives' perceptions regarding lack of touch in e-commerce and elicits their views on the potential role of haptics in digital fashion. Findings indicate that even though fashion executives consider lack of touch sensation an unsurmountable gap between the physical and the digital experience, leveraging haptic data within the value chain and adopting haptic technologies to enhance the digital customer experience will confer competitive advantage to fashion brands.

The Conclusion, the Appendixes and the References close this thesis.

1. Position paper

Ornati, M. (2019). Touching the Cloth: Haptics in Fashion Digital Communication. In N. Kalbaska, T. Sádaba, F. Cominelli, & L. Cantoni (Eds.), *Fashion Communication in the Digital Age* (pp. 254–258). Springer International Publishing. https://doi.org/10.1007/978-3-030-15436-3_23

2. Conceptual capstone and literature review

Ornati, M. (2022). A true feel: Re-embodying the touch sense in the digital fashion experience. In T. Cinque & J. B. Vincent (Eds.), *Materializing Digital futures: Touch, Movement, Sound and Vision* (pp. 205–222). Bloomsbury Academic.

3. Critical content analysis of tactile cues in e-commerce websites

Ornati, M. (2021). Touch in text. The communication of tactility in fashion E-commerce garment descriptions. In T. Sádaba, N. Kalbaska, F. Cominelli, L. Cantoni, & M. Torregrosa Puig (Eds.), *Fashion Communication* (pp. 29–40). Springer International Publishing.

4. Case-study investigation of touch surrogates: Fit and sizing solutions and platform phenomena

Ornati, M., Picco-Schwendener, A., & Marazza, S. (2022). Sizing up the body: Virtual fit platforms in fashion e-commerce. *International Journal of Fashion Studies*, 9(1), 199–218.

5. Overview of work in progress using haptic devices

Ornati, M. (2022). Fashion touch. Surface haptics in fashion e-commerce. In H. Seifi, A. M. L. Kappers, O. Schneider, K. Drewing, C. Pacchierotti, A. Abbasimoshaei, G. Huisman, & T. A. Kern (Eds.), *Haptics: Science, Technology, Applications: 13th International Conference on Human Haptic Sensing and Touch Enabled Computer Applications*, *EuroHaptics 2022, Hamburg, Germany, May 22–25, 2022, Proceedings* (Vol. 13235, pp. 464–467). Springer International Publishing. https://doi.org/10.1007/978-3-031-06249-0

6. Focus group exploration of consumer attitudes towards surface haptics digital fashion experiences

Ornati, M., & Cantoni, L. (2020). FashionTouch in e-commerce: An exploratory study of surface haptic interaction experiences. In F. F.-H. Nah & K. Siau (Eds.), *HCI in Business, Government and Organizations.* (Vol. 12204, pp. 493–503). Springer.

7. Enquiry into industry stakeholders' perceived value and limitations of haptic technologies (expert interviews)

Ornati, M., Kalbaska N. (2022). Looking for Haptics. Touch Digitalization Business Strategies in Luxury and Fashion during COVID-19 and beyond. *Digital Business*, 10035. Elsevier (Open Access) https://doi.org/10.1016/j.digbus.2022.100035

Table 1.1. Thesis chapters and corresponding publications, double-blind peer-reviewed except Ch. 5, 6 (peer-reviewed). Highlighting indicates research involving haptic devices.

2. Contribution

Chapter 1

Touching the Cloth: Haptics in Fashion Digital Communication

Published as:

Ornati, M. (2019). Touching the Cloth: Haptics in Fashion Digital Communication. In N. Kalbaska, T. Sádaba, F. Cominelli, & L. Cantoni (Eds.), *Fashion Communication in the Digital Age* (pp. 254–258). Springer International Publishing. https://doi.org/10.1007/978-3-030-15436-3_23

1.1. Introduction

From the novelty of Le Bon Marché department store in 1880s Paris – where ladies could indulge in socially acceptable modes of touching (Classen, 2012) – to Farfetch's mixed-reality beta-version of the "Store of the Future" in contemporary London (Kansara, 2017), fashion retailers have always aimed to offer consumers entering their premises a sensory touch experience which includes physical (Lund, 2015) and, more recently, virtual access to products via instore digital devices (Ornati, 2011; Sacerdote, 2017; Schögel & Tischer, 2018). Yet online the tactile experience is, at best, limited (Pacchierotti et al., 2017). Developments in haptic technologies suggest a more sophisticated, mediated tactile experience may become reality, filling the sensory "void" (Van Kerrebroeck et al., 2017) between reality and virtuality in the experience of fashion. This research proposal briefly describes these issues and posits the direction of future investigations.

1.2. Background

Touch is the first of our senses to develop, providing us with the means to access the external world via haptic exploration (Bremner & Spence, 2017). Hence, it has long been a topic of speculation and the object of research, from antiquity to present day haptic technologies, which promise to narrow the gap between the off- and the online experience of fashion.

The sense of touch

Touching is a fundamental human need (Field, 2014). Since antiquity, the sense of touch has been the subject of philosophical speculation, intellectual debate and scientific enquiry (Paterson, 2007) possibly because of its complexity – it is distributed throughout our body. The sense of touch is in fact sub-served by the somatosensory system, a term deriving from the Greek word soma, or body. Together with the vestibular system (which oversees the movement and position of the body in space) and the visual system, the purpose of the somatosensory system is to relay information to the brain concerning "the mechanical state of the body that it inhabits" (Hayward, 2018: 40). Unlike the vestibular and the visual systems, however, the somatosensory system is distributed in – and collects input from the entire body: skin (mucosal, hairy and glabrous); connective tissues (tendons and ligaments); and muscles.

Despite the complexity of somatic input arising from the somatosensory system, the sense of touch is usually described as having two distinct modalities, or states: kinesthetic and tactile. Kinesthetic refers to the sensation of forces and torques relayed by connective tissues and muscles. Tactile indicates sensations of pressure, shear, and vibration picked up by mechanoreceptors (specialized sensory organs) embedded in the skin. Hence, somatic information includes pain sensations, thermal sensations (hot and cold), proprioceptive signals (internal stimuli arising from tissues, ligaments and muscles), and exteroceptive signals (external stimuli affecting the skin) (Bossomaier, 2012).

The palm of the hand and the sole of the foot are particularly sensitive to touch sensation due to the density of mechanoreceptors present in the glabrous skin (Culbertson et al., 2018). Not surprisingly, it is the hand – an organ which unifies both sensory and motor functions (Hayward, 2018) – which is generally associated with touch sensation and manipulation. Information attained through touch with one's hands "is important for the evaluation of products that vary in terms of material properties related to texture, hardness, temperature and weight" such as an item of clothing (Peck & Childers, 2003a).

Haptic technologies

We define haptics as computational systems and applications aiming to artificially reproduce the sense of touch (Bossomaier, 2012; Culbertson et al., 2018). The term haptics derives from the Greek word *haptesthai* meaning "of or relating to" the sense of touch (Classen, 2012); it is used within diverse disciplines to imply both the act of sensing and its effects.

A haptics-based system can be described as a system which enables human-computer interaction by exploiting kinesthetics and/or tactile modalities (Bayousuf et al., 2019). Creative, technical, economic and market constraints have influenced haptic technology development, contributing to the fragmentation of systems and solutions (Parisi, 2018; Schneider et al., 2017). Culbertson et al. (2018) categorize haptic systems based on the type of interaction they require (graspable, wearable, touchable, contactless or mid-air) and the type of mechanism used (kinesthetic, skin deformation, and vibration). Haptics can be found all along the reality-virtuality continuum (Flavián et al., 2019) in devices as diverse as, for example, smartphones, wearables or virtual reality displays (Parisi, 2018).

Haptic technology has "immense potential within it to bring about a drastic change in [the] communication field" (Sreelakshmi & Subash, 2017, p. 4186) in the near future. Instances of considerable financial investment in haptic startups and in spinoffs developing haptic applications (University of Bristol, 2018) and the recent launch of industry-driven conferences (Smart Haptics 2018: Haptics Industry Conference, n.d.) hint at haptic technology's potential for economic value creation. According to analyst firm Markets and Markets, by 2020 haptics will be a USD 30 billion industry (MarketsandMarkets, n.d.).

Haptic marketing will become strategic in consumer industries (Magnarelli, 2018). Haptics technologies will play into the trend towards a more immersive digital customer experience (Cearly et al., 2017; Press, 2017) and contribute to a radical shift in consumer orientation towards tactility (Parisi et al., 2017). Given this scenario, fashion brands need

to consider the role haptics – and other sensory-enabling technologies – will play in their digital communication and ecommerce strategies (Petit et al., 2019).

Haptics in fashion ecommerce

Fashion e-commerce is expected to reach a turnover of EUR 542 billion in 2019 and reach EUR 757 billion by 2023. Within this category, apparel represents the largest segment ("Fashion Worldwide Statista Market Forecast," 2019). Despite this trend, the e-commerce shopping experience is still characterized by "a dearth of sensory input" (Van Kerrebroeck et al., 2017, p. 892). The lack of physical inspection possibilities not being able to touch, feel, or try out a product before buying it (Mansfield, 2017) – is perceived as a major barrier (Van Kerrebroeck et al., 2017). Cognitively congruent audio-visual sensory online strategies can elicit positive consumer response and increase purchase intention (Park, 2006; Rodrigues et al., 2017). But touch evaluation – to varying degrees based on individual need (Peck & Childers, 2003b) – is "a critical and symbolic aspect of the apparel purchase decision-making process" (Lund, 2015, p. 19).

Haptic technologies and devices promise to fill the tactile lacuna, thereby narrowing the gap between the online, virtual experience of fashion and the situated, embodied practice of dress in real life (Entwistle, 2015; Shinkle, 2013). Consumer acceptance and readiness for haptic technologies will need to be assessed (Petit et al, 2019), but a recent study conducted on a panel of university students suggests (Van Kerrebroeck et al., 2017) that haptic devices such as interactive gloves may readily find acceptance with specific fashion consumer market segments.

1.3. Research Objectives

When shopping for clothes online, we cannot feel them. Haptic technologies might change this, impacting fashion digital communication and the online consumer experience (Van Kerrebroeck et al., 2017). Yet insofar as the fashion system is concerned, research on touch in fashion digital communication, and the potential impact of the forthcoming haptic "revolution" (Parisi, 2018) is, to date and to the author's best knowledge, still limited. The author intends to address this gap by conducting the following research:

- Qualitative research on how fashion brands currently express functional and hedonic tactile properties online;
- Quantitative analysis of a representative data set of product returns, leading to an assessment of the relevance of tactility in the online sales of the fashion firm supplying the data;
- Quali-quantitative research using a haptics application already developed for fashion e-commerce to investigate the perception of haptics within a representative sample of potential adopters (university students);
- Qualitative research on fashion digital managers' perception of haptic technologies.

It is the author's wish that in carrying out this research, she will make a relevant contribution to the community of practice in digital communication, fashion studies and haptics. Furthermore, the research will have implications for the fashion industry.

Chapter 2

A true feel. Re-embodying the touch sense in the digital fashion experience

Published as:

Ornati, M. (2022). A True Feel: Re-Embodying the Touch Sense in the Digital Fashion Experience. In T. Cinque & J. B. Vincent (Eds.), *Materializing digital futures: Touch, movement, sound and vision* (pp. 205–222). Bloomsbury Academic. https://www.bloomsbury.com/uk/materializing-digital-futures-9781501361258/

2.1. Introduction

Clothing ourselves is a communicative experience. Through dress, we express our identity, situate ourselves in the context of our historical time and social space, and contribute to the phenomena of evolving modes and styles called fashion (Kalbaska et al., 2018). Donning garments is also a bodily act – a multisensory experience triggering sensations and perceptions (Bruno and Pavani, 2018) in which touch, in all its complexity (Field, 2014), plays a central role. Thus, dress is an *embodied* practice (Entwistle, 2000; 2015) which affects emotional and psychological processes in distinct ways. Over the last twenty years, the rise of electronic, mobile and social media platforms have created new venues for clothing distribution, promotion, consumption and communication (Kalbaska et al., 2019; Rocamora, 2019). This process has digitized but also de-materialized dress practices (Shinkle, 2013). In fact, a fundamental difference between a brick and mortar apparel store and an e-commerce website is the physical accessibility of clothing. In the digital domain, clothes are visually accessible but cannot be touched or tried on; this leads to issues of size, fit and feel. This disembodied nature of the e-commerce fashion experience contributes to the costly phenomena of product returns (Lieber, 2019). Thus, reintroducing touch is critical for the sustainable evolution of digital fashion.

Indeed, touch sensations and its potential surrogates have fascinated scientists for over a century (Parisi, 2018). Today, haptic (touch) technology is a lively field of research. Haptic devices such as interactive touchscreens and wearables are increasingly present in consumer markets. Also, virtual and mixed reality developers are integrating haptics into their solutions to better approximate touch effects in virtual settings. This accelerating technological convergence points to a possible future of immersive virtual shopping in the home, on the go and in fashion outlets; a multisensory, re-embodied experience of dress which will affect the way clothing is chosen, purchased and consumed (Bonetti et al., 2018; Flavián et al., 2019).

In this chapter I explore the constitutive elements and theoretical underpinnings of this scenario. First, I introduce the sense of touch, and how wearing clothes activates the somatosensory system. Then, I review two distinct, but related, theoretical approaches to embodiment focused on the effects of dress: the *enclothed* cognitive sciences approach and the *embodied dress* fashion perspective. Via these interpretive lenses, I discuss the physical experience of fashion retail practices and its disembodied counterpart in the online domain. Finally, I discuss haptic technology systems and devices, suggesting that technological convergence with virtual reality might change the way dress is embodied and experienced in digital fashion futures.

2.2. Clothes on the body: The sense of touch

The sense of touch plays a fundamental role in development (Field, 2014), social communication (Jewitt et al., 2019) and in the exploration and understanding of the world which surrounds us (Fulkerson, 2014); its centrality in experience exerts a powerful influence on our lives (Linden, 2015: 18). Together with other sensory stimuli arising from vision, hearing, olfaction and the body itself, touch sensation contributes to the body's cyclical, multisensory perceptual processes. The 'optimal integration' of these sensory stimuli in the brain (Bruno and Pavani, 2018: 103) gives rise to the 'rich, nuanced perception' we have of the world (Linden, 2015, p. 77). Consequently, its nature being both passive and active influences emotions, thoughts and actions, including decisions regarding our clothing choices (Peck and Childers, 2003a). In the following section I

briefly illustrate, without exhaustive detail, the manner in which this highly complex sense functions, consequently suggesting connections to the everyday practice of dress.

The sense of touch is a complex system[10] of information gathering, also called *somatosensory*, from the Greek word *soma* for body. This system is distributed in almost the entire body: skin (mucosal, hairy and glabrous), connective tissues (tendons and ligaments), and muscles. The type of information the system relays to the brain (Bossomaier, 2012; Linden, 2015) can be described in terms of the effects of wearing a particular garment, including proprioceptive signals (the pressure of tight jeans on the lower body), exteroceptive signals (external touch stimuli affecting the skin, such as the smooth or rough texture of cloth), thermal sensations (the warmth of cashmere or the coolness of linen on the skin), itch (the prickly stimuli of a rough wool sweater), pain (the effects of toes squeezed inside tight shoes), and inflammation (which might be induced by a reaction to textile fibres or to the chemical substances present in a garment (Ngan, n.d.).

Despite the complexity of somatic input arising from the somatosensory system, the sense of touch is usually described primarily in terms of two *modalities* or *states*: kinaesthetic (proprioceptive) and tactile. *Kinaesthetic* refers to the sensation of forces and torques relayed by connective tissues and muscles. *Tactile* indicates sensations of pressure, vibration and shear picked up by highly specialized touch receptor systems. These systems are also called mechanoreceptors, because they transform mechanical energy into electrical signals which are then relayed to the brain via the corresponding nerve fibres embedded in the skin. Mechanoreceptors are particularly dense in the glabrous skin of the hand and fingertips, which explains the organ's sensitivity to touch. Specifically (Linden, 2015, pp. 92-107), *Merkel disks* 'allow us to distinguish individual surface features' like the fine ridges on a coin (or of a fabric weave); *Meissner's corpuscles* enable us to 'manipulate objects with delicacy, using the minimal force for the job at hand' as in

[10] Perception scientists question the traditional separation and classification of the senses, but concede it is convenient to study them as *systems*, defined as 'a set of interconnected elements forming a complex whole' (Bruno and Pavani, 2018: 2).

handling a coin (or holding a button); *Pacinian corpuscles* 'provide a high-fidelity neural image of transient and vibratory stimuli transmitted to the hand by an object held in the hand' such as a chisel, so that 'we can perceive tactile events at the working end of the tool almost as if our fingers were present there' (as when holding the sliding piece of a clothes zipper to open and close its two metal rows); *Ruffini endings* sense horizontal skin stretching. All four touch sensors are activated when grasping and applying force to an object, as would be the case when we grasp and manipulate a garment to put on, for example, a t-shirt or a shoe. Other non-mechanical touch receptors, such as free nerve endings, directly convey sensations of temperature, pain, itch and chemical inflammation. Finally, specialized nerve fibres, which innervate the hairy, non-glabrous skin, react to hair deflection (such as can be caused by a caress, or by fabric sliding on the body) giving rise to 'multiple sensations' which may or may not be emotionally neutral (Linden, 2015: 170).

Touch is passive and active: we identify and perceive the properties of objects through explorative touch (Jones, 2018). Active touch is also referred to as *haptics*. Haptics derives from the Greek word *haptikós* meaning the ability to grasp or to perceive (Jones, 2018). Haptic sensing enables a bi-directional exchange of information with the environment, a unique property of the sense of touch as opposed to vision or hearing (Bayousuf et al., 2019). Explorative touch is performed primarily through the organ of the hand, which unifies both motor and sensory functions (Hayward, 2018). Not surprisingly, it is the hand which is generally associated with sensing and manipulating textiles and garments, literally and metaphorically (as in expressing appreciation for fabric with the comment, 'a nice hand'.

Touch sensations unleash complex multisensory processes. Put simply, stimuli are transmitted via the nervous system (or other pathways) to different areas of the brain responsible for emotion, action and thought. 'Ultimately', states Linden (2015, p. 147), 'representing the tactile world in the brain is in service of achieving some particular outcome: making a decision, forming a memory, or initiating an action'. A tactile representation of dress in the brain serves the same aims. To explore this concept further, I turn to research on the effects of clothing on the body, the mind and the wearer's

experience of the world within two very diverse fields of enquiry: the cognitive sciences, specifically research in embodied cognition, and fashion studies.

2.3. Embodying dress: Theoretical perspectives

Embodied cognition theories are a perspective on the connection between bodily and mental processes which consider the *physical body* of an agent as relevant to cognition (Miłkowski et al., 2018). Theoretical approaches focus on the role bodily states (modalities) and sensorimotor abilities play in affecting cognitive processes. Grounded cognition is specifically concerned with the role of simulations, which are 'the reenactment of perceptual, motor, and introspective states acquired during experience with the world, body, and mind' (Barsalou, 2008, p. 618). Embodiment theories view cognition as being 'constrained and enabled by the specific characteristics of our own brain-body system' (Miłkowski et al., 2018, p. 2). They also acknowledge external factors, situating cognition within social contexts and stressing the role of the natural and cultural environments in which cognitive processes take place. Donning clothes is a tactile, bodily experience. Embodied cognition theories are, therefore, an appropriate perspective from which to study the effects that wearing clothes – and the context in which this process occurs – may have on cognitive processes.

In fact, embodied (and implicitly grounded) cognition frames the theory of enclothed cognition proposed by social behaviourist Hajo Adam and social psychologist Adam D. Galinsky (Adam & Galinsky, 2012, 2019). In a series of experiments set up by the researchers, participants were given a plain lab coat to wear that could be interpreted as belonging either to a doctor or to a painter; then they were entrusted with a specific cognitive task. Based on their results, Adam and Galinsky argue that 'actually wearing a piece of clothing and having the accompanying physical experiences (e.g. seeing it on one's body, feeling it on one's skin, etc.)' will make it 'significantly more likely' for the piece of clothing and its attendant symbolism to influence the wearer's psychological processes and behavioural tendencies 'above and beyond basic material priming effects' (2012, p. 919). The *embodiment* of the clothing's symbolic meaning, that is, 'the co-

occurrence of two independent factors: the symbolic meaning of the clothes and the physical experience of wearing the clothes' (2012, p. 922) is therefore central to the enclothed cognition framework.

To further the discussion, I wish to anchor the concept of embodied dress arising from the perspective of the cognitive sciences within the social sciences and more specifically, fashion theory. The work of fashion sociologist Joanne Entwistle serves that purpose. In her writings (Entwistle, 2000; 2015), the author constructs a theoretical framework centered upon dress as a socially situated, embodied practice. Fashion, she writes, 'is about bodies: it is produced, promoted and worn by bodies' (2015, p. 1) located within social, historical and cultural contexts which define 'expectations about the body and about what constitutes a "dressed" body' (2015, p. 11). But in the everyday practice of dress, of interacting with the body by clothing it, social norms are constantly renegotiated and redefined. For example, wearing a corset or bustier to achieve a fashionable hourglass-shaped figure was the norm in Western countries up to the early 1900s (Steele, 2001). But at the turn of the twentieth century, women's emancipation movements and the introduction of the *brassiere* (the precursor of today's undergarment) made softer silhouettes both desirable and socially acceptable (Steele, 2005, pp. 188–92).

Entwistle's embodied and socially constituted dress framework draws from sociology, anthropology, and philosophy (2000, pp. 323–48). Her discussion of Merleau-Ponty's phenomenology is especially relevant in the context of this chapter because phenomenology is, in some respects, the philosophical counterpart of embodied cognition: it emphasizes the *embodied* nature of subjectivity, meaning the body is an agent – rather than a passive object – in the active perception and experience of the self and its temporal and spatial location in the world. In *Phénoménologie de la Perception* (2009), Merleau-Ponty extensively investigates the subjective effects of passive and active touch, and in the context of fashion theory, his writings have 'drawn attention to the ways in which body adornment is experienced by its wearers not just as a visual phenomenon but also as a haptic experience' (Negrin, 2015, p. 122). For Entwistle, approaching dress from a phenomenological viewpoint means acknowledging dress as part of the experience of the body 'which in turn works on and mediates the experience of self' (2000, p. 334) in a

specific time and place. In fact, identity is routinely 'managed through dress' (2000, p. 338) in a process of ongoing negotiation within socially constituted norms and codes. Connecting the enclothed cognition perspective to Entwistle's theory of embodied dress helps define and enrich the concept further: clothing the body is a (socially) contextualized experience which affects the wearer's physical states and, consequently, psychological processes (the sense of self) and behaviour (the adherence or rejection of norms and codes of dress).

In the Western world, the mundane act of embodying dress theorized by Entwistle, and the cognitive processes it triggers, usually begin in front of a closet or a chest of drawers. Garments and accessories stored therein, if not otherwise acquired, have been at some point purchased somewhere; that is, engagement with dress and its effects begins in a physical or in a digital store. However, a fundamental difference between these two retail *touch*points – as they are aptly called in the field of marketing – is the possibility they afford to actually enjoy a multisensory, on-body experience of dress before a decision is made regarding them. The online experience of fashion is digital and, lacking touch, disembodied.

2.4. The dis-embodiment of dress: Digital fashion actualities

From eye-catching window displays to in-store atmospherics, physical retail offers a multisensory shopping experience (Arnold, 2009, pp. 67–84; Classen, 2012, pp. 191–6) and, most importantly, a place where customers can inspect products. Garments accessibly displayed on racks or shelves are a fixture of the retail experience, because the need to touch clothes (Peck and Childers, 2003b) is 'a critical and symbolic aspect of the apparel purchase decision- making process' (Lund, 2015, p. 19). Even in the most technologically advanced, prototypical store such as the one temporarily showcased by online multi- brand seller Farfetch in London, the clothes are tangibly present (Kansara, 2017). Inspecting garments to evaluate their feel and trying them on to check how they fit are core elements of the physical retail experience which are still lacking in digital retail.

This experiential barrier has not held back fashion e-commerce. Over the last twenty years, fashion and luxury websites have evolved from being little more than digital

storefronts to full-fledged sales channels. Today, most apparel and fashion brands feature dedicated online business divisions which directly manage digital marketing, sales and promotion strategies. The ongoing Covid-19 pandemic has underscored the importance of having a digital presence and accelerated the growth of fashion e-commerce. About 71 per cent of the executives interviewed for the State of Fashion annual report expect their online business to grow 20 per cent in 2021 (Amed et al., 2020), while a survey conducted by online marketplace Zalando on a panel of 118 fashion brands selling through the platform indicated that by 2023, online sales could account for 57 per cent of their total sales (*After Covid*, 2020).

One of the key priorities for apparel brands is online personalization (Nobile & Kalbaska, 2020) particularly product size and fit. Websites usually include country-specific sizing charts or sizing guides (e.g. bust, hip, waist measures in inches or centimetres and corresponding sizes) by product type. Some websites also integrate cloud-based, third-party online virtual fit engines (e.g. FitFinder or TrueFit) offering size recommendation, fit recommendation and fit visualization options (Gill, 2015). However, the need to innovate garment sizing and fit functionalities to facilitate purchasing, to increase customer satisfaction and therefore to decrease product returns (Miell et al., 2018) has overshadowed the closely connected element of garment *feel* – the sensorial and perceptual affordances of dress. All fashion e-commerce websites need to showcase products, which are depicted worn on a model or displayed flat, sometimes both. Some brands include videos of a model wearing a garment and moving. These video clips provide some visual cues about a garment's characteristics when worn: for example, how it drapes over the body or flows with the wearer's movement. As mentioned, fashion websites also include textual descriptions, which tend to focus on technical or functional elements: for example, style, cut, length, material composition and so on. Feel is conveyed, if at all, using a limited range of technical terms (e.g. 'velour', 'twill weave', 'bi-stretch') and adjectives (e.g. 'soft', 'snug', 'smooth'). Thus, to understand the chosen garment's properties, performance and effects when worn, customers must be able to interpret the textual information in relation to the moving, still, or 3D visual information provided, and project the outcome onto their own mental body image. This simulation is a re-enactment

of dress which – as explained in the discussion on grounded theory – builds upon prior perceptual experience, stored in memory (Papies et al., 2017). This condition may not be fulfilled for all consumers and all garments in question.

Thus, customers make online buying decisions based on assumptions about fit and on partial information about garment characteristics, particularly feel. When the chosen items are delivered and tried on, these decisions might prove to have been misguided. The garment might fit but not drape well, because bodies are rarely perfectly symmetrical; or it might feel unpleasant to the touch or on the skin. Consumers manage the perceived risk engendered by the uncertainties connected to buying online in a variety of ways (Ornati and Cantoni, 2020). They practice webrooming, which entails searching for brands online but trying them on and purchasing them in a store; and showrooming, which involves evaluating items in a store and then shopping for them online. They order multiple sizes of the same item, or material variants, and take advantage of lenient shipping and return policies (Wang et al., 2019) to send back the garments which do not correspond to the fit or the look they had anticipated. In fact, according to a survey conducted on end customers of e-commerce platform provider Shopify.com, 'consumer preference-based return reasons (e.g. size, fit, style, etc.) tend to drive around 72 per cent of all returns in fashion product categories' (Orendorff, 2019). In the US alone, clothing and shoes bought online have return rates of 30 to 40 per cent (versus 5 to 10 per cent if purchased in-store) (Reagan, 2019) and fashion product returns generate 5 billion pounds of landfill waste a year (Schiffer, 2019) – thus contributing to the increasingly unsustainable environmental impact of the fashion and textile industry (Dean, 2020). When considering these developments, the implications of the sensory limits of the digital fashion experience, particularly relating to the sense of touch, become readily apparent.

However, the fashion industry has taken notice. In a recent live discussion organized online by Vogue.com, Stephanie Phair, Chief Customer Officer of Farfetch, mentioned 'huge developments' in size and fit technologies as well as in augmented and virtual reality applied towards fashion; technologies which, she believes, will eventually provide a digital sensory experience approximating '*feel'* (Yotka, 2020). Technological innovation might indeed help the fashion industry overcome the sensory limitations of e-

commerce. Ongoing research in *haptics* (touch technologies) and *virtual reality* might create the necessary conditions for the re-embodiment of the digital fashion experience sometime in the (near) future. In the next section I will provide a brief overview of these technologies and their application, introduce some devices currently entering or already on the market and discuss their potential relevance for fashion business-to-business and end-customer contexts.

2.5. Technological embodiments: Haptics

Haptics is touch, engineered. In fact, haptics refers to integrated mechanical, electronic and computational systems and non-invasive applications enabling human–computer interaction (HCI) by artificially reproducing the sense of touch (Culbertson et al., 2018; (Kuchenbecker, 2018). By definition, these systems involve "sensing, processing, and actuating" (Kuchenbecker, 2018, p. 3). Haptic systems can be deployed for interaction in different kinds of environments, from the user's physical setting, to a tangible but remote environment (e.g. when performing surgery on a patient at a distance), to an immersive, virtual one (Kuchenbecker, 2018). Following is a short introduction, by no means exhaustive, to those haptic systems and applications which are more widely discussed in the literature and are particularly relevant to digital fashion.

Haptic systems can be categorized by type of interaction: graspable, wearable, touchable (Culbertson et al., 2018, p. 387–8) and *contactless* or mid-air (Rakkolainen et al., 2020). Graspable systems are kinaesthetic devices, typically manoeuvred via a hand-held tool, which enable the user to exert force and feel force or other sensory feedback. Wearable systems are cutaneous devices which are worn on the body – typically the hands – and which convey sensations directly to the skin. Touchable systems are also cutaneous devices, but usually in the form of a surface which changes tactile properties based on the location of the user's fingers during the interaction. Contactless or mid-air haptic systems function by exerting pressure on the skin (via ultrasound, air jet or other technologies); unlike the systems just described, they do not require physical contact with the user.

Haptics systems can also be distinguished in terms of where they are mounted: *grounded* devices are objects attached to a surface; *ungrounded*, or – confusingly – *body-*

grounded devices are held in the hand or worn on the body (e.g. thimble-like devices or exoskeletons). *Surface* haptic interfaces are surfaces which may be stationary, such as a computer screen or mobile, as in the case of a smartphone screen; their defining characteristic – with reference to the other types of systems described here – is the fact that tactile feedback is generated via direct interaction with the fingers or a tool, such as a stylus.

Haptic devices usually incorporate actuators, sensors or both. *Actuators* are machine components which control the haptic system or parts of it. *Tactile sensors* are data acquisition devices designed to detect diverse properties of objects upon direct physical contact; these devices approximate human touch sensing and perception capabilities, converting the information acquired so that it can be processed and analysed within an intelligent system (Martinez-Hernandez, 2015). Using actuators and/or sensors, most haptic systems deliver tactile information to the user in one of the following ways: via kinaesthetic forces or pressure felt on joints and body parts; through vibrations or pulses, which exploit the human ability to sense and distinguish between frequencies; and by skin stretching, which triggers the skin's sensitivity to tangential forces. (Basdogan et al., 2020; Bayousuf et al. 2019; Culbertson et al., 2018).

Three examples of haptic systems and devices which could be particularly relevant in the context of touch sensing for the digital fashion domain are TanvasTouch® (www.tanvas.co), WeArt (www.weart.it) and TeslaSuit (www.teslasuit.io). The Tanvas haptic system includes an interactive screen which enables garment texture surface effects simulation (Ornati and Cantoni, 2020)[11]. WeArt is a double ring, wearable haptic sensor system which reproduces tactile cues (forces, textures and temperature changes) on the wearer's skin, and has been tested in virtual reality (VR) environments (Spagnoletti et al., 2018). Tesla's full-body suit is currently used to simulate real-life bodily interactions (such as impact) and sensations (such as heat) for personnel training purposes in public safety scenarios (e.g. firefighters and construction workers). Were it to evolve into a lighter –

[11] A video recording of the interaction can be viewed here: https://youtu.be/ NEtf1d53eZ8.

and more affordable – version, it could very well be used in consumer settings, possibly even the home, to deploy haptically onto the wearer the fit and feel properties of clothing.

The haptic interfaces described are a limited sample and a modest indication of the innumerable interfaces and devices engineered, prototyped and developed in interdisciplinary research centres around the world, as exemplified by publications in IEEE Transactions on Haptics and dedicated conferences such as EuroHaptics. Haptic interfaces and the 'fundamental understanding of touch' have made 'remarkable progress in recent years' ('Eurohaptics 2020 Conference', 2020). In the last decade, haptic systems 'have started to be designed with wearability and portability in mind' thereby increasing adoption within 'teleoperation, gaming, rehabilitation', augmented reality (AR), VR, mixed reality (MR) 'and many other application domains' (Prattichizzo et al., 2019, p. 228). In addition to being lighter and smaller, haptic systems are becoming less expensive, a fact which 'opens great opportunities in the consumer market for applications such as gaming and interaction in VR and AR' even though there are still 'significant drawbacks' to their diffusion such as 'limited actuation and sensing capabilities' (Prattichizzo et al., 2019: 228).

Haptic systems, however sophisticated, are still quite far from being able to comprehensively reproduce the exquisite sensitivity of the somatosensory system. Yet, TanvasTouch, WeArt and TeslaSuit afford two constitutive dimensions of the embodiment of dress: the tactile perception of material feel (roughness, temperature, shear and so on) under the hand and on the skin; and the on-body kinaesthetic sensation of being clothed (pressure, pull, and so on) both in the physical and in the virtual domain. In fact, the vision of researchers in the haptic field is one of 'rich touch interactions' with 3D objects in AR, MR and VR applications – 'embodiments of an immersive haptic reality' which 'have the potential to change the way we live, work, learn and leisure' ('Eurohaptics 2020 Conference', 2020); and thus, I add, potentially modify the practice of dress in the digital fashion domain.

Innovation at the crossroads of haptic and virtual technologies, coupled with the fashion industry's pressing need to deliver engaging, multisensory digital customer

experiences, is already impacting the way clothing is promoted, sold and experienced. In the following section I discuss recent AR and VR technology applications in the fashion industry and speculate on the digital future of virtual dress embodiment made possible by converging technologies.

2.6. The re-embodiment of dress: Technological convergence

Luxury brands – particularly watches and jewellery – have been experimenting with AR as a promotional tool for almost two decades (Javornik, 2016); more recently, fashion brands have introduced AR effects and virtual try-on mirrors in physical stores (Bonetti et al., 2019). Spurred by the need to digitize store experiences made inaccessible during the Covid-19 induced confinement, fashion brands are adopting AR technology mobile applications such as smart mirrors and add-on filters (for makeup and clothing). Cases include AR applications developed by Holition for l'Oréal and Uniqlo (www.holition.com/work), Louis Vuitton promotions (Papagiannis, 2019) and many others (Boardman et al., 2020, p. 156).

While AR technologies superimpose virtual content onto real-world environment, VR technologies afford the user multisensory experiences of immersion and the psychological phenomena of presence (Herrera and Bailenson, 2020). Immersion and presence are exactly what the fashion industry was unable to offer its business and end customers during pandemic-induced shutdowns. Fashion shows scheduled during the Copenhagen, London and Paris summer of 2020 fashion weeks – when buyers and journalists the world over still could not travel – were video streamed synchronously or asynchronously online. Retrospectively, industry experts judged 2D screenings unengaging, because the sensorial dimension was missing (Farra, 2020). Thus, fashion industry experts have been increasingly discussing VR technologies and haptics (Turra et al., 2020) as an alternative approach to brand promotion and sales. When asked how live fashion shows could be recreated effectively in a virtual setting, designers and consultants interviewed by Vogue Business (McDowell, 2020a) emphasized the importance of creating virtual 'presence' via multisensory stimulation – being able to smell something or to touch fabric swatches. They also mentioned the possibility of using haptic gloves to

replicate the sensory feedback one might get from touching a garment. The need for presence was exacerbated during the winter of 2021 fashion shows, which again were presented exclusively online.

The technological convergence of haptic and virtual technologies, coupled with the trend towards smaller, more accessible haptics and VR devices (Perkins Coie LPP, 2020; Robertson, 2020) is bound to attract the most innovative players in the fashion industry. In addition to existing physical and digital channels, brands will be able to leverage V-commerce, or 'electronically mediated commercial transactions that originate from an alternate reality technology platform and involve either digitally-generated or real-world products and services' (de Regt and Barnes, 2019, p. 19). Fashion brands working with 3D computer-aided design and garment prototyping software systems will be well positioned to do so, as they will be able to deploy the technology downstream – for example, by integrating digital production with existing e-commerce platforms' fit and sizing solutions – thereby offering consumers a 'made-to-measure' virtual fashion experience (Tabuchi, 2015) fuelling more sustainable, on-demand supply mechanisms of production and distribution. The customer experience will be virtual, but multisensory and embodied, thus impacting the perceptual, emotional and cognitive processes of situated dress practices in novel ways.

I envision two embodied customer experience future scenarios: out-of- home, in physical retail, and at home or on the go, in digital retail. The first scenario has already been tested by Nike. In the NikeiD VR STUDIO clients were able to customize, order (and later purchase) sneakers while immersed in a 3D environment (Adlatina, 2016). The immersive in-store experience pioneered by Nike could also be offered in pop-up or itinerant brand store formats. Nomadic (www.blurtheline.com), a VR production firm which designs MR environments incorporating real objects and touch feedback into the virtual experience, has developed a modular VR system which can be adapted to a brand's need and integrated into existing spaces such as shopping malls (Matney, 2017).

The second scenario envisions digital retail as an immersive, MR experience leveraging body-scanning mobile phone applications, AR applications, VR consumer

systems (including smaller headsets and haptic wearables simulating not only fit but feel, such as gloves, vests or very lightweight haptic body suits, like undergarments) and necessarily, brand websites designed for V-commerce usability. Materializing this future vision of touch in the digital fashion embodied dress experience will be a challenge for the fashion industry. It will require a digital transformation of the supply chain, the technological convergence and market readiness of innovations still in the prototypal stage, consumer acceptance and the implementation of sustainable and ethical promotional and sales practices. But the innovation imperative (Amed, Balchandani, et al., 2020) forced upon the industry by the Covid-19 pandemic has accelerated these processes of radical change, propelling digital adoption (Amed, Berg, et al., 2020).

2.7. Conclusion

Clothing ourselves is an embodied practice which involves physical and cognitive processes. Donning garments activates our diffused sense of touch, unleashing sensations, perceptions and emotions. These multisensory processes affect the way we experience clothes, ourselves and the world around us, impacting our behaviours. The acts afforded by dress practices are palpable and have real-world outcomes. In the last two decades, the rise of electronic commerce has created a digital channel for fashion experience and consumption which limits the embodied, multisensory quality of dress experience. Size, fit and feel are unresolved issues in online shopping. For most consumers, nothing can quite replace the act of physically handling and trying on clothes.

Haptic technologies aim to replicate this active touch experience, via interactive, wearable and other devices increasingly accessible to the ordinary consumer. Advances in haptics and convergence with virtual technology systems suggest electronic commerce might one day become *virtual* commerce, an immersive *meta*-experience involving body and mind. ‘Faster and more realistic computer graphics, goggles that allow three-dimensional immersive contexts, and sensors capable of detecting body movements in real-time are making the experience of visual duplicates (avatars) of ourselves increasingly common’ (Bruno and Pavani, 2018, p. 38). In the future, trying clothes on our projected selves, directly experiencing their *true feel*, might become part of a normal digital fashion

experience, extending the embodied, situated practice of dress to another dimension of time and place.

Chapter 3

Touch in text. The communication of tactility in fashion e-commerce garment descriptions

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3.1. Introduction and research objective

Touch in the online experience of dress. The sense of touch is central to the embodied practice of garments (Ornati, 2022), because dress engages this particular sense in all its complexity (Field, 2014). When our hands reach out to actively touch and grasp a garment, we collect information about its material and thermal properties via highly specialized receptor systems embedded in the skin. While getting dressed, we activate and engage other parts of the body, triggering kinesthetic touch sensations such as pull and pressure. When the clothes we put on graze the skin, passive touch sensations relayed to the brain contribute to the multisensory perception and evaluation (Linden, 2014; Bruno & Pavani, 2018) of our bodily experience of dress. Thus, touch sensation (Jones, 2018) is inseparable from our interaction with garments – material items intended to physically cover, protect and adorn (Wilson, 2020) our bodies.

Research objective. Because of the COVID-19 pandemic and the restrictions governments worldwide have imposed on retail operations, fashion e-commerce has grown considerably and, consequently, so has digital fashion communication's relevance for fashion brands (Amed, Balchandani, et al., 2020; Cantoni et al., 2020; Noris et al., 2021). With stores shuttered, the experience of dress needs to shift online and communicated within the sensory constraints of available technological affordances

(Ornati, 2019); still and moving images, sound and text can be mobilized to this effect. However, much attention has been paid to digital effects such as augmented and virtual reality (Bonetti at al., 2018) but not, to date and to the author's best knowledge, to the online communication of the embodied, tactile experience of dress; or, more specifically, to the role of sensory text. The purpose of this study is to address this gap. In so doing, the researcher does not wish to dismiss the importance of images in digital fashion, nor the significance of multisensory processes in visual and textual perception and ultimately, consumer behavior (Krishna & Schwarz, 2014; Spence & Gallace, 2011). Rather, the objective of this study is to analyze, within a representative sample of popular fashion e-commerce websites, if and how the written word (independently of moving and still images) makes reference to the intrinsic, tactile properties of garments – thereby contributing, by virtue of the processes briefly described above, to the viewer's perceptual and cognitive understanding of the materiality of dress.

3.2. Background: Approaches to sensory evaluation of materials and garments

Wearing garments activates the tactile perception of garment material feel under the hand and on the skin, and the on-body kinesthetic sensations of being clothed. This research focuses primarily on material feel, although as we shall discuss, attributes from on-body effects emerge as well. The subjective perception of material feel is influenced by a variety of physiological, psychological, social and cultural factors; therefore, consistently measuring material attributes, or describing them in technical and layman's terms poses unique challenges (Pan, 2007). In order to solve these issues, researchers and industry actors have developed different approaches involving mechanical measurements, human judgement, or a combination of both. This study leverages evidence gleaned from the literature on sensory evaluation, as described below.

Sensory evaluation research in textiles and apparel. Sensory evaluation is a procedure which aims to establish a product's sensory profile, that is, a qualitative and quantitative assessment of the sensory properties of an item, based on human judgement. The International Standards Organization - ISO has established specific guidelines for this method (*ISO 13299:2016*, 2016). Sensory evaluation includes the development of

descriptive sensory lexicons for which the ISO 5492:2008 "Sensory analysis - Vocabulary" guidelines can serve as a starting point (*ISO 5492 :2008*, 2008). Lexicons enable standardization, serve as a common language to researchers and business, and are used as a basis for the design of consumer research (Lawless & Civille, 2013).

In the textile and apparel domains sensory evaluation dates to the 1920's, when the first large-scale study of subjective material perception was conducted by H. Binns (1926). An investigation – by no means exhaustive – of the literature indicates that just in the last two decades, research in textile sensory evaluation has employed various methodologies (Brandt et al., 1998; Philippe et al., 2004; Slater, 1997; Zhu et al., 2010), covering numerous textile materials (Bensaid et al., 2006; Bogaty et al., 2004; Civille & Dus, 2004; Harpa et al., 2018; Sülar & Okur, 2007) – or specific material attributes, such as surface texture (Holliins et al., 1993; Okamoto et al., 2013; D. Picard et al., 2003) – and apparel products (Budeanu, 2018; Q. Zhang & Kan, 2019) in several countries (Abreu et al., 2020; Behery, 1986; Dhingra at al., 1983).

Textile and apparel sensory evaluation procedures may involve one or more of the senses. Tests focused on haptic perception are conducted by asking panellists to manipulate a fabric hidden behind a screen. Evaluation categories (for example, fabric properties related to hand or surface texture) and descriptive vocabularies may be selected in advance or developed in the course of the procedure. Depending on the objective of the analysis, panellists may be experienced judges (such as quality control experts) or untrained users. By involving non-experts, researchers can study potential consumers' perception of a given material and the terms chosen to describe its properties, thereby developing layman sensory vocabularies.

Material Attributes	Hand Attributes	Surface Attributes
Pliability (Responsiveness or Springiness)	Flexibility (Suppleness) / Stiffness (Rigidity)	Flatness (vs. Relief)
Thickness	Thinness / Thickness	Density (vs. Sparseness)
Flexibility (Elasticity)	Softness / Hardness	Rigidity (vs. Softness)
Drape	Temperature (Warmth vs. Coldness)	Temperature (Warmth vs. Coldness)
-	Fineness (Smooth) / Coarseness (Roughness)	Friction (Sticky vs. Slippery)
-	Moistness / Dryness	Liquidity (Moist vs. Dry)
-	Lightness / Heavyness	Flexibility (Elasticity)
-	-	Pilousness (Plushiness)

Table 3.1. Textile Sensory Evaluation: Lexical Categories

Lexical categories. In the textile and apparel sensory evaluation literature reviewed for this study, tactile attributes fall within three lexical categories, as summarized in Table 1 above. Material attributes are referred to in terms of a textile's pliability (for ex., how fabric springs back to shape when unfolded), thickness, flexibility and drape (how fabric falls). Hand attributes fall within descriptive extremes (for ex., from flexible to rigid, or from cold to warm). Finally, textile surface attributes are characterized in diverse terms ranging from flatness to pilousness. The lexical categorization of material attributes provides a semantic framework with which to proceed with the analysis of online textual product descriptions, as follows.

3.3. Research design and methodology

The research adopts a pragmatic approach (Savin-Baden & Major, 2012) to the analysis of online content (Fielding et al., 2017), focusing on textual product descriptions. The sensory evaluation lexicon (Table 3.1) serves as an interpretative lens for how the subjectively perceived tactile qualities of products are communicated to consumers online. This line of enquiry was pursued as follows: first, by identifying a representative sample of popular fashion e-commerce websites; second, by analyzing several individual women's garment webpages and product descriptions within the sample; and third, by identifying textual references within these descriptions which could be ascribed to the sensory evaluation framework. Tactile references which did not fall within the framework were noted as they emerged. The methodological approach is presented in detail below.

The research was conducted from May to October 2019, and then from September 2020 to January 2021. The fashion e-commerce websites included in the sample were identified by comparing and cross-referencing both worldwide and country-by-country ranking information as provided by third-party online statistical services Alexa (www.alexa.com) and SimilarWeb (www.similarweb.com). The overarching criteria for the website selection was the parent firm's incorporation in a Western country and researcher fluency in one of the country's officially recognized languages.

The final sample comprised six globally ranked websites plus seven websites top-ranked in the country of incorporation. The first includes Nike, HM, Asos, Mango, Zalando and Shein, which was included as an exception – it being incorporated in Hong Kong – because of its ranking relevance both worldwide and within countries. The country sample included Yoox (Italy), LaRedoute (France), Zara (Spain), Globus (Switzerland), Next (UK), Gap (USA), and Marks (Canada). The six globally ranked websites were accessed using the international or Swiss site version set to the English language (.com or .ch extensions). The country sites were accessed with the country specific extension (for ex.: .it, .fr, .es, .ch) and in a local language (except for the German-language Zalando site, where English was preferred). The analysis focused on products in the women's clothing category.

From the links provided in the landing page menu of each fashion e-commerce website included in the sample, the researcher accessed the women's clothing category section – or product sub-sections thereof –and selected items as they appeared when scrolling down the page. Product page structure, functionalities, and content were annotated for each page until feature saturation was reached; this led to a different number of product pages and corresponding garments being studied within each website. In total, the analysis includes 75 items distributed across 7 apparel categories, as illustrated in Table 3.2.

Swimwear	Sportswear (Technical)	Outerwear	Lingerie (Nightwear)	Dresses	Bottoms	Tops
2	5	8	9	10	15	26

Table 3.2. Distribution of 75 items per Apparel Category, including, for *outerwear*: coats, jackets, blazers; for *bottoms*: skirts, pants, shorts; for *tops*: shirts, t-shirts, sweatshirts, sweaters.

Each product webpage was captured with several screenshots; most available text was culled manually. Subsequently, the product descriptions were scrutinized for terms which could mapped to the material, hand and surface attributes provided by the sensory evaluation lexical categories (Table 3.1), and results quantified. As mentioned, emerging touch-related textual evidence was also annotated, and instances categorized across items until saturation was reached.

3.4. Findings: Sensory evaluation vocabularies in sample text

The complete list of terms referring to garment tactility culled from the sample – vocabularies referring to material, hand and surface attributes – is presented in Table 3.3.

Categories	Sensory Evaluation Sample Vocabularies
Material Attributes	Flexible, stretch / stretching, bi-stretch, *mi-lourd* (mid-heavy), heavyweight, *fluide* (fluid), drapey, tumbling, stays true (to shape), *grosse* (rough) or *fine (maille)* / fine (knit)
Hand Attributes	Soft / *(toucher) doux*, light / *léger*, crisp, airy, heavy, warm / *chaud*, *toucher ferme* (firm hand)
Surface Attributes	Padded, fleeced, with vents, *crêponné* (crinkled), *structuré* (structured), ribbed / *côtelée*, smooth / *lisse*, flat, stitched, plush, *moelleux* (fluffy), *plumetis* (satin-stitch relief)

Table 3.3. Sensory evaluation sample vocabularies. In italic: French terms (if an equivalent term was not found in English, the author's translation is given between parenthesis).

Although all website pages featured basic product information such as garment type, material composition (including, in some cases, weave and knit type) as well as style, few included sensory descriptions; references to tactility were scarce and, in some cases, absent. Table 3.4 lists the fashion e-commerce websites within which such terms were found, the language of analysis, how many items were analyzed per brand and the number of unique terms observed per lexical category. Since the frequency with which the same terms were used was not of interest in the context of this study, terms oftentimes repeated – within a single product page or within the same brand – were counted only once.

Website	Lang.	# items	Material Attributes	Hand Attributes	Surface Structure Attributes	Total Unique Terms
Gap	En	5	2	1	2	5
Globus	Fr	7	2	3	1	6
HM	En	8	1	2	0	3
La Redoute	Fr	8	2	2	3	7
Marks	En	4	2	1	3	6
Next	En	6	2	1	2	5
Nike	En	8	1	4	1	6
Shein	En	5	1	0	0	1

Table 3.4. Number of unique terms found per sensory category and in total per brand

Asos, Mango, Yoox, Zalando and Zara are not featured in Table 4 because the product pages analyzed in these websites did not include textual references to sensory evaluation lexical categories.

Emerging sensory categories. In addition to the terms detailed in Table 3, other sensory content categories emerged from the sample analysis. Of these descriptive vocabularies, three specifically refer to on-body perceptual effects: material comfort, garment comfort and kinesthetic feel. Another category makes indirect reference to touch sensation by referring to the bodily outcomes of dress. These four emerging vocabularies and the terms ascribed to them are detailed in Table 3.5.

On-body Effect Type	Sample Vocabularies
Material Comfort	(Wicking) breathable, warm, (feels) dry, (feels) cool, cooling, regulating (temperature), soft
Garment Comfort	Comfortable, cozy, *agréable à porter*
Kinesthetic feel	Snug, tight, body-hugging, streamlined, tailored, loose / *ampio*, non-restrictive, relaxed, easy, covering, supporting, shaping, accentuating (hips and thighs), close fitting / *attillato*, *ajusté*, [feels] locked in
Bodily outcomes	(body) skimming / trimming / slimming enhancing / accentuating / revealing (body part)

Table 3.5. On-body effect type descriptions (in italic: French and Italian language terms)

In contrast with the paucity of touch-related terms, garment descriptions, where available, contained ample reference to construction, detailing, style and "look".

3.5. Additional observations and study limitations

Tactile narratives. As highlighted in Table 3.4, LaRedoute, Globus, Marks and Nike product pages contained several instances of material tactile attributes. Both Globus and LaRedoute featured detailed products descriptions, but while the former's narrative style was matter of fact, the latter felt conversational, almost intimate. Nike and Marks, which sell technical garments as well as ready-to-wear (sportswear in the first case; outdoor or extreme weather wear in the second), also exhibited a factual style which emphasized material and product comfort. However, Nike product narratives stood apart from those of the other brands. By suggesting that a material "stretches while you move" "hugs your body" "[makes you] feel locked in" "when you go hard," "as you move through your flow," "while you bend and stretch," "during your run," or "while you train or compete" – actions the viewer "silently" names by reading – Nike's textual descriptions effectively

trigger mental simulations (Papies et al., 2017), thereby mobilizing motor responses (Elder & Krishna, 2012) and thus, kinesthetic dress embodiment sensations.

Customer comments. Websites which include a review functionality (8 out of 13) offer viewers additional information uploaded by previous customers. In the comments reviewed for the analysis (up to ten per product page, where available, for a total of approximately 230 reviews) mentions of the tactile, material features of garments abounded, enriching touch perception: "*tissu très agréable*" (very pleasant material), "*tissu souple très comfortable*" (very comfortable fluid-soft material), "*laine brute, pique beacoup*" (rough wool, itches a lot), "super soft and nice material," "soft against the body," "very comfortable," etc. These statements enrich touch communication within a product page. In fact, research suggests touch-related customer reviews influence consumer perceptions and evaluation of garments (Huang et al., 2019).

Study limitations. The analysis focuses on thirteen fashion e-commerce websites. In the future, the sample size could be increased or diversified; for example, by focusing on non-Western fashion e-commerce websites in different languages. Alternatively, the study could be conducted vertically by product category (for ex., fashion e-commerce sportswear or lingerie websites only). Additional research is warranted as fashion e-commerce grows worldwide in response to the COVID-19 pandemic and solutions are introduced for improved online customer experiences.

3.6. Research discussion

Discussion. Consumers' visual and tactile interaction with products triggers multisensory processes which lead to cognitive, emotional and behavioral responses (Krishna, 2012). While these processes are highly personal and cannot be affected *per se*, fashion firms can modify visual and tactile cues within a retail environment's atmospherics, thereby influencing consumers' sensory perception and evaluation of products (Eklund & Helmefalk, 2018). This also hold true for digital retail. In fact, in e-commerce settings consumers are more inclined to consider material products, such as garments, when the items' features are written about in terms of touch properties rather than visual properties (McCabe & Nowlis, 2003) such as style or design; a finding which points to the

importance of carefully curating tactile material descriptions. However, in the fashion garment pages analyzed for this study textual reference to material, hand or surface properties were limited to a small number of recurring terms, seemingly confirming that "vocabularies for the haptic sense is a particularly barren area" (Kreifeldt & Chuang, 2011: 321). Research (Majid et al., 2018) has shown that in English, linguistic encoding of the touch domain is lower in ranking than any other perceptual domain with the exception of olfaction. But a crucial skill for industry experts – including textile and fashion designers – is the ability to apprehend, and communicate about, the properties of materials (Huang, 2019; Petreca et al., 2015) through verbalization of the subjective nuances of tactile perception (Atkinson et al., 2016). Were that knowledge and its attendant vocabularies be made to percolate through the value chain to online product descriptions, the outcome could be a distinct sensory enrichment of consumers' digital fashion experience. Additionally, fashion brands could leverage embodied narrative approaches such as Nike's or introduce review functionalities aimed at eliciting customers' responses to their tactile interaction with physical garments.

Practical implications, originality, and value. The findings of this study have underscored a dearth of sensory terms referring to touch in e-commerce webpage texts describing women's garments. This suggests companies should review their online textual communication strategies, leveraging industry experts' sensory material knowledge to enhance consumers' digital fashion experience. Thus, the study makes an original and valuable contribution to the study of communication practices in the digital fashion domain.

3.6. Conclusion

The objective of this research was to analyze touch in text, or the communication of tactility in a sample set of fashion e-commerce women's product pages. The results point to a dearth of textual sensory touch stimuli online, with some interesting exceptions, particularly in the technical clothing domain. Together with visuals, text can help convey the multisensory, embodied experience of dress, even where dress cannot be touched, nor worn. With consumers increasingly privileging e-commerce buying because of the

COVID-19 pandemic, tactile communication in product webpage descriptions is an opportunity digital fashion firms should not let slip by.

Chapter 4

Sizing up the body. Virtual fit platforms in fashion e-commerce

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4.1. Introduction

Dress is a material (Smelik, 2018, p. 33) and embodied experience (Entwistle, 2000, p. 323) - except in the online domain, where dress is dematerialized and disembodied. On a fashion e-commerce website, clothes can be seen, but they cannot be touched nor tried on until they are delivered. To overcome this deficit, brands provide sizing and fitting charts by product type, including descriptive text which may suggest touch properties (Ornati 2021a, p. 29), and visuals such as product stills, zoom-in images, and videos. Content strategies suggest how products might look, fit, and feel when worn. But clothes purchased online may still be too small or too big, or simply not fit well because the body has changed (Kapner, 2020). Negative online experiences with sizing and fitting have taught customers to "bracket" (Hartmans, 2021), that is, to purchase multiple sizes and return those they do not need. In fact, size and fit issues are a leading cause (Narvar, 2019, 2021) for the costly and unsustainable phenomena of e-commerce returns (Dean, 2020; Schiffer, 2019). Product returns require additional reconditioning and packaging, which in itself is e-commerce's largest contributor to greenhouse emissions (Fernández Briseño et al., 2020). Thus, size and fit issues are a key challenge for fashion e-commerce brands wishing to become more sustainable.

To address this problem, individual fashion brands and fashion e-commerce marketplaces are increasingly resorting to external platform providers offering size and fit

recommender systems and virtual fit solutions; some firms are developing such applications in-house. systems and virtual fit solutions; some firms are developing such applications in-house. Charts traditionally used by customers to find their size originate from the fashion industry's uneven historical efforts at standardizing body measurements (Merlo, 2015, p. 919) for mass production, and from more recent adaptations which, as studies have shown, are largely outdated (Kapner, 2019) and socially non-inclusive (Bishop et al., 2018, p. 180). Virtual fit applications, on the other hand, leverage machine learning and artificial intelligence to process big data sets of product and sales information, biometric body data, or both (Januszkiewicz et al., 2017, p. 210), in order to steer customers towards items most likely to align with their preferences as well as their size and fit requirements.

The growth of e-commerce brought about by Covid19 has accelerated the drive towards size and fit virtualization (Bhattarai, 2020; Fortune Business Insights, 2021; McDowell, 2020c). From a business perspective, virtual fit innovations have several advantages, including better online personalization (Dietmar, 2021; Nobile et al., 2020) leading to potentially fewer returns (Arnett, 2019) and improved customer satisfaction. From the consumer's point of view, fit and sizing applications offer ways to improve the outcomes of online shopping and thus diminish the perceived risks involved (Ornati & Cantoni, 2020, p. 493). However, the collection of customer body data enabled by fit and sizing applications and its use for commercial purposes is also, in the specific field of fashion, a manifestation of problematic online platform mechanisms and effects such as the datafication, curation and commodization of personal data, previously described in the health, education, and media sectors (van Dijck, 2014, p. 197; van Dijck et al., 2018). Understanding virtual fit services as effective platform systems, and analyzing them through the lens of platform mechanisms, raises additional questions concerning the impact that the increasing popularity of fit and sizing applications may have on the digital lives of fashion consumers, especially with regard to privacy and inclusivity.

Thus, the following sections provide an introduction to virtual fit technologies, followed by a summary definition of online platform concepts and a description of three

virtual fit platforms found in fashion e-commerce. A discussion of the issues raised by the growth of such services, and suggestions for further research concludes the chapter.

4.2. Virtual fit technologies and their adoption

Virtual fit technologies. Virtual fitting or virtual try-on technologies can be classified into three main systems: size recommendation, fit recommendation and fit visualization or a combination thereof (Gill, 2015, p. 1). Generally speaking, recommender systems (Schafer et al., 1999, p. 158) use statistical or deep learning approaches (for a definition see W. J. Zhang et al., 2018, p. 1) to suggest products based on a customer's online browsing, purchasing and return data history. If a customer is new to a website, recommender system data is cold-started by soliciting customers for personal information, thereby involving him or her in the data collection loop (Lefakis et al., 2020, p. 9).

Size and fit recommender systems in fashion e-commerce use different data sources depending on the objectives. Datasets may include fashion brand product information; consumers' online behavior data, including product page browsing history (types of items chosen, styles, colors etc.); customers' purchase and return history; and additional information collected via consumer feedback or comment features where available. Recommender systems might also integrate and analyze "rich" marketing data (Wedel & Kannan, 2016, p. 97) collected via other consumer touchpoints such as social media, brand apps or physical retail.

While size and fit recommendation systems suggest products with a predictably better fit, fit visualization enhances the experience with a three-dimensional (3D) representation of how the product might look, fit and possibly feel (Lapkovska et al., 2019, p. 196) on the body when worn. This can be achieved by layering digital brand assets such as 2D or 3D fabric and garment prototypes (Ornati, 2011) onto a 3D digital body shape generated via body scanning technologies.

Research in the field of 3D body scanning is several decades old (Januszkiewicz et al., 2019, p. 210). Three-dimensional body scanning hardware and software technologies are the focus of several research networks, standardization efforts (Gill et al.,

2016, p. 281) and a dedicated academic and industry conference.[12] Although there are many different types of body scanning systems, generally speaking, scanning technologies collect multiple data points originating from a subject's body surface in order to reconstruct the body's shape in a digital environment. To achieve virtual try-on, product construction (digitized garment patterns), size and fit data is matched with this virtual body "copy", or avatar (Surville & Moncoutie, 2013, p. 56). Scanning devices run the gamut from very sophisticated standalone stations, such as walk-in booths, to simple in-app mobile solutions. Commercial applications have been developed for a variety of fields, including fashion (Daanen & Psikuta, 2018, p. 237). In fashion e-commerce, body scanning technologies converge with recommender systems to support digital fit outcomes based on body visualization. Thus, virtual fit systems leverage body scan databases - either pre-existing or newly-generated - to depict how products might look on the customer's body when worn and to recommend items which might best fit (Werdayani & Widiaty, 2021, p. 1).[13]

Virtual fit technology adoption. Fashion retailers in the USA, Europe, and Asia (Hwangbo et al., 2018, p. 94) are aggressively investing in fit recommender solutions. Scanning technology is contactless - a critical feature in a retail context still affected by COVID-19 pandemic restrictions (McDowell, 2020c). Thus, some brands are experimenting with in-store, third-party 3D scanning systems with which to collect customer data (Lewis & Loker, 2017, p. 95) for size and fit recommendation and fit visualization in virtual fitting rooms (Werdayani & Widiaty, 2021, p. 1). For example, in late 2020, several malls owned by Brookfield Properties in the USA installed temporary scanning stations operated by Fit:Match. In these studios, "a 3D camera takes a full-body

[12] 3DBODY.TECH Conference & Expo. See: http://3dbodyscanning.org.

[13] Virtual fit, even if self-activated via customer facing applications, should not be confused with self-tracking technologies, which are intended to quantify and monitor personal user data through time. That said, virtual fit apps might one day include functionalities which enable tracking one's evolving body shape, size, and fitting choices - possibly embodied in a personal avatar - across time. Presently, however, none of the systems surveyed offer such options.

scan of a shopper that registers 150 data points of measurement. The scan creates an ID to match the shopper with styles from participating retail brands that are a perfect fit" (Verdon, 2020). The matching process could then be replicated in fashion brands' online shops (Chen, 2021).

Other retailers are acquiring startups and developing technologies in-house. In 2021, US retailer Walmart bought Zeekit (www.zeekit.com) a virtual fitting room based on proprietary body-scanning technology, developed by an Israeli startup. In 2017 Amazon bought Body Labs (Lomas & Crook, 2017), a 3D body modeling startup aspiring to be - according to one of its founders - "a vehicle for organizing the world's body shape information" (O'Reilly, 2015). The German firm Zalando, an online-only fashion marketplace - Amazon's direct European competitor in this domain - is also experimenting with 3D scanning. Zalando recently bought Fision AG, a spinoff of ETH Zurich, and the novel fit visualization technology it had developed, meepl (Zalando, 2020). Zalando is in fact leading a massive, worldwide body scanning and avatar generation initiative involving on-location fit models and the company's own employees. Its "Size and Fit" research unit, soon to be relocated from Berlin headquarters to Zurich, employs engineers, data scientists and business developers. According to information posted on the company's blog, Zalando customers will soon be able to "generate precise body measurements which they can use to receive even more accurate size advice" while brands will "gain a deeper understanding of how well their assortment addresses the size and fit needs of a target audience" (Zalando, 2019).

Besides sophisticated but costly standalone scanning systems, applications already exist which place the technology directly in the hands of consumers (*Can the Promise of a Perfect Fit Disrupt Fashion?,* 2018). Thanks to latest generation smartphone cameras, customers can scan themselves - albeit less accurately than stationary technologies allow - and upload their body data into a recommender system which will guide their online fashion choices and visualize products on their body avatar.

Whether web-based or mobile, virtual fit solutions "provide additional ways of positioning the consumer more intimately within the process of selection of garments

online" (Gill, 2015, p. 15). Virtual fit solutions may indeed lead to higher intention to purchase (Beck & Crié, 2018) and improved customer satisfaction (Buyukaslan et al., 2020; Januszkiewicz et al., 2017; H. Lee & Xu, 2020) as well as lower returns (Holte, 2020). Given these developments, it is not surprising that the size of the in-store and online virtual fit technologies market - valued at USD 2.44 billion in 2019 - is projected to reach USD 10 billion by 2027 (Fortune Business Insights, 2021). Furthermore, innovation - including the use of augmented reality (Baytar et al., 2020) - is blurring the lines between virtual fit systems (H. Lee & Xu, 2020), potentially bridging the physical and online retail worlds with an ideal, cross-channel "omni-fit" model (Miell et al. 2018, Fig. 1, p. 9).

For the moment, however, companies developing and commercializing recommender systems and virtual fit solutions position themselves primarily as online, rather than omni-channel, service platform providers. Their value proposition is driven by multi-sided relationships linking distinct markets from different sides of the platform's customer networks (Sanchez-Cartas & León, 2021). Virtual fit systems triangulate between two groups of actors: on the one hand, fashion brands and, on the other, fashion consumers; both are providers (of data) and users (of data outcomes). Virtual fit platforms provide an infrastructure, or architecture, which facilitates network user interactions and a set of rules - including protocols, rights, and pricing - governing these transactions. In the process, dress embodiment is folded within platform mechanisms of datafication, selection and commodification, as discussed in the following section.

4.3. A brief description of online platforms

According to authors Jose Van Dijck, Thomas Poell, and Martin de Waal - whose publication *The Platform Society: Public Values in a Connected World* (2018) greatly influenced the conceptualization of virtual fit systems discussed in this article - an online platform is "a programmable digital architecture designed to organize interactions between users" which is "geared toward the systematic collection, algorithmic processing, circulation and monetization of user data" (van Dijck et al., 2018, p. 4). Importantly in the context of fashion e-commerce and in the discussion of virtual fit systems, "users" refers not only "to end users of platforms but more broadly includes any entity that is facilitated

by platforms to produce, consume, or aggregate content or services," including businesses (van Dijck et al., 2018, p. 167).

Single platforms evolve within platform ecosystems, "an assemblage of networked platforms, governed by a particular set of mechanisms […] which shapes everyday practices" (van Dijck et al., 2018, p. 4). In the Western context "the ecosystem is mostly operated by a handful of big tech companies (Alphabet-Google, Apple, Facebook, Amazon, and Microsoft) whose infrastructural services are central to the ecosystem's overall design and the distribution of data flows" (van Dijck et al., 2018, p. 4). Sectoral platforms offering digital services for a specific sector, as in the case of single virtual fit platforms for the fashion industry, "seamlessly integrate" with this "infrastructural core" (van Dijck et al., 2018, p. 4). From a technological perspective, platforms are constituted by the data flows they control and the proprietary algorithms and interfaces they use to process and structure the data. From a business perspective, platforms are defined by data ownership and the agreements which govern its ownership and control, for example, terms of service or privacy agreements (van Dijck et al., 2018, p. 9). Platform technologies collect vast amounts of content and user data through hardware - including mobile phones - and software such as the applications people use to access platform services. Subsequently, algorithms automatically process and filter the data, transforming input into "a desired output" (van Dijck et al., 2018, p. 9). These backstage processes are mostly inaccessible and invisible to users, who access user-ready, curated data flows through application programming interfaces (APIs) or customer-facing applications. The mechanisms driving these operations are datafication, selection and, concurrently, commodification.

Datafication is a term initially coined to describe the "ability to render into data many aspects of the world that have never been quantified before" made possible by increasingly powerful information technologies and new approaches to big data (Cukier & Mayer-Schönberger, 2014, p. 2). In the context of online platforms, datafication is a deliberate technological and business strategy premised on the availability of big data. Amassing large volumes of information "endows platforms with the potential to develop techniques for predictive and real-time analytics" (van Dijck et al., 2018, p. 33) and thus

monetize data outcomes through services. Although large-scale data collection is not a novel practice - not even in the apparel domain, as mentioned above with regard to historical sizing studies - it has intensified with the digitization of many aspects of one's personal and social life and the rise of online platforms. In fact, consumers routinely "datafy" personal information through their own online activities (Cukier & Mayer-Schönberger, 2014).

Furthermore, platforms (and, more generally, recommender mechanisms) influence user interaction by algorithmically curating the information available to them. One such *selection* strategy is personalization, which is based on a user's aggregated data history and the predictive analysis of possible future behaviors. Finally, platforms *commodify* data flows to create value. The economic exchanges and pricing strategies governing these flows vary: business users are charged for platform services, whilst end customers might be incentivized to access them for free. Since a platform "aggregates, facilitates and controls the connections and transactions between distinct groups of users" (van Dijck et al., 2018, p. 38) the more users it links, the more successful its strategy will be. The technological and commercial peculiarities defining online platforms also characterize virtual fit systems, as the following three cases will make clear.

4.4. Virtual fit platforms: Three cases

The virtual fit business landscape is populated with a few well-established players and a score of of smaller but fast-growing entities - some of which are still at a startup stage. Since a comprehensive review would be beyond the scope and purpose of this article, the following section includes a brief description of three companies: FitFinder, True Fit and WAIR. The first two are featured most prominently in a sample of Western fashion e-commerce websites previously analyzed by one of the authors (Ornati, 2021a). WAIR is a recommender system which aptly illustrates how body scanning data can be used for fit virtualization purposes.

FitFinder is a size recommender system integrated within a suite of data analytics and fit recommender solutions developed by Fit Analytics GmbH (www.fitanalytics.com), a German company bought in March 2021 by US imaging company Snap (owner of social

media platform Snapchat). Fit Analytics's tools are powered by machine learning and artificial intelligence. The original FitFinder solution, an early self-scanning system, captured images through desktop webcams and created a personalized fit profile. Subsequently the company abandoned this system and developed a virtual fit platform including a suite of analytical tools. FitFinder is a customer-facing application functionally embedded within fashion brands' e-commerce websites. The underlying engine, FitAnalytics, triangulates between customer data and fashion brands' garment fit, sales and returns information, thereby matching users with appropriately fitting products. On its website, the company claims these datasets include millions of customers, cover 19 thousand fashion brands, and are the largest in the industry. Fit Analytics' suite of products also includes a style recommender solution (FitConnect) and a business insights tool (FitIntelligence) which leverages the data collected via FitFinder. According to the claim published on its home page, the FitAnalytics suite is used by "the world's top apparel companies" to "boost conversion and slash returns" (Fit Analytics, 2021).

True Fit is a recommender system marketed by US-based startup True Fit Corporation,[14] which recently raised 55 million USD (Dylan, 2018). True Fit "runs a sophisticated concert of AI models to match attributes and preferences, constantly refining its recommendations with machine learning" (True Fit, 2019). Its suite of tools is hosted on Google Cloud (True Fit, 2020b) and includes, in addition to size, fit and style recommender systems, data analytics and business intelligence products such as competitive benchmarking on product return rates. Its flagship solution is *The Fashion Genome*™. In a data sheet downloaded from the True Fit website in August 2020 (True Fit, 2020a) the company claims the Fashion Genome to be the world's largest and most highly structured dataset for footwear and apparel, with personal preference data from over 180 million True Fit registered users which it can profile by demographic, body, style, and fit. In the same document the company also declares that Fashion Genome data includes 675 million anonymized user profiles, 171 billion USD in anonymized sales and return records, and product information for 17 thousand fashion brands. According to

[14] True Fit Corporation. See: www.truefit.com.

William A. Adler, True Fit's CEO, "by structuring and connecting data across devices, retailers, and brands" the company has "unlocked incredible insights about each consumer" and their preferences (True Fit, 2019). In fact, Adler states, True Fit enriches a "virtuous circle of personalization" by integrating its platform within "an ecosystem" of personalization service providers, thereby "dramatically" benefiting both consumers and retailers (True Fit, 2019).

WAIR is a subsidiary of FIT3D, an international, US-based company which develops and commercializes body scanning software and technology solutions for the fitness industry. According to information published by the company on its website (www.fit3d.com), FIT3D has placed 3000 proprietary scanners in 2000 fitness and wellness centers across 55 countries (including EU and Swiss locations), where they are used to assess and monitor end customer's body states through time. The body scan data they generate, which includes 400 body measurements, is uploaded to FIT3D's US-based servers. Using this data, FIT3D software generates a three-dimensional body replica, or avatar, of the scanned individual. FIT3D claims its current database includes over 2 million body scans, and that 500 thousand new scans are collected every year (although it does not clarify whether these are original or same-body re-scans). Leveraging this massive dataset, FIT3D has developed and is now commercializing a virtual fit system under the WAIR brand (previously BodyBlockAI). The system generates "a complete 3D view of each unique shopper" based on "a few easy questions" they are required to answer when accessing the WAIR platform - either through a fashion retailer's website or via the WAIR mobile app. As an additional service to business customers, WAIR promotes an "Order Insights Feature" which "conjoins a 3D representation of each shopper's body with their shopping journey, purchasing behavior, product reviews, and returns information" thereby giving retailers "a clear understanding of which body types are interacting with their brand" (WAIR, 2021).

FitFinder, True Fit and WAIR's business models drive value by triangulating between two different markets - consumers buying, and firms selling, fashion products - and operate through the datafication, curation and commodization mechanisms typical of online platforms. They collect and process fashion customers' information and body data

as well as fashion companies' product and sales records; they leverage the data to generate recommendations via proprietary algorithms; they commodify the outcomes to produce additional value. Furthermore, smart algorithmic systems learn from platform data, constantly growing and repurposing a "body" of knowledge (such as True Fit's The Fashion Genome™ and WAIR's "globalized human body") in the form of insights and solutions which are (re)sold to fashion brands. Like platforms in other industries, virtual fit systems are designed to "*co-opt* assets, resources, and activities that are not part of the firm," generating value from *users* and *providers* in "a triangular geometry" which leverages "practices of algorithmic management" over which neither users nor providers have authority (Stark & Pais, 2020, p. 47, original emphasis) beyond that which is stipulated by terms of service and privacy policies (van Dijck et al., 2018). Virtual fit platforms drive mechanisms of datafication, curation and commodization of bodily data - including how a specific garment may fit on a particular person - and raise a number of questions regarding privacy and inclusivity, as underscored in the next section.

4.5. Virtual fit platforms issues

Virtual fit systems succeed by adroitly addressing unfulfilled market needs: they provide innovative technological solutions to the unresolved issues of sizing and fitting in the e-commerce domain. From a fashion brand's business perspective, this is a positive development in the decade-old struggle to match garment design, production and online merchandising to customers' size and fit requirements - adopting such solutions, providers claim, diminishes returns and increases profit margins. From an end consumer perspective, virtual fit innovations present novel and engaging personalization approaches to online shopping.

However, following Van Dijck's critique of the platformization of society - which, as this article illustrates, also includes the processes of online fashion consumption - a number of questions should be raised regarding the "capabilities and constraints" of individuals (end users) - swept into the mechanisms of platform ecosystems "primarily staked in, and driven by, economic values and corporate interests" (van Dijck et al., 2018, p. 139). The following discussion focuses on two such questions and ensuing concerns.

The first regards the ideology of *dataism*, which expresses itself in the drive towards end user personalization and has implications for personal data and individual privacy protection. The second centers on selection, or *profiling*, which raises issues of inclusivity.

Dataism, Personalization and Privacy Concerns. *Dataism* is the unquestioned belief in the benefits of datafication. Dataism "presumes trust in the objectivity of quantified methods as well as the independence and integrity of institutions deploying these methods" (van Dijck 2014, p. 204). In marketing practices, dataism expresses itself as an "ideology of personalization" which makes tracking and surveillance "seem attractive" (Couldry & Mejias, 2019, p. 16) even when it extends to the physical self. As one researcher unequivocally states, "in the last decade, we have become accustomed to digitizing our letters (via email), our books (via eBook) and music (via iTunes) - even our social connections (via social media). Why not the human body?" (Peng & Al-Sayegh, 2014, p. 157).

In fact, in her study of fashion wearables, Wissinger (2020, p. 189) observes that consumers increasingly tolerate the "potentially creepy levels of data gathering" required by wearable technology interfaces "in exchange for the convenience of personalization, and the access to 'cool' events, services, and feedback". Similarly, virtual fit solutions invite users to upload their personal data in exchange for personalized size and fit clothing recommendations; suggestions improve with each additional interaction, thereby increasing the appeal of the service itself. As Fit Analytics tellingly states on its website, consumers "trust" fit recommendation systems "to solve the sizing problem" (Fit Analytics, 2021).

But incremental improvements may generate a "dependent relationship" which discourages customer opt-out and achieves platform "lock-in" (Stark & Pais, 2020, p. 53) of "sensitive personal data" (Lefakis et al., 2020, p. 2): anthropomorphic information such as weight, waist or hip circumference, upper and lower body shape, demographics (age and gender) and, depending on the technology, photographs, videos, or body scans (Januszkiewicz et al., 2017; Lefakis et al., 2020). According to the European General Data Protection Regulation or GDPR (Regulation (EU) 2016/679 of the European Parliament

and of the Council of 27 April 2016, 2016), such data is indeed "sensitive" data - a special category of information, within an individual's personal data, which includes biometric characteristics (art. 9 GDPR). Although processing personal data - collection, storage, analysis, anonymization, and so forth - must already abide by specific norms in compliance with art. 5 GDPR, sensitive data requires enhanced protection, because processing it entails particularly high risks of causing harm to the individual.

Firms are aware that protecting clients' personal data - or, more specifically, managing data processing in a manner which lowers risks - is a strategic imperative (Brodherson et al. 2021) conducive to building consumer trust (Swani et al., 2021). In fact, protecting customer data in a manner ensuring respect for privacy is an ongoing marketing concern (Krishna, 2020); or it should be, particularly when managing personalization processes - such as ad-hoc garment sizing and fitting - at scale (Boudet et al., 2019). Of course, firms processing consumer data must also abide with country-by-country legislation. In particular, the GDPR is considered one of the most protective legislations worldwide with regard to personal data, with non-compliance heavily penalized.[15] Robust security measures ensuring data protection, however, are not necessarily the norm for retailers operating online (S. Picard & Bacos, 2020), including those active within the EU. In recent years, fashion firms have become increasingly and alarmingly vulnerable to cyberattacks (Gonzalez-Rodriguez, 2018; Kondruss, 2021; Shackleton, 2021); several have had to pay ransomware in order to recover their (possibly compromised) data (Sadun et al., 2021). The same could happen to service providers which fashion firms rely on (Moore, 2021), including virtual fit platforms made all the more attractive by the massive amounts of consumer information they process.

Presumably, consumers using virtual fit applications do not consider the more serious implications of sharing body data, even whilst consenting to its use. Importantly, the GDPR requires firms (those who control the data, or data controllers) to notify individuals - in a clear and easily comprehensible way - regarding their intention to collect

[15] https://gdpr.eu/fines/

and use personal information. Privacy policies serve this purpose: after having read them, consumers should be able to choose whether to fully, or partially consent (or reject), processing of their data. Privacy policies, however, are notoriously long and difficult for the layperson to understand (Roshankish & Fornara, 2021); if simplified, "important and complex details, which describe the ways in which personal data is actually used" are likely omitted (Barassi, 2020, p. 148). Thus, fashion consumers might opt-in to web-based virtual fit services without fully understanding how their sensitive data is handled and repurposed. The issue is exacerbated when consumers access services and grant permissions through mobile solutions (Victoria & Rindasu, 2021) such as self-scanning applications.

For example, a person shopping on the website of a well-known Italian merchant might be enticed, once they have consulted the traditional size guide, to click on a FIND YOUR SIZE link, prompting a popup window titled YOUR MEASUREMENTS (see Fig. 4.1).

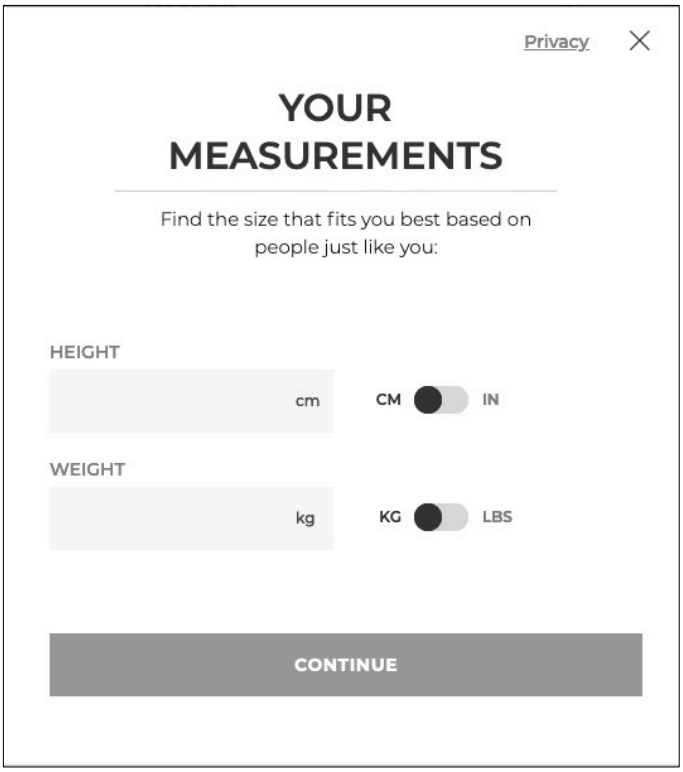

Fig. 4.1. Find your size. Source: yoox.com (https://yoox.ly/3FAUuM0).

The window features an invitation to find the size which fits the shopper best for the particular product, based on people "just like" them. The customer is then requested to enter specific body measurements (height and weight), after which the word "Privacy" appears in the upper right-hand corner. By clicking on it, a text cloud appears, partially overlaying the popup window itself (see Fig. 4.2). This text includes additional links to two distinct privacy policies: that of the fit recommender system, and that of the fashion merchant. The first one is 4,073 words long; the second contains approximately 6,120 words (including a summary of 1,117 words). It is indeed unlikely that the person shopping, however motivated to verify the manner in which his or her personal data will be used, will actually take the time to read a total of over 10,000 words.

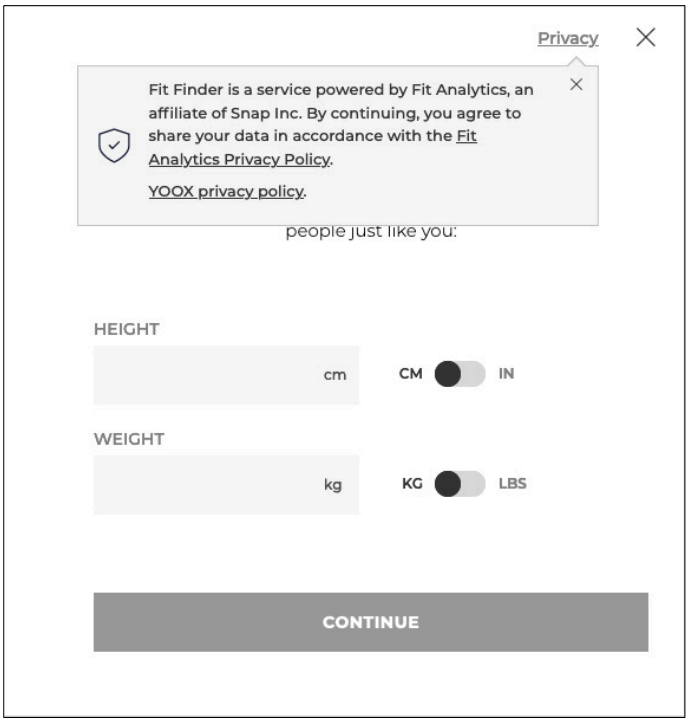

Fig. 4.2. Privacy policies. Source: yoox.com (https://yoox.ly/3FAUuM0).

Profiling and Inclusivity Concerns. As discussed in the section on platforms, one of the driving mechanisms through which these business models operate is selection. This is the "ability of platforms to trigger and filter user activity through interfaces and algorithms, while users, through their interaction with these coded environments, influence the online

visibility and availability of particular content, services, and people"; although consumers might find such selections "democratic," the "black-boxed techno-commercial strategies" which govern them are "anything but transparent" (van Dijck et al., 2018, pp. 40–1). Similarly, virtual fit platforms generate select garment recommendations based on the algorithmic processing of large sets of information provided by customers and fashion brands. To users, this may seem like a very efficient way of accessing a wide range of appropriately fitting items. Nevertheless, one may question how bodily data is "black-boxed" in order to generate such curated content, and whether the outcomes ensure "*equality*, *inclusiveness*, and *fair treatment*" (van Dijck et al., 2018, p. 140, original emphasis) or whether they are potentially conducive to discriminatory practices of profiling.

Profiling is defined by art. 22 of the GDPR as an automated form of personal data processing carried out on a large scale and with the objective of evaluating personal information, such as economic situation, health, personal preferences, interests, and behaviour (Article 29 Data Protection Working Party, 2018). When discussing profiling, it is useful to distinguish between "anonimization" and "pseudo" anonimization of aggregated personal data. Data is considered anonymized when it is treated in such a way that tracing a data subject's identity is impossible. Data is pseudo-anonymized when information that can directly identify an individual is replaced, coded, or removed, but when such processes cannot impede possible re-identification by means of data cross-matching (Article 29 Data Protection Working Party, 2014). Pseudo-anonymized data falls within the scope of GDPR data protection legislation, whereas anonymized data, given it is no longer considered personal data, does not. Unfortunately, profiling can potentially create such a convoluted system of crossmatching and re-identification that absolute anonymization is unachievable, even when it should be. Furthermore, inferences drawn from the data may lead to the real likelihood that a given characteristic will be wrongly attributed to an identified or identifiable individual (Article 29 Data Protection Working Party, 2018) with the resulting misattribution potentially leading to further discrimination. In this context, the following statement by Greg Moore, CEO of WAIR, speaks volumes regarding virtual fit systems' body profiling capabilities and commoditization

mechanisms, as well as the potential risk this poses to consumers whose data is re-aggregated from multiple sources:

> "Our [business] customers are constantly analyzing purchase, review, and returns data to squeeze the most profit out of their [end customers] shopping experience, but until now, *they never knew the body of the shopper*. For example, if 48% of shoppers leave a review stating the sizing is too small and 52% of shoppers leave a review stating that sizing is too big, what does the brand do? *Until they know the shoppers' bodies*, they can't make valuable *quantitative decisions*" (WAIR, 2021, emphasis added).

In its landmark "Rights to Privacy in a Digital Age" 2017 resolution, the UN Human Rights Council expressed "concern that automatic processing of personal data for individual profiling may lead to discrimination or decisions that otherwise have the potential to affect the enjoyment of human rights, including economic, social and cultural rights" (UN Human Rights Council, 2017, p. 3). Virtual fit platforms mechanisms and profiling practices raise similar concerns. Body profiling might challenge fairness and inclusivity principles and affect social norms in the fashion domain. Apparently, this is already an issue. According to Mastamet-Mason of Tshwane University of Technology, whose body scanning research focuses on a novel 3D classification of South African pear shaped or hourglass bodies (Sokhetye & Mastamet-Mason, 2021), to date "efforts by industry players to become more body shape inclusive have not borne as much result as would have been anticipated". Ironically, inclusivity and diversity offered up as a marketing gimmick may result in adding layers of personal information and compound profiling issues. For example, virtual fit platform Zeekit offers a "SwitchModel" functionality which allows customers to choose - and digitally model their preferred garments on - the body types they most identify with.

4.6. Closing thoughts and considerations

The growing phenomena of virtual fit platforms described in this article is a response to the disembodied nature of the fashion e-commerce experience and the issues of size and fit it engenders, which in turn leads to economic and sustainability problems. Thus, virtual fit solutions are appealing to both fashion brands and fashion consumers. However, as we

have seen, virtual fit platforms are business models driven by datafication, selection and commoditization mechanisms involving the processing of massive amounts of transactional, behavioral, and personal information. Thus, virtual fit profiling and personalization practices, however attractive for marketing purposes, raise privacy and inclusivity concerns underscored by the increasing risk of cyberattacks, which potentially expose fashion brands to economic and reputational costs, and end consumers to a violation of their rights.

The objective of this article is to spotlight the rise of virtual fit platforms. In doing so, it raises awareness regarding the digitized, enclothed, and increasingly precise rendering of physical bodies which virtual fit technologies make possible. What are the risks of exploitation (Zuboff, 2019), loss of control (Crain, 2018), and alienation from the digital self (Laterza, 2021) that these data doubles (Lupton 2015, 2020) may pose to the individual? Might those risks extend beyond the e-commerce realm to an increasingly colonized (Couldry & Mejias, 2019) and commercialized (Carmi, 2021) "metaverse" ? These questions problematize the expanding terrain of virtual fit platforms and open the field to further research and alternative theoretical approaches.

Chapter 5

Fashion touch. Surface haptics in fashion e-commerce

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N.B. The poster accompanying this contribution is included in the Appendix, section 4.1.

5.1. Introduction

The sense of touch is central to the fashion and luxury experience: dress is experienced with and on the body. Actively touching and physically trying on a garment is an essential part of the customer journey. In the digital domain, however, fashion is hands-off – consumers cannot actively sense, perceive and understand tactile garment qualities in an e-commerce website as they would in a retail store. The lack of sensory inputs in the online domain has long held back luxury and fashion brands from pursuing e-commerce strategies. During the Covid-19 lockdowns, however, firms had to shift customer operations almost entirely to digital channels. Digital acceleration during the pandemic spotlighted issues connected to lack of embodiment in e-commerce, such as the unsustainable and costly phenomena of product returns.

In this scenario, technologies which enrich the audio-visual digital experience by adding touch feedback might be of interest in the fashion and luxury sector. The author's doctoral research (Ornati, 2019, 2022) explores such a possibility, focusing on surface

haptics. The objective is threefold. First, to assess in what way the lack of physical interaction is currently addressed by fashion and luxury brands in the online domain (Ornati, 2021a). Second, to investigate consumer reactions to the introduction of haptic feedback in a fashion e-commerce context (Ornati & Cantoni, 2020); and third, to explore executives' opinion on the role these technologies may play in addressing the sensory limits of the online experience. To pursue these last two objectives the author adopted a pragmatic and qualitative research design which includes the use of two surface haptic devices: TanvasTouch® (www.tanvas.co) and the WeArt (www.weart.it) Touchkey. The haptic feedback experience enabled by the devices is partially customized and the devices are used as prompts within focus groups and in-depth interviews, as illustrated in the next sections.

5.2. Fashion touch in e-commerce: Haptic simulation

As described above, the research design required simulating a fashion e-commerce website on the TanvasTouch and WeArt surface haptic devices. To create the mock website's content from scratch, five women's and three men's garments (including a knitted cotton top, corduroy pants, a woolen houndstooth skirt and a jeans jacket) were purposefully selected based on diverse material and surface characteristics, then the garments were photographed on real models. Subsequently, a graphic designer created a home page showcasing the eight garments, plus a product page for each garment. The latter featured five different views of each garment and a detailed image of the corresponding material. To enhance these material images with haptic effects each device required a different approach, as detailed in the following paragraphs.

TanvasTouch enables precise fingertip tracking and simultaneous surface haptic rendering. It can be programmed to accurately deliver real-time variable-intensity friction and electrostatic haptic feedback within a specific area of the touchscreen. In collaboration with colleagues working in the USI eLab[16], the zoom-in image of each garment material was rendered in black and white, enhanced and uploaded to the software environment of

[16] https://www.usi.ch/en/university/info/elab

the device, where surface texture characteristics were matched with modulated, ad-hoc haptic feedback effects. The finished, full-color mock website – entitled *FashionTouch* – was uploaded locally on a personal computer and simultaneously displayed on the paired TanvasTouch display. Users navigating the website and accessing a product page can click onto any garment image to access the zoom-in of its material. Then, by stroking the display screen, they can experience a simulation of the material's surface effects[17].

WeArt currently features a wearable haptic system which reproduces tactile cues (forces, textures, and temperature changes) on the wearer's skin in virtual reality environments (Gioioso et al., 2019). However, in this study an earlier, non-wearable Touchkey was used which similarly features incorporated force feedback, texture-based vibrations, and thermal cues. The haptic feedback effects for the WeArt interaction were recorded in the supplier's laboratories directly from the original garments and synched with a graphical video rendition of the stroking gesture. The mock website and the interaction simulation for each garment were made accessible on an Apple iPad (using a TestFlight application) and paired to the WeArt Touchkey via bluetooth. Thus, when users place a finger on the Touchkey with one hand and choose a garment on the iPad screen with the other, they simultaneously see a pointer moving across the material and feel the corresponding force-feedback effects under their fingertips[18].

5.3. Early research results and discussion

The author has leveraged the *FashionTouch* experience on TanvasTouch and on WeArt as a prompt in focus groups and in-depth expert interviews, in pursuit of the second and third research objectives described in section 2 above. In other words, the devices are not used to evaluate the technologies per se, nor their maturity for the luxury and fashion sector, but to stimulate research participants' thoughts and opinions on the possibility and potential value of enhanced surface interaction in an e-commerce brand setting. Participants in the first focus group – conducted in late 2019 using TanvasTouch –

[17] See: https://youtu.be/NEtf1d53eZ8

[18] See: https://youtu.be/_wt_6IG-NU8

expressed interest in the future of sensory enrichment via haptic technologies, but held reservations regarding their haptic experience. These included feeling constrained by the flat, two-dimensional surface – which limits the gestures one would habitually adopt to handle textiles (e.g., stroking vs. grasping) – as well as being unable to adequately distinguish different garment materials. In the course of 2021, the author conducted fourteen expert interviews with luxury and fashion digital marketing executives in Italy and Switzerland, using both TanvasTouch and the WeArt Touchkey. While interacting with the technologies, experts expressed reservations similar to those of focus group participants. However, early research insights suggest decision-makers are very attentive to any haptic technology development which might enhance the customer experience – either in digital or phygital (retail) contexts – underscoring the relevance of haptic research for the fashion and luxury industry.

Chapter 6

Fashion touch in e-commerce: An exploratory study of surface haptic interaction experiences

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6.1. Introduction and research objectives

Throughout history, fashion clothing has always been a form of expression (Kalbaska et al., 2018; Geczy & Karaminas, 2019), an embodied practice which engages the senses (Entwistle, 2015), particularly touch. We explore the tactile properties of garments with our hands, and we feel those qualities on our bodies upon wearing them (Field, 2014; Lederman & Klatzky, 2009). In the digital domain, however, the fashion experience is hands-off. Consumers cannot apprehend tactile garment qualities online, actively sensing and perceiving as they would in an offline retail setting (Shinkle, 2013).

On fashion e-commerce websites, the tactile properties of garments are suggested with both still and moving images, sounds, and texts uploaded by brands and by customers, should the review feature be available (Huang et al., 2019). These cognitively congruent sensory cues act as surrogates for touch sensations (Jansson-Boyd, 2017).

The role and the importance of touch in the purchasing stage of the online customer journey has been researched and its importance debated since the early days of Internet retailing (Citrin et al., 2003), but it is still an unresolved design and business issue (Ackerman, 2016; Liu et al., 2017) with direct implications for online fashion retail (Manzano & Gavilan, 2016). Advances in human-computer interaction and mulsemedia

systems leading to more engaging multisensory experiences (Covaci et al., 2018; Chung et al., 2018; Petit et al., 2019) may help address these concerns. Specifically, innovations in haptic technologies (Gallace & Spence, 2014) – defined as computational systems and applications aiming to *artificially reproduce the sense of touch* (Bossomaier, 2012; Culbertson et al., 2018) – could introduce a hands-on dimension of active texture exploration[19] within the digital fashion experience (Ornati, 2019).

Haptics-based systems include graspable, wearable, contactless, mid-air and surface solutions which enable human-computer interaction by exploiting kinesthetics and/or tactile modalities (Bayousuf et al., 2019). This study exploits developments in surface haptics and makes use of an innovative haptics device, described in detail below.

Recent research into the significance of haptic information in apparel e-commerce (Kim & Forsythe, 2008; Rodrigues et al., 2017; Riedel & Mulcahy, 2019; Van Kerrebroeck et al., 2017) has not involved the use of surface haptic technologies for active texture exploration. The objective of the study was to address this gap with a pragmatic qualitative research design focused on exploring and describing participants' responses to the introduction of dynamic haptic surface effects in the context of a simulated fashion e-commerce interaction experience.

6.2. Background: Haptic technologies and devices

The research was designed using TanvasTouch (www.tanvas.co) – an innovative surface haptic device recently made available for academic research. The device requires the interaction of both hardware and proprietary software and is safe for use in an experimental setting. Two such devices were used for this research.

TanvasTouch enables precise fingertip tracking and simultaneous surface haptic rendering. It can be programmed to accurately deliver real-time variable-intensity friction and electrostatic haptic feedback within a specific area of the touchscreen. Thus, it is

[19] Active texture exploration is defined as "the ability to infer information about object texture by using one's fingertips to scan a surface" (O'Doherty et al., 2019).

possible to map specific textures and effects onto an image and to feel these effects with a swipe of a finger on the touch-enabled surface.

Using TanvasTouch to deliver dynamic haptic surface effects in the context of a simulated fashion e-commerce experience required the design of a mock fashion website featuring real clothes. Five women's and three men's garments were purposefully selected based on diverse material and surface characteristics. The garments were photographed on real models. The final photoshoot selection included five different full-color images of each item, plus a detailed image of the corresponding material, akin to the zoom-in garment images available on most fashion websites.

A simple website was designed, which included a home page showcasing images of the eight garments – as shown in Fig. 6.1 – each leading to a dedicated garment page.

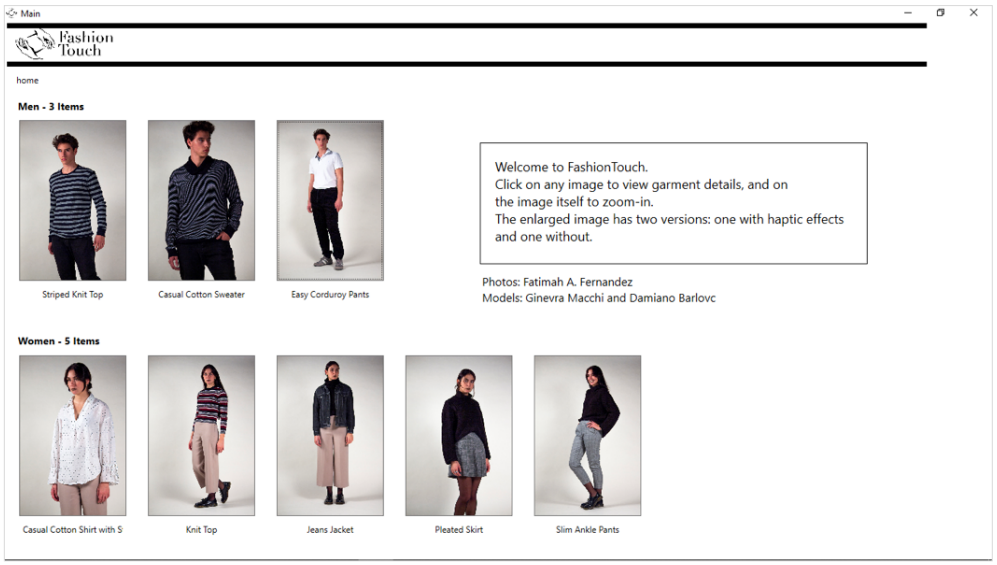

Fig. 6.1. *FashionTouch* mock-website home page

The garment page featured descriptive text, one main image, and four thumbnails. Clicking on the main garment image opened a zoom-in window with interactive haptic **effects, shown in Fig. 6.2. An alternative, effect-free window was also provided.**

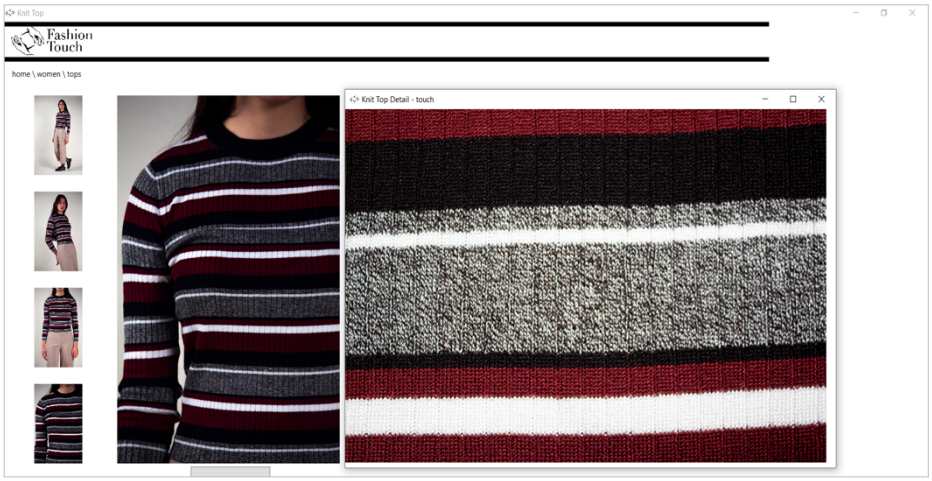

Fig. 6.2. The zoom-in interactive area on the *FashionTouch* application

To achieve the effects, intermediate working steps were required. Each zoom-in image was refined and contrasting textures enhanced in black and white using Photoshop. The images were then uploaded to TanvasTouch's proprietary software environment, and surface texture characteristics matched with ad-hoc haptic feedback effects. The finished, full-color mock website – entitled *FashionTouch* – was uploaded locally on two personal computers and simultaneously displayed on paired TanvasTouch screens.

It is important to note that at this stage, the aim of the research was not to test the technology per se, nor the degree to which the TanvasTouch device enables faithful garment texture replication to touch. The purpose is rather to use a surface haptic technology to design a simulated online environment enriched with tactile feedback, thereby enabling a discussion on the relevance of haptics in the fashion e-commerce context.

6.3. Research design and methodology

The study adopts a qualitative methodological approach using focus groups to explore and describe users' responses to the introduction of dynamic haptic surface effects in the context of a simulated fashion e-commerce experience. Focus groups are informal discussions between participants on a topic decided a priori by the researcher. Focus groups allow for exploring participants' subjective experiences, attitudes, and opinions, thereby generating data that is emic in nature (Cyr, 2019). As the intent of this research is to gain knowledge on potential consumers' perceptions of surface haptics in fashion e-commerce, focus groups are considered a suitable method of inquiry.

To access multiple perspectives on a specific topic, qualitative research usually relies on four to six focus groups (Cyr, 2019). This paper describes the findings from the first focus group of the study, which was held (in English) at USI – Università della Svizzera italiana, Switzerland, in December 2019. Additional focus groups have been planned in collaboration with the University of Applied Sciences and Arts of Southern Switzerland (SUPSI), Switzerland; ISEM Fashion Business School, Madrid, Spain; Université Paris 1 Panthéon-Sorbonne, France; and Reutlingen University, Germany. Upcoming studies will be conducted by local researchers in the participants' native language.

The recommended group size for a focus group varies between 6 and 12 participants, with 8 participants considered ideal for moderation and analysis (Barbour, 2018). For this focus group, eight volunteers were recruited from Master students. These students – ranging between 22 to 27 years of age, all female except one – are a homogeneous group representative of a segment of young, technology-savvy consumers attentive to innovation (Amed et al., 2019) and fashion trends. They come from international backgrounds and are proficient in the English language. Before the activity, each volunteer was informed about research content and methodology and their informed consent was collected for the study. Prior to the activity each volunteer also completed an anonymous questionnaire featuring a "Need for Touch" (NFT) 12-item scale. The scale is "designed to measure individual differences in preference for haptic (touch) information"

along autotelic and instrumental dimensions (Peck & Childers, 2003). The questionnaire also included some questions concerning individual offline and online shopping behavior.

The focus group was hosted on a weekday afternoon on the university campus, in a dedicated space. Food and beverages were provided. Before the focus group, each participant had the opportunity to individually interact with the touchscreen application for about ten to fifteen minutes, freely navigating between images and exploring haptic effects. After the interaction, and with the device set aside, each participant was asked to quantitatively evaluate the influence individual effects may have had on the perception of each corresponding garment. A researcher was in attendance during the entire activity.

The focus group lasted about an hour and a half. One of the researchers observed the proceedings, whilst the other moderated, following a question protocol compiled a priori. Although the focus group method emphasizes free participant exploration of a given topic, the question protocol facilitates a semi-structured group discussion steered in the direction of answering the research question (Cyr, 2019; Barbour, 2018). Thus, the discussion progressed from an exploration of participants' relationship to fashion and clothing to the elicitation of specific factors – including the availability of visual and textual information – affecting participants' self-declared attitudes and behaviors with regards to offline and online fashion shopping. Finally, the discussion focused on volunteers' perception of the *FashionTouch* experience. During the last half hour of the focus group, the moderator used the actual garments as prompts, thereby provoking a lively debate regarding surface haptics renderings and corresponding originals. In closing, volunteers shared their opinion on potential uses of surface haptic technology in the context of fashion e-commerce.

During the discussion, participants were asked to jot their ideas down on a notepad as well as to share them out loud. The entire proceedings were audio-recorded and subsequently transcribed. The data was triangulated with participants' handwritten notes and the researcher's own live observations. Individual and group-level data was analyzed using a thematic analysis method, defined as the process of identifying, analyzing and reporting patterns in the data (Savin-Baden, 2012). The resulting document – a qualitative,

low-inference description (Sandelowski, 2000) of emergent themes – was discussed and reviewed by both researchers. The focus group's findings are reported in the following section.

6.4. Findings: Fashion e-commerce and device interaction

Several themes emerged from the analysis of the focus group discussion transcript, as described below and in the participants' own words wherever possible.

Growing up by dressing up: fashioning the creative self. Focus group participants describe their relationship with fashion and dress as intrinsically bound to their personality and way of being. Fashion is "an inspiration and part of […] daily life," as well as a "creative outlet" for individual expression. Embodying fashion is a means to affect and control "how I want to be or feel" because clothes "are actually part of my feelings, my emotions." During childhood, dress enables a measure of independence, from "going around and deciding what to wear, what to buy" to making deliberate choices about "the way you want to present [yourself]" whether in "loud and colorful" clothing chosen as an act of rebellion, or princess-like "Disney movie" outfits with which to "walk around the house." Through dress, participants gradually discovered "new aspects" of their personality. As adults, getting dressed is both outward expression – how "to be seen for that day" – and playful fantasy – "a costume party […] just in your head." From childhood to adulthood, dressing up is "something creative and fun." Finally, focus group participants perceive fashion as a form of art, a creative space where "a lot of things, new things [are] happening." Fashion is "innovation."

Investing vs. wasting: balancing the fashion act. Focus group participants describe their approach to fashioning a personal look or style as an ongoing strategic activity, which entails careful planning and financial discipline as well as creative vision. For one participant, building a fashion closet is a deliberate, careful form of long-term investment centered upon a coherent "style or look." Spending more now "so that I know for sure that I can wear [clothes] for the following 5 to 10 years" "is more of an investment than a waste of money" because "after a few years you have a collection of a few very

good pieces and then you can use them more." Buying into fashion trends is "a waste" if "I just wear it one season and then I cannot wear it anymore," regardless of the expenditure – "if it was ten euros or 100." Other participants lament having to make compromises between "standing out" and owning "a valuable classic piece so that I have something to wear at all" because of budgetary concerns ("it's the price or the money that I am limited in"). Looking for less expensive garments in second-hand stores is one way to creatively balance the fashion act, to "find things that no one would wear now, and combine them with basic things" in order to "explore" a very personal look or style.

The shopping experience: from showrooming to webrooming. Focus group participants manage their journey between retail and e-commerce with pragmatic ease. They reluctantly admit to being frequent shoppers, as confirmed by questionnaire responses (Table 6.1).

Times shopped per year	1 to 5	5 to 10	10 to 20	20 or more
N. of participants shopping in offline retail	0	4	2	2
N. of participants shopping online	2	4	2	0

Table 6.1. Participants' shopping frequency based on questionnaire responses

Participants also described both *showrooming* and *webrooming* behaviors. Showrooming is the consumer practice of trying out the products they want in a physical store before buying them online. Webrooming is the opposite, i.e., researching products online before buying them in a physical store (Techopedia, n.d.). As a group, they tend to privilege showrooming – visiting physical venues to explore, try on and evaluate items, but shopping for them online. They shop online when stores are not accessible, or if they cannot find a product and/or size, knowing that "you can order two different sizes and send it back and it's all for free." In fact, online shopping offers "more options at once" such as greater product range, size availability, delivery options, and lower prices.

However, participants also describe webrooming: "sometimes I would […] browse online first, [in] a specific store, to see if there is something interesting; and then I would go to the store" (at times with the article number) "and look for exactly *these* items." Shopping in a physical store is a fun, social activity that affords instant gratification ("having it right after paying for it") but shopping online can also be a social activity ("we just send each other messages") and "way cheaper." As mentioned before, for most participants "price is the biggest factor" affecting the choice of where to buy.

Evaluating online information: a question of trust. As a group, participants tend to go online to look for "what is new" in fashion. Consistent with their strategic approach to fashion buying, they all tend to check price and discounts, payment terms, shipping costs and service options, such as free returns. However, as individuals, they differ in terms of the kind of information they pay the most attention to. Some participants carefully check product size and length (comparing it to model height) as well as sizing guides ("I measure myself every centimeter and look at the size guide"); others don't, "because I know I can return it. So, I don't check." A few participants pay careful attention to product composition and performance ("if you get sweaty, it stinks, so it's better to choose real cotton") and product care instructions. Participants carefully examine visuals to understand "how [a product] sits on the model," but tend to consider images limited if not misleading ("I know that it will look different on me"). One participant is annoyed that she "always [has] to compromise and just trust" the visual and textual information provided by the brand. Customer reviews are either considered helpful ("the only thing I really trust") or paid-for "fake[s]." Shopping online can be a disappointing experience when "most of the things did not fit, the fabric was not how I expected […]." Buying "things which don't necessarily change" like cosmetics, basic shoes and fashion accessories is less risky than buying fashion items such as clothing. Regardless of how much information brands may provide, garments are "still something you need to feel on your body."

The interaction experience. The focal part of the activity is discussed in the second half of the focus group. Participants are first asked to recall and describe their interaction with the technology. Several elements emerge:

Participants put the technology to the test. "And a thing that I did is to touch the other part of the screen and then go back to the item to see the difference, to really perceive the difference of the technology and of the other part of the screen." "And then what I figured is the vibrations only come upon the contrast, because most of the items were black and grey, black and white, so only when there was the contrast of stitching, for example, then you would feel the vibrations." "I tried to touch with my entire hand but then only one finger was identified."

Participants compare the surface interaction experience with multidimensional garment manipulation, such as handling and grasping materials, rubbing fabric between the thumb and index fingers or several fingers, applying pressure to a garment and stretching it. Participants recall "pushing towards something" which is not like "grabbing […] something between your hands – you cannot feel the thickness of the product." Stroking the surface with one finger "is not enough for touch. There must be something between two fingers, between the thumb and […] the index finger." "When I touch something, I want to know how stretchy it is" or "to massage it. Grab it in my hand, squeeze it, take it out." Participants consider it unusual, even "weird," to explore a garment just by stroking its surface, as opposed to handling it: "I am not used to touching a thing like that."

Participants conflate garment information (visuals and text) and corresponding effects, evaluating them contextually or in comparison to real-life experience: "I could not recognize the fabric from the knowledge that I have [about] how wool feels like." "I think *we need to know* all the different feelings, *touchings* [*sic*] to then make sense out of what is what." Certain interactions are judged more effective than others in triggering "some sense of how the garment would feel like." "When I touched – I think it was the sweater for men – with the little bumps – [I] could actually […] get a sense of what it would be like to touch it." "You could actually really feel … the little jumps [in the men's corduroy

pants].” “The white [stiching] lines, I could really feel them.” Opinions are otherwise mixed: “the blouse was […] too hard for a [cotton] blouse,” says one participant, whereas another insists that “when you stroked over the little dots you could feel the bumps, so there was a difference.” When prompted with the real items (Fig. 6.3), participants agree that three out of eight haptic feedback effects had a strong, even “over-amplified” correlation with the real-life feel of corresponding garments: the ribbed corduroy pants, the knit sweater and the jeans jacket with contrast stitching. Three items were judged as having no correlation, and two items as being somewhere in between.

Participants have mixed opinions regarding the *FashionTouch* experience. Several participants were “super excited to have a try” but then were “disappointed because I didn’t know what to expect but then secretly in my head, I did expect *something*.” Others are disappointed with the artifact itself, which is “just a screen.” Some participants recall feeling frustrated and confused by the experience, and distrustful towards the technology because it is “not reliable to me, not true.” Although some “would not use it because it’s so misleading” others think it may be “helpful for feeling the structure” of a garment’s surface. One participant observes that the technology cannot replicate “being in the store, touching something” because “to be fair” online shopping is not like going to a shop – “it’s online shopping” and “not [a] substitute [for] a shopping experience.”

Participants are intrigued by the technology. Overall, participants seem to share a positive perspective on the technology’s innovative potential: “it’s a great idea” which “can be improved to the point where it can be used widely” to “definitely” improve the online experience. As such, it is perceived as a technology with commercial potential, one which “could be developed” and that “a company can monetize on.”

6.5. Discussion and managerial implications

Findings of the first *FashionTouch* study indicate focus group participants are interested in the sensory enrichment which surface haptic technologies might bring to the fashion e-commerce experience. They are savvy omnichannel shoppers, expressing a degree of critical weariness with regards to product information found online. Therefore, the finding

is moderated by this specific customer segment's perceived risk of experiencing a disconnect – were the technology to be implemented in the future – between the digital touch feedback experience and the actual garment feel.

This initial exploratory study sets the groundwork for upcoming research using surface haptic technology in a fashion e-commerce context in collaboration with an international network of partner universities[20]. The second stage of the research will capitalize on the current study's learnings, and the research design will be improved as needed. The study's initial and future insights on innovations involving surface haptic technologies in fashion digital communication will be shared to the benefit of the wider academic community. On a local level, they will also serve as stimulus for discussion and learning within the publicly funded, applied higher education communities, particularly in the context of fashion design and sartorial schools. During the first phase of the research both the local media ("Il Quotidiano: Toccare con il Tablet," 2019) and the fashion industry have expressed considerable interest in the practical implications of the research on touch for fashion e-commerce, confirming the originality and value of the ongoing study.

6.6. Conclusions and limitations

The *FashionTouch* research explores consumer perspectives on surface haptic technologies for fashion e-commerce by exploiting TanvasTouch, an innovative haptic technology device. The technology is still in the development stage and not yet available for widespread commercial use; when and if it will be available to consumers it might be in a radically altered or modified form. Therefore, the *FashionTouch* study makes an early-stage, original and – hopefully – a valuable contribution to the growing literature on multisensory human-computer interaction (Obrist et al., 2017) and specifically, on the sense of touch in the digital fashion communication domain.

[20] N.B. The research had to be cancelled shortly after article submission due to the COVID-19 pandemic.

Study findings point to some limitations in research design, which are also opportunities for improvement and enrichment in the upcoming research steps. Firstly, focus group volunteers came from diverse international backgrounds. Although English-language proficiency is a requirement for Master studies, it is not the volunteers' native language. Thus, they may have had some difficulty in expressing certain concepts during the discussion. Secondly, the fact that the moderator was a professor may have caused participants to be reticent, at first, in expressing their opinions. Thirdly, the introduction of garments prompted a lively exchange amongst participants. This focus group section is difficult to analyze because participants spoke excitedly and simultaneously with each other. Video recording of this specific phase might have yielded more comprehensible visual as well as verbal data and might be taken into consideration for upcoming focus groups. Finally, in this study, results are derived almost exclusively from focus group data. Upcoming studies will integrate results from the questionnaires, thereby providing opportunities for triangulation.

Fig. 6.3. Prompting session with original garments (unpublished).

Chapter 7

Looking for Haptics. Touch Digitalization Business Strategies in Luxury and Fashion During COVID-19

Ornati, M., & Kalbaska, N. (2022). Looking for haptics. Touch digitalization business strategies in luxury and fashion during COVID-19 and beyond. *Digital Business*, 100035. https://doi.org/10.1016/j.digbus.2022.100035

7.1. Introduction

The sense of touch (Field, 2014; Linden, 2015) is a central element of the fashion experience, because dress - garments and accessories - is experienced with and on the body (Entwistle, 2000, 2015). In the last two decades, the growth of digital fashion channels such as e-commerce websites and social media accounts has created new opportunities for consumers and brands to experience fashion on digital interfaces such as personal computers, tablets, and smartphones (Kalbaska et al., 2018; Nobile et al., 2021; Ornati, 2011; Rocamora, 2017). Although these devices offer rich audio-visual content and some haptic effects, such as feedback and vibration, they currently lack the tactile qualities which characterize bodily interaction with materials. Still and animated images provide some sensory substitution (Coëgnarts, 2017; Gallese, 2020b) but cannot entirely replace the information gleaned from active touch evaluation (Jones, 2018).

Business-to-business and business-to-consumer digital fashion communication has grown exponentially during the COVID-19 pandemic, driven by the unprecedented need to urgently shift all interactions online (Amed, Berg, et al., 2020, 2021; Noris & Cantoni, 2021). Digital fashion communication is understood as a set of strategies and tools enabled by information and communication technologies and applied towards the digitalization of traditional fashion communication content through digital channels (Kalbaska et al., 2018; Noris et al., 2021; Sádaba et al., 2021). During confinement, and for a certain period afterwards, trade and runway shows were cancelled, showrooms were

closed, and retail stores shuttered (BOF Team, 2020; Ilchi, 2020). Fashion and luxury industry suppliers and brands were compelled to address business and end-customer needs to identify digital alternatives to physical product showcasing and on-location selling strategies. At the time of writing - that is, two full years after the onset of the pandemic - European countries are only now beginning to ease restrictions; in other parts of the world, COVID-19 is still a public health and an economic issue.

These unprecedented socio-economic conditions have spurred the digital acceleration (Amankwah-Amoah et al., 2021; Brennen & Kreiss, 2016) and digital transformation (Verhoef et al., 2021) of many sectors, including the fashion and luxury industry (Amed, Berg, et al., 2021). Indeed, fashion and luxury e-commerce is forecast to grow, if unevenly (Amed, Berg, et al., 2021) to USD 149.34 billion by 2025 (Koncept Analytics, 2021). Concurrently, in business-to-consumer markets, the high rate of product returns e-commerce engenders, primarily due to size and fit issues (Ader et al., 2021; Narvar, 2021; Salerno-Garthwaite, 2022) - which are related to touch, feel and dress embodiment - is fueling unsustainable business and environmental costs (Schiffer, 2019). And in the business-to-business market, fashion buyers - accustomed to the physical handling of materials - still find lack of touch in the digital experience "a challenge" (Fernandez, 2020) because "there's no substitute for the physicality of the product" (Turra et al., 2020).

Haptic technologies are computational systems and applications aiming to artificially reproduce the sense of touch (Basdogan et al., 2020; Culbertson et al., 2018; Kuchenbecker, 2018; Prattichizzo et al., 2019). Research in the field of haptics is over a century old (Parisi, 2018). Today, haptic applications can be found in a number of fields, from defence to automotive and gaming, thereby contributing to a global industry currently worth an estimated USD 13.8 billion (Global Industry Analysts, 2022). However, to date and to the authors' best knowledge, the potential role of haptic technologies as surrogates for touch in fashion and luxury e-commerce has not yet been investigated, nor have decision makers who work in marketing related functions been involved. Thus, this exploratory research and prior publications by one of the authors (Ornati, 2022; Ornati et al., 2022; Ornati & Cantoni, 2020) are of interest to actors in both

the haptics and in the fashion domains: haptic technology researchers, developers or startups interested in entering the fashion and luxury industry; or business executives intrigued about the potential that haptics may hold to create novel customer experiences - and thus, business opportunities - by enriching the digital sensorium.

The research was conducted in 2021 - beginning when COVID-19 restrictions were being partially lifted - and thus, contextualized within the unprecedented crisis which had recently confronted participants. Anchored in theories on touch, embodiment, and sensory marketing, the enquiry focuses on fashion and luxury business decision makers' strategies to address lack of product touch interaction in marketing, communication, and sales during lockdown, including their views - using two devices as prompts - on whether haptic technologies could potentially address lack of touch in luxury and fashion e-commerce. In the next section we discuss the theoretical assumptions and research questions which guided the investigation, followed by an overview of the methodology, the presentation of the findings, and a discussion of their managerial implications.

7.2. Theoretical background and research questions

The research is grounded in the assumption that fashion is a communicative act (Wilson, 2020) expressed through the socially situated, embodied experience of dress (Entwistle, 2000, 2015), and enabled by the sense of touch. Touch is a highly complex sense which plays a fundamental role in the development of human beings (Field, 2014) and social interaction (Gallace & Spence, 2010, 2016; Jewitt et al., 2019) and an integral part of the multisensory processes which inform our perception of the world (Linden, 2015). Touch affects emotions, thoughts, and actions, including our clothing choices (Peck, 2010; Peck & Childers, 2003a). Explorative, or active, touch - also referred to as haptic touch - allows us to grasp objects and perceive their properties (Jones, 2018), primarily through the hand (Hayward, 2018). Indeed, we often describe interaction with woven or knit materials as "handling," and we evaluate them in terms of their "hand" (Behery, 1986; Civille & Dus, 2004; Philippe et al., 2003).

Lack of touch interaction is one of the factors which has long held back fashion and particularly luxury companies from selling online (Batat, 2019; Kapferer & Bastien,

2012; Okonkwo, 2010). This is partly because, given the two-dimensional affordances (Davis, 2020) of desktop and mobile screen technologies through which e-commerce websites are currently accessed, luxury and fashion items cannot be *worn on the physical body* nor their tactile properties *experienced through touch*. However, the physical properties of items - such as surface texture - can be perceived through audio-visual sensory substitution and integration mechanisms (Bruno & Pavani, 2018) and their effects re-enacted by virtue of mental simulation processes (Barsalou, 2008; Elder & Krishna, 2012; Papies et al., 2017). Garment fit can also be estimated via sizing charts, textual descriptions, still images, and videos; for example, a person modeling a garment while walking or turning. Fit can also be assessed via innovative customer-facing applications which enable self-scanning (via latest generation mobile phones or desktop cameras) and thus, the upload of personal bodily data for virtual fashion try-on using digital twins or avatars; consequently, garments can be visualized on the self before the physical item is purchased (Ornati et al., 2022).[21] Visual strategies such as those described above trigger embodied cognition (Barsalou, 2008; Miłkowski, 2019) and mental simulation processes grounded in sensorimotor experience (Coëgnarts, 2017; Gallese, 2020a, 2020b), which in turn inform consumers' judgment and behavior (Krishna et al., 2017; Krishna & Schwarz, 2014; Papies et al., 2017). Ultimately, however, garments and accessories must be felt to the touch and on the wearer's skin for pleasantness and comfort (Kamalha et al., 2013) Thus, depending on factors such as need for touch (Peck, 2010; Peck & Childers, 2003b) and attitudes towards risk (Sutinen et al., 2021) consumers may be more or less averse to shopping online rather than in a store, where items can be tried and felt *in situ*.

In fact, the role touch plays in shaping consumer attitudes while shopping in interactive online environments has been the focus of several recent studies, for the most part involving widely available haptics interfaces (laptops, tablets, mobile phones and peripheral accessories) which provide regular feedback such as vibration or pulses. Racat et al. (2021) provide an extensive overview of the literature. In the same article, the authors

[21] If preferred, garments can now be consumed in digital form only, as envisioned by purveyors of virtual creations such as DressX (https://dressx.com/) or the Fabricant (https://www.thefabricant.com/).

also underscore "the importance of interface touch for inferring product information or pleasure to interact with the product," thereby "confirming the relationship between knowledge and mental representation, body sensory-motor actions and online shopping contexts" (2021, p. 1). In an early exploratory study, Van Kerrenbroeck et al. established that " touch-enabling technologies can provide utilitarian and hedonic value to consumers, mainly at the pre-purchase stages in the path-to-purchase" (2017, p. 892). De Vries et al. later suggest that being able to interact with objects (such as images) using a touch interface is "a predictor of online shopping enjoyment independent of product category" (2018, p. 64) while Riedel & Mulcahy affirm that haptic feedback "improves the experience of advertisements and this strengthens purchase intentions" (2020, p. 1). In 2020, one of us carried out a study focused on fashion consumers' interaction in an e-commerce setting using one of the devices presented in section 3. Results established that "providing richer perceptual cues – tactile and visual – with interactive surface haptic effects, adds value" to online fashion shopping, "particularly at the information-gathering stage" of the customer's e-commerce journey (Ornati & Cantoni, 2020, p. 493).

In addition to end-consumer research, an ample body of literature focuses on the importance of touch to other actors in the textile and fashion value chain, such as designers. Petreca et al. explore designers' sensory experience of materials (2015, 2016), underscoring the lack of digital fashion tools which might provide adequate sensory feedback to design experts (Petreca, 2017); the authors propose novel, embodied design methods involving material "sensing" technology (Petreca, 2017, p. 261). Bridging textile sensory research with interactive design, Atkinson et al. (2011) explore how to effectively communicate textile properties via digital media; while in a later study, the authors develop a framework which facilitates the "systematic analysis and comparison of tactile experiences" and thus, can be applied by designers as a communication tool (Atkinson et al., 2016, p. 1). Finally, it is important to note that research in the sensory evaluation of apparel and textiles dates as far back as the early 21st century (Binns, 1926); and that several methodologies have been developed since, using both human-centered and mechanical approaches (for a review see Abreu et al., 2020; and Ornati, 2021a).

As discussed, the role of touch and tactility has been investigated at different stages of the fashion value chain and involving diverse stakeholders. However, to date, research on touch sensation has not focused on business actors - specifically, fashion and luxury business managers and executives with roles in marketing, communication, sales, or general management. This is surprising. Within firms, these actors define strategies and are responsible for their execution, and thus, their opinions regarding touch - or the lack of it - in fashion digitalization, and their views on how to address the issue, are relevant to researchers and practitioners alike. Furthermore, given the role these executives played during the COVID-19 pandemic - which removed touch interaction in day-to-day operations while accelerating the shift to digital - investigating their experience is a timely and potentially valuable endeavor. In sum, by interviewing fashion and luxury business managers regarding the role of tactility in e-commerce and the potential which haptic technologies may have in this domain, we aim to fill a gap in the research, and seek to answer the following questions:

- RQ1 - In what way was lack of touch interaction with fashion and luxury products addressed by luxury and fashion firms during the COVID-19 shutdown?
- RQ2 - What are the opinions of business executives in luxury and fashion firms regarding the challenges and the opportunities posed by haptic technologies in addressing lack of product touch interaction in digital environments?

In the following sections we will present the research design and the haptic technologies utilized.

7.3. Method and technologies

This research is based on a set of fourteen interviews conducted in Italy and Switzerland between May and October 2021, in different locations based on interviewee preferences and in a manner respectful of COVID-19 safety guidelines. It was conducted using a qualitative and pragmatic approach. The fourteen participants were purposively sampled from within the network of peers cultivated by the main researcher during a previous

career in fashion and luxury. Sampling criteria included having extensive experience in the industry, currently holding a managerial role in marketing-related functions, and lastly, being available for a one-on-one interview. Thus, the sample includes executives, senior managers, and managers with, on average, twenty years of professional experience; out of the fourteen, five are women. Their current employers include medium-sized, family-owned firms as well as multinational groups. Following Kapferer's typology of brands (2012), the companies included in the sample can be clustered in the luxury, premium, and fashion segments (two interviewees are from the same firm but hold different roles) as illustrated in Table 7.1. Most firms serve both end customer (B2C) and intermediary (B2B) markets. The research has been approved by the Ethical Committee of USI - Università della Svizzera italiana, and participation in the study is anonymous.

CODE	TITLE	SEGMENT
Exp1	Founder & Managing Director	Luxury
Exp2	Head of E-commerce	Fashion
Exp3	Senior Director Digitalization	Premium
Exp4	Chief Operating Officer	Luxury
Exp5	Global Merchandising Manager	Premium
Exp6	Senior Manager E-commerce	Premium
Exp7	Head of E-commerce & Digital	Premium
Exp8	Marketing Director	Premium
Exp9	Managing Director	Fashion
Exp10	Digital & E-commerce Manager	Luxury
Exp11	Head of Digital	Luxury
Exp12	Chief Marketing Officer	Luxury
Exp13	Chief Executive Officer	Premium
Exp14	E-commerce Director	Premium

Table 7.1. Participants

Two surface haptic technologies were adopted as prompts for the study: TanvasTouch® (www.tanvas.co), and WeArt (www.weart.it). These devices function with proprietary hardware and software and are safe for use in an experimental setting. Neither TanvasTouch nor WeArt have been developed specifically for the fashion industry, but both offer features suitable for this research - including the possibility of simulating the e-commerce user experience as it might take place on a computer, tablet, or mobile phone screen. The first device was purchased by the researchers' university lab in 2019 and used in prior research (Ornati & Cantoni, 2020); the second was acquired in 2021. Although a detailed discussion of the technologies is beyond the scope of this paper, following is a brief explanation of the setup. The TanvasTouch haptic system includes an interactive screen and a proprietary software engine. The custom electronics situated behind the Tanvas screen enable the precise tracking of the fingertip(s) sliding across its surface and the simultaneous delivery of friction effects, which can be programmed ad-hoc with varying degrees of intensity. Thus, it is possible to simulate, with some

approximation, the uneven surface characteristics one feels while stroking a flat swatch of material. To provide these effects in context, a mock fashion e-commerce setting called *FashionTouch* (consisting of a landing page plus several product pages) was created from scratch and uploaded locally (Fig. 7.1). By interacting with the screen, users can select a garment, navigate to the product page, choose an image, enlarge it, and view a close-up of the material while perceiving diverse surface texture stimuli in the corresponding area (Fig. 7.2). As mentioned in section 2, this setup had already been tested and employed in an earlier study (Ornati & Cantoni, 2020).

WeArt, the second technology, currently includes a wearable haptic system which reproduces tactile cues (forces, textures, and temperature changes) on the wearer's skin in virtual reality environments (Gioioso et al., 2019). However, in this study an earlier, non-wearable Touchkey was used, which similarly features force feedback, texture-based vibrations, and thermal cues. The haptic feedback effects for the WeArt interaction were recorded in the supplier's laboratories directly from the original garments and synched with a graphical video rendition of the stroking gesture. The mock website and the interaction simulation for each garment were made accessible on an Apple iPad (using a TestFlight application) and paired to the WeArt Touchkey via bluetooth. Thus, when users place a finger on the Touchkey with one hand and choose a garment on the iPad screen

with the other (Fig. 7.3), they simultaneously see a pointer moving across the material and feel the corresponding force-feedback effects under their fingertips (Fig. 7.4) [22] [23].

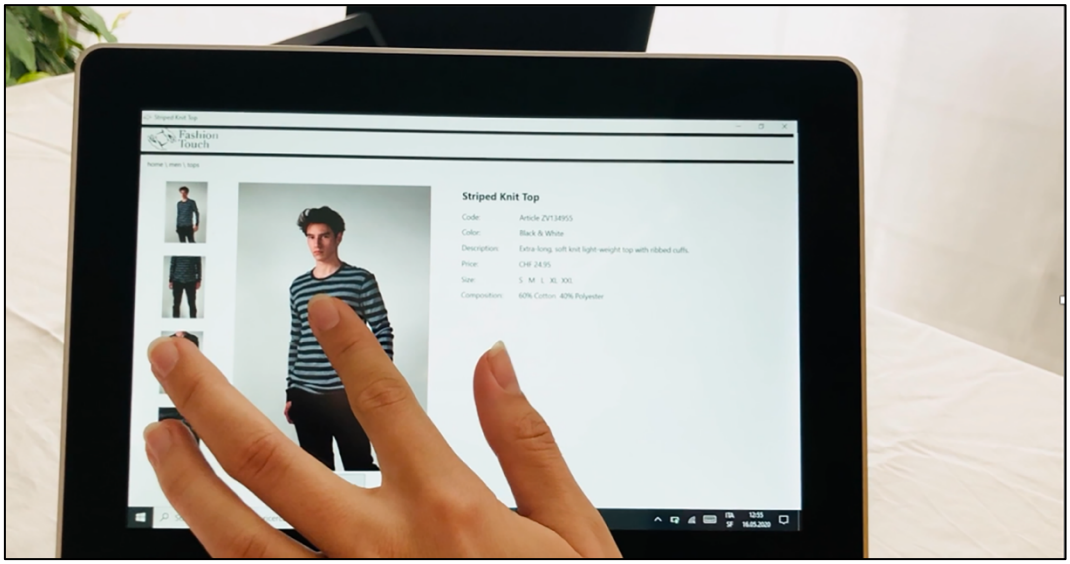

Fig. 7.1. *FashionTouch* product page on TanvasTouch.

[22] As indicated in the Introduction, two private videos illustrating FashionTouch interaction are accessible online: https://youtu.be/NEtf1d53eZ8 (TanvasTouch) and https://youtu.be/_wt_6IG-NU8 (WeArt).

[23] The hot and cold thermal cues are synchronized with a video (also created by researchers in the WeArt lab) showing interaction with a hot teacup and a cold soda can. For technical reasons not all participants were able to test this feature.

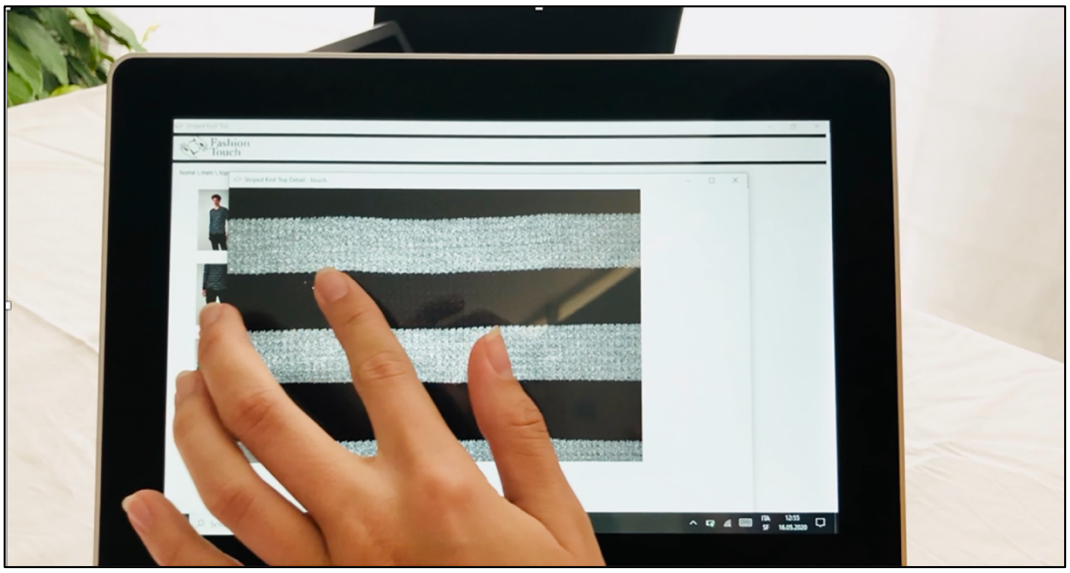

Fig. 7.2. *FashionTouch* product detail on TanvasTouch.

Fig. 7.3. *FashionTouch* product list on WeArt iPad app; Touchkey.

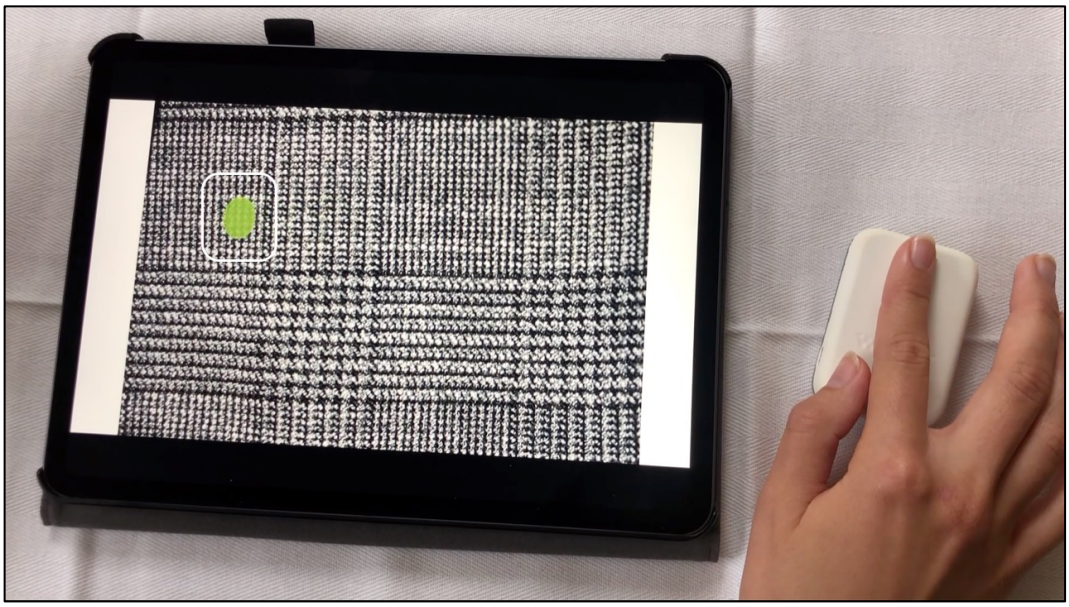

Fig. 7.4. *FashionTouch* product detail on WeArt iPad app; Touchkey; pointer (circled in the upper left-hand side)

As suggested by the literature on interviewing experts (Meuser & Nagle, 2009), a semi-structured interview topic guide was prepared to loosely frame the encounter. Previously, each participant had received a detailed description of the research project, a summary description of the technology and a consent form for review. Although interviews were audio-recorded, care was taken to ensure anonymity throughout the process. Most interviews - lasting approximately 90 minutes - were conducted in English, the working language of interviewees; a few were held in their native Italian (the authors are fluent in both). Throughout the interview process, the researcher deliberately positioned the interview as a conversation between "colleagues" or co-experts (Trinczek, 2009, p. 58) - a safe space within which the interviewees were able to "voice their views on issues without reservations" (Bogner & Menz, 2009, p. 208). Furthermore, it was made clear that the two haptic technology devices had been bought for research purposes, and that only the *FashionTouch* mock website setup had been created ad-hoc.

The interviews were loosely structured in three sequential phases, each one intentionally designed to help address the research questions detailed above. The first phase, *contextualization* (section 4.1 below), aimed to situate the research and "set the stage" for questioning by encouraging the interviewee's recollection of events during COVID-19, including the marketing and communication problems encountered at the time and the digital strategies and tools adopted as a response. The second phase, *problematization* (section 4.2), explicitly addressed RQ1 by directing the interviewee's focus on issues specifically connected to lack of touch in fashion and luxury digital environments. The third, *elicitation* (section 4.3), aimed to answer RQ2 by stimulating - during or immediately after interaction with TanvasTouch and WeArt - the expression of the interviewee's opinions on the role surrogate technologies for touch may have in digital fashion and luxury business. After the first interview, the semi-structured interview guide was modified slightly; the final version is summarized on the next page in Table 7.2.

PHASE I – CONTEXTUALIZATION	
Q. 1	Can you tell me about your business?
Q. 2	Can you tell me more about your role in the business?
Q. 3	Can you describe how the COVID-19 pandemic has impacted your business?
Q. 4	During this time, which were your company's biggest challenges in the digital domain?
Q. 5	How were your e-commerce strategy and tactics affected?
PHASE II – PROBLEMATIZATION (RQ1)	
Q. 6	When customers shop online, they can see your products, but they cannot touch them. What are your thoughts on this?
Q. 7	Is lack of touch relevant to your online customers?
Q. 8	Have you addressed the issue in any specific way?
Q. 9	What can you tell me about product returns?
Q. 10	What are your customers' motivations for returns?
PHASE III – ELICITATION (RQ2)	
Q. 11	Screens are smooth to the touch. By adding texture to the interaction, what changes?
Q. 12	In the e-commerce domain, what difference would the addition of touch sensation make?
Q. 13	What obstacles or difficulties do you foresee in future adoption of haptic technologies?
Q. 14	Would your business adopt technologies making touch possible in digital fashion?
Q. 15	Do you have any suggestions for future research in haptics for digital fashion?

Table 7.2. Semi-structured interview guide.

The interviews yielded a large corpus of textual material (approximately 66.000 words) which was manually transcribed by the researchers. Transcriptions were reviewed at least once, together with the audio, to ensure comprehension of the professional terminology used by the interviewees and fidelity of meaning; this activity was accompanied by extensive memoing. The data was uploaded to Atlas.ti version 9.1.3 and an analytical strategy devised which purposefully leveraged the software's capabilities (Woolf & Silver, 2018). The process of analysis was conducted in cycles following a deductive and an inductive approach (Bingham & Witkowsky, 2021). Thus, the data was organized and the initial a priori coding structured on the basis of the three interview phases. Subsequently, the corpus was re-analyzed and inductively coded to identify

relevant topics and spotlight emergent themes; coding within and across interviews was scrutinized for relevance and coherence.

Several steps were taken to ensure the qualitative study's descriptive and interpretive validity (Sandelowski, 2000). First, the authors discussed the coding book (see Appendix 4.2) and revised the coding where necessary. Second, several interviews - fully anonymized - were distributed amongst the small circle of doctoral students working within the researchers' lab, who first read, and then discussed, the corpus together. This peer-debriefing activity (Steinke, 2010, p. 187) yielded an inter-subjective, agreed-upon list of topics and overarching themes which the authors used to cross-check their own coding and findings. Lastly, the interview material was triangulated with publicly available information on the interviewees' firms as well as trade publications.

7.4. Findings

In this section we provide an overview of the key issues arising from the interviews. The narrative is structured following the *contextualization*, *problematization*, and *elicitation* phases described above. Expressive quotations are extensively used to illustrate emerging themes.

The context: digital transformation. This first phase set the stage for the interview and provided first insights into possible answers to RQ1. Participants were initially asked to briefly describe their jobs, their companies, and how the pandemic had affected their business and their actions. When answering, interviewees framed their role beyond formal titles and responsibilities, and contextualized it within the unprecedented demands the pandemic had placed upon their functions. While vividly describing their personal experiences, they recalled the digital strategies and tactics they had adopted to confront the emergency. During the pandemic, "everything was urgent: to be done, to be 'live,' to be made available to customers" (Exp3). The marketing, digital and sales functions took on a central role. Or, as one interviewee put it:

> It was really our moment… you are in a theater, you are (on stage) and the spotlight is on you, and you need to sing, with the loudest and best voice, because everyone

> is relying on you to impress the public! I think that was the key thing for us to accelerate. We found ourselves not only in charge of the commercial performance, but also stewards of the brand in a way (Exp2).

In fact, with retail stores, offices, and showrooms fully or partially shuttered, digital business-to-business and end-customer channels for communication, promotion, and sales acquired unprecedented importance. The e-commerce channel in particular - for which several of the executives interviewed are responsible - "was no longer looked down upon as the youngest child; it became a big player" (Exp12). Digital content distributed through digital channels became "the only way to communicate, to showcase products, to tell our stories" to brand customers (Exp2). Customer-oriented activities normally held in person had to be recreated digitally while "staying true" to brand identity (Exp8). A sense of urgency drove innovation:

> For sure the pandemic has greatly accelerated the need to complete a digital transformation. Taking the *maison* to the customer, rather than the customer to the *maison*, has demanded a different kind of commitment - trying to convey the experience of a luxury garment, of an accessory, in a way which was completely different from what we were accustomed to doing before (Exp11).

Executives narrate having to digitalize the customer experience by reproducing, as best as possible and across all digital channels, the physical interaction the COVID-19 pandemic had fully or partially upended. To achieve this, participants described engaging in several activities, which varied depending on the market (B2B and/or B2C), the size and the financial means of the company they work for. These included making use of available technologies in novel ways or quickly adopting new ones (for ex.: photogrammetry, 3D rendering, CGI video, augmented reality); creating high-quality digital assets (while acquiring or enhancing content and digital asset management tools); revising brand narratives and product descriptions; reviewing customer-facing online functionalities; and redirecting employee knowledge and skills. Digitalization tactics were at times combined and then implemented across different channels to maximize impact on

promotional and sales activities. For example, one interviewee recalled "shooting all the collections, night and day" (Exp8) to acquire 360-degree views of the product which could be shared during online meetings with business customers. Another participant described staging a closed-doors runway show which included filming the garments from the podium with two camera operators and recording an explanation of each look. Practically in real time, the resulting three-minute audio-videos were sent to VIP and B2B customers via WhatsApp - thereby somewhat replicating an in-house sales and promotional event. The same interviewee also described how these digital assets were archived and repurposed for the brand's e-commerce website (Exp11).

In the contextualization phase of the interview, executives' narratives underscored a common process of digitalization and, for some companies, cultural transformation. In their recollection, marketing and communications had a leading role in digital acceleration, being called upon to leverage their expertise, as well as guide and support other company functions. Furthermore, interviewees describe engaging in innovative representation practices aiming to reproduce online the multisensory nature of the physical customer experience. Thus, contextualization provided significant first insights and a rich backdrop on which to anchor the following phases of the interview: problematization and elicitation.

The problem: digitizing touch. While going into considerable detail about the problems caused by COVID-19 and the solutions adopted to confront the crisis, during the contextualization phase of the interview participants rarely referred to the physical nature of the interaction which brands were attempting to replace or represent digitally. Nor did they ever refer to touch sensations or embodied feel. However, in the second phase - which explicitly addressed RQ1 - executives were prompted to reflect on these topics via direct questions such as "Is lack of touch an issue online?" and "How is lack of touch addressed?" Executives were also questioned about product returns, how this phenomenon had been confronted during the pandemic, and the role lack of touch might play in causing it.

With regards to the first line of questioning, executives' replies shared a similar narrative: although lack of touch represents the "greatest gap" (Exp8) between the physical

and the digital environment, the problem is more nuanced than it seems, requiring pragmatic, tactical workarounds. Executives shared the view that material touch cannot be fully replicated, as expressed in the following statement:

> When we kicked off video production for remote selling, touch was the first thing (salespeople) sensitized us about. They told us, 'But ... how can we make a customer understand what the sensation *is* of touching one fabric versus another?' And I told them, what we used to do, we can never reproduce one hundred percent" (Exp11).

But interviewees also believed that the need for touch varies, depending on factors such as brand familiarity, product categories and consumer typologies, including habitual versus first-time online customers or buyers. Consumers shopping online may not need to touch “the more iconic part" of a collection "because products are so well known" (Exp2) that "product feel is a given" (Exp14) - something a returning customer who "knows the brand, the quality, can imagine" (Exp4). But the same customers might want to touch new products, particularly if made with innovative materials they are not familiar with - for example, sustainable leather substitutes (Exp10). Unlike existing customers, first-time online shoppers "are not one hundred percent confident because they can't touch the product" (Exp8) and in fact, it is "very difficult to transfer the (touch) experience to them" (Exp4). This is also true in a B2B setting:

> I see a great difference between buyers who have been working with us for many years and know our collections, our fit. When they see eighty percent of the collection, the materials, the colors, (they can easily imagine the rest) because they have already handled it. The reaction is very different with someone who has not yet bought the collection and ... feels there is something missing. A new partner must come in person, must touch (Exp13).

The same participant pointed out that garment information retrieved via active touch "is not just tactile: it has to do with (understanding) wearability, how a fabric drapes" and moves on a body (Exp13). Translating these properties digitally is a challenge which

should be attended to, as the interviewee confronted with concerned colleagues recalled (Exp11):

> What we can do, I told them, is provide a sensibility of how a fabric falls on a model, to go into the details and show the weave, the transparency of the fabric ... not flat, but in movement.

Thus, during the pandemic, while producing digital assets, he and his team took care to portray dynamically, through audio-visual means, the embodied and material representation of dress:

> There is a difference between having a static mannequin, dressed up, and a model wearing the same garment, walking. It provides a sense of how the garment falls, how comfortable it is. We worked a lot on the details to narrate what a shoulder seam is like, an embroidery, a button, several layers of fabric, and lace, which is so rich in our collection. All this is not quite like ... touching it and *knowing* what it is, but certainly it gives you ... a perception of how it *might* be.

Other participants, likewise preoccupied - but working for smaller companies - devised new ways to photoshoot "with moving content and closeups where you could see the lace in detail" (Exp12), and described efforts made to "show the beauty of the material and of the fabric" (Exp7) or the complex construction of a garment. In digital representation "we try to be true to what we promise," stated a participant (Exp2), by "using the only media we have ... videos and pictures and copy" (Exp7). Yet, as the interviews progressed, a subtle sense of frustration emerged in the executives' narratives regarding the limits of digital:

> ... We tried to eliminate that barrier of the monitor ... but (digital) cannot compare to reality. The real approach, in presence, cannot ever be fully substituted in our industry because feeling, touching the product, the merchandising – are really hard to picture in a (digital) environment (Exp8).

At this point during the interviews, interviewees were questioned about product returns: could the phenomena be at all connected to not being able to touch products prior to purchase? Executives are convinced that most returns are driven by fit and sizing issues; the question of touch or feel is too granular to be raised during the return process. When returning "the only thing on the customer's mind is to get the money back. That's something we sometimes forget" (Exp8). The problem of returns should be addressed by striving to "provide good images, video, content - anything that could help eliminate" the tactility gap between physical and digital interaction (Exp8) as well as by improving customer service and channel integration - for example, by accepting returns in-store (Exp3). Several executives added they had also tested fit and sizing third-party tools (such as Rakuten Fits Me or EyeFitU), and in some cases had adopted them. The benefit of such applications, they said, was twofold: supporting customers in finding their right size and fit, thereby reducing returns; and acquiring brand visibility on the fit and sizing provider platforms.

In the problematization phase described above, executives were invited to focus on lack of touch in the e-commerce domain. Their replies were pragmatic and solution oriented. They unequivocally framed the issue as an unsurmountable gap between the in-person and the online experience, one reason being the sensory complexity of touch itself. Given the mediation of the screen, they expressed conviction that well-crafted, evocative audio-visual product presentations are acceptable in lieu of physical interaction. The issue of returns might be connected to the sense of touch but - they claimed - it can be tactically addressed by improving customer service, terms of sales, or, in some cases, by introducing fit and sizing functionalities. At this point, the interview entered its final phase. Prompted by interaction with haptic devices, executives were invited to exercise their imagination about the future of touch in the business of digital fashion and luxury, as described below.

Elicitation: the future of haptics. In this phase of the interview, structured around RQ2, participants were invited to interact with the two surface haptic technologies (described in section 3) and comment freely on their experience. Several questions were asked to stimulate their imagination regarding the possible future role of haptics in their business, including: "What difference would adding touch sensation make in the e-

commerce domain?" and "Would you adopt haptic technologies enabling online touch? What obstacles do you foresee in doing so?" Although this phase yielded rich phenomenological data, in keeping with the pragmatic quality of the research design, the focus of the analysis is primarily on the business-oriented findings which emerged from the interviews.

As mentioned in the methodology section, participants in the study have considerable industry experience: most of them exuded quiet confidence when describing their first-hand knowledge of textiles. Thus, interviewees were frank - even blunt - in their comments regarding the characteristics tactile technology should have in order to meet their (very high) sensory expectations - and those of their customers. "It takes little to give the wrong impression, especially in fashion. If I want you to touch a cashmere sweater, the tool must be perfect. Otherwise, it's better not (to do it)" (Exp14). Participants also pointed to the differences between the limitations imposed by the flat TanvasTouch screen and WeArt Touchkey, which require one-dimensional finger actions, compared to the three-dimensional hand gestures involved in grasping garments and fabrics:

> If you want to understand how the surface is, how it's made, if it's a honeycomb weave ... (stroking her jacket) a three-dimensional pattern ... one finger is enough. But if you really… want to (convey) a product, to give information about the softness of a fabric - one finger is not enough (Exp9).

Manipulation provides additional kinds of information, stated one participant, because "when I touch, I am measuring many things, and not just surface properties" (Exp13). But another participant found value in haptic surface rendering, because in her opinion it conveyed additional information regarding surface texture or construction. Yet another participant opined that "a normal customer probably does not realize when seeing the picture of a knitted garment that the structure is not flat; I know it when I see it. For some people (haptic information) might help" (Exp9). Participants commented on how haptics could effectively convey surface treatments on garments or accessories, such as embroidery, appliqué, or decorative stitching. Haptics could help distinguish between sustainable products which have different textures but are otherwise similar. "By (using

haptics) you could convey additional data points ... and tell a consistent product story" (Exp3). Tactile attributes could also be matched with customer data to improve merchandising and selection:

> The information that is collected through these (haptic) experiences could potentially be translated into another attribute of the product. For us it could mean the ability to filter or that of saying to the customer "if you like this soft texture, there are also other products that have similar textures." Of course, the more you add in terms of senses, the more granular the categorization can be, and more complex... We could feature it in the product detail page or in the product listing page, or in any pieces of the journey where customers are looking for the product. But we could also use this information in other ways ... in the recommendation process, in understanding preferences, potentially even in addressing some production choices for the next season, if I understand that there are some patterns in the data. I think the potential there is really infinite (Exp3).

Participants spontaneously pondered the challenges posed by acquiring and managing haptic data but were not at all daunted by the prospect, especially considering digital advances made during the COVID-19 emergency. "I do not think it is something very complicated. Instead of acquiring a color swatch, or a close up (of the garment), you just need to acquire something else ... It's just a matter of building a database of information related to the touch, rather than standard things" (Exp8). However, because adding such data is likely to increase digital asset management complexity, haptic technologies for data acquisition and deployment must easily integrate with legacy systems. "It's about budgets ... you really need to have something cheap, fast, easy to use, easily implemented with tools which already exist" (Exp5) and monitored "for success" through key performance indicators (Exp3). While the investments required to reach "a level of (haptic technology) implementation that is worth the game" could be perceived as a barrier (Exp8), one must not forget that trying to digitally convey the physical properties of a garment - by filming a moving model, for example - is a resource-intensive, expensive process; thus, whatever "can help convey additional information ... versus what one can

get through the standard (audio-visual approach) ... can make a difference to the business" (Exp3). Interviewees also speculated on, and tried to envision, how to engage consumers by enriching audio-visual digital content with haptic data. On an e-commerce site, haptic effects could be judiciously applied to push select products on a landing page (Exp12). Tactile product information could also be matched with congruent auditory and visual stimuli, embedding multisensensory effects within promotional offers, brand videos, or even live streaming fashion shows, thereby potentially driving sales (Exp14).

However, haptic technology adoption and its potential to scale hinges on "hassle free, barrier free" accessibility to consumers (Exp12). Having to use "a small piece of (additional) hardware" - such as the TouchKey - means "disrupting the whole (experience) process. It's not a sustainable model" (Exp2). Ideally, the technology should be incorporated into widely available and affordable devices, such as desktop computers or smartphones; "everything in one device" (Exp9). However, some participants mentioned innovative flexible screen technologies for smartphones - surfaces "you could grab, manipulate" (Exp6) - and hypothesized the development of accessible soft, three-dimensional screens through which consumers could perceive volume, thickness, and other material properties (Exp4, Exp11, Exp6). Perhaps haptic feedback will really become part of consumers' lives, one participant considered, if a company such as Amazon, which has already sold Kindle and Alexa "to millions of people," would add "a tactile, more emotional component" to such devices (Exp13). "We need to consider how customers like it and accept it, first. But I think it's the future to go in this direction. In some years or even short-term a lot of companies will use (haptic technologies)" (Exp9).

Finally, participants agreed that those luxury and fashion companies which will innovate first to close the tactile gap in the online domain will have a competitive advantage (Exp6). "There is a technology maturity barrier. But that's the beauty of technology: you never know when to adopt it" (Exp3). When envisioning a future for digital touch, one interviewee optimistically affirmed, "I do not see any limitations. Most probably in a few years (haptic) technologies will be super advanced. If I look back… I am 38 years old this year. When I started school, I did not even have a smartphone. It was not 50, but 25 years ago! In that sense, there are no limits at all" (Exp8).

In conclusion, experts had very high expectations regarding both the degree of fidelity haptic feedback should have compared to reality, and how gestures involved in product manipulation should be reproduced. To ensure adoption, they concurred, haptic technologies should easily and seamlessly integrate with both front-end and back-end legacy systems; using the devices did not suggest that was the case at present. However, interviewees did foresee value in delivering haptic data within the digital customer journey, and imagined alternative ways in which the technology could be deployed for brand promotion and engagement, granting competitive advantage to firms which adopt early.

While gazing toward the future, the experts interviewed were generous in sharing their thoughts on the immediate past. And, as illustrated above, they offered rich insights into digital business management issues during the COVID-19 pandemic, the problem of digitizing material touch, and the future potential of haptic technologies. In next section we will discuss the findings, the managerial implications, and possible research directions this study suggests.

7.5. Discussion and managerial implications

This study investigates the digital strategies and tools adopted by fashion and luxury business actors to convey product touch interaction during the COVID-19 lockdown and, using two devices as prompts, their perception on the role haptic technologies may play in the digitalization of product touch. Findings illustrate - answering RQ1 - that during lockdown, participants adopted innovative digital communication practices aiming to reproduce the customer experience online. These practices included the creation of engaging audio-visual representations of in-person product and service interaction experience. According to interviewees, the perceptual complexity of real-life touch cannot be reproduced in digital environments. And yet, touch sensation was implicitly folded into the participants' visual practices through the purposeful simulation of materials and dress embodiment. In answer to RQ2, we learn that in the interviewees' opinion, haptic data - and, possibly, haptic technologies as they may be available in the future - could be strategically and tactically leveraged to digitalize fashion to competitive advantage. In the

next section we will discuss these findings by exploring the potential of haptics in association with virtual prototyping and virtual reality.

Virtual prototyping. As mentioned by some interviewees, haptic data - sensory information regarding the subjective tactile properties of items - could be integrated at different stages of the value chain, from 3D design to prototyping and merchandising, thereby adding a layer of valuable information to digital fashion. Two technologies already on the market help us illustrate this hypothesis: Browzwear, a 3D computer aided design (CAD) platform which offers a suite of software tools serving the entire fashion design workflow (https://browzwear.com); and SynTouch Toccare, a haptics measurement system originally developed at the University of California (Fishel et al., 2016; Fishel & Loeb, 2012). With Browzwear's suite of software tools, fashion designers can create digital garment patterns, select materials from digital textile libraries, refine stitching and trimming, and finally visualize product look and fit on diverse body shapes, both still and in movement. Using a plugin by 3D body modeling and virtual model imagery provider MeTail (https://metail.com/products/ecoshot/) [24] designers can also obtain photorealistic renderings of the garments draped on virtual humans. 3D digital assets such as these can be showcased in digital showroom settings - thereby replacing physical sample collections - and embedded in e-commerce websites, to be produced on demand (McDowell, 2020b). We assume that Browzwear workflow renderings are associated with objective materials data, such as visual and mechanical properties, but that they lack subjective sensory information. As mentioned in the review (section 7.2), technological solutions already exist to bridge this gap, such as SynTouch, which employs a robotic fingertip which mimics human sensing properties. This Toccare sensor measures and quantifies materials properties biomimetically along fifteen dimensions, correlated to human sensing data and subjective descriptors such as softness, thickness, or warmth (https://syntouchinc.com/technology/). If the materials (i.e., textile) libraries used to create the virtual prototypes in Browzwear included sensory data - collected via a system such as SynTouch - the on-model digital assets would include that data as well, helping the

[24] For a case study, see https://browzwear.com/case-study-browzwear-puma/.

viewer understand how materials rendered digitally might feel to the touch and on the skin. Given available screen technologies, this information could be conveyed to buyers and end consumers through textual product descriptions and incorporated into virtual fit simulations. At future stages of client-facing haptic technology maturity, sensory data could be relayed haptically, in whatever form these technologies might afford, thereby enriching the overall digital fashion product experience. As posited by Vincent et al.: "As new consumer and industrial applications (across the growing immersive reality sector, the games industry and through advancement of smart device technology) are developed and reach their respective audiences, feedback and control mechanisms that more directly engage a digital physicality of touch will again redefine how the digital is both controllable and recognizable. The capacity to feel the 'shape' of certain characteristics of data - potentially enhancing the ways in which users can perceive it - presents different ways to understand, interpret and interrogate vast and complex data sets" (2022, p. 195). Indeed, as discussed below, one way of experiencing touch data might be, in the future, that of wearing virtual garment prototypes on one's digital twin (or body avatar) in augmented or virtual reality (Kishino & Milgram, 1994), and "feeling" them via handheld or wearable haptic devices. And, as research by the Tangible Media Group at MIT (https://tangible.media.mit.edu/) suggests - and some participants presciently imagined - to grasp and manipulate tactile data through material user interfaces (Ishii, 2017; Lakatos & Ishii, 2012).

Virtual reality. Computational power, converging technologies and less expensive VR devices - headsets, haptic vests and gloves - are raising intriguing questions concerning the possibility of expanding the meaning and experience of touch in mixed or virtual reality, thereby enriching the digital sensorium (Huisman et al., 2020; Vezzoli et al., 2022). Research and use cases can be found in virtual commerce (de Vries et al., 2018; Hu & Wise, 2020; Racat & Capelli, 2020), arts and culture venues (Ablart et al., 2017; Velasco & Obrist, 2021; Vi et al., 2017), tourism (Flavián et al., 2020) and fashion and luxury retail (LVMH, 2022). Convergence is making "metaverse" spaces (Kanterman & Naidu, 2021; Lee et al., 2021; Park & Kim, 2022; Ratan & Lei, 2021) more accessible to consumers and attractive to businesses, including fashion and luxury firms (Friedman,

2022; McDowell, 2021, 2022). According to a recent report by McKinsey and BOF, "over the next five years" innovative fashion brands "could generate up to 5 percent of their revenue from activities in the metaverse" (Amed et al., 2022, p. 8). Balmain, Gucci, Nike, Tommy Hilfiger and others have tested communication initiatives in virtual worlds (Bain, 2021; Poppe et al., 2017), garnering considerable media attention (McDowell, 2022). Research indicates that V-commerce, or "electronically mediated commercial transactions that originate from an alternate reality technology platform and involve either digitally-generated or real-world products and services" (de Regt & Barnes, 2019, p. 19) might interest young consumers (Semerádová & Weinlich, 2022). Thus, brands might consider offering hyper personalized (Amed et al., 2022, pp. 26–31), haptically enriched, virtual dress experiences in phygital contexts (Pantano & Willems, 2022), thereby extending the value of their digital assets. In luxury settings, the perceived usefulness, ease of use, and value of such immersive experience will likely determine their acceptance (Altarteer & Charissis, 2019).

7.6. Conclusion and possible limitations

The digitalization of business processes imposed by the pandemic has spotlighted the advantages, but also the deficiencies, of technologically mediated experiences, particularly those involving touch (Jewitt et al., 2021). In addition to the human and emotional toll exacted by the pandemic, one of the major business issues confronted by fashion and luxury executives during lockdown was the need to recreate the material and embodied experience of dress which characterizes their customers' habitual retail journey. As this study shows, participants did not dwell on the role touch sensation plays in this process. Rather, they pragmatically devised ingenious visual workarounds, which leveraged both information and communication technologies as well as digital channels to best advantage. In this context, we enquired whether haptic technologies might potentially address the tactile deficiencies of the online domain, specifically in e-commerce. Notwithstanding some criticism of the technologies used, the results of the enquiry underscore the relevance attributed by these fourteen fashion and luxury digital business

experts to the potential role haptic technologies may play in the future domain of digital fashion and luxury communication.

In addressing these issues specifically with marketing and communication decision-makers, the research fills a gap in the literature on embodiment and sensory experience in the fashion and luxury domain. It also provides valuable insights into the experience of product touch digitalization from the perspective of industry players, which may be leveraged to accelerate developments in haptic technologies specifically for this sector. The enquiry has some possible limitations. These are the expertise of the participants, which far exceeds the knowledge and expectations average consumers might have towards haptic feedback in the e-commerce domain; the specific type of haptic devices used; the size of the sample and the location of the firms involved, which are primarily Western; and the possibly uneven level of their digital maturity. Thus, future research might extend the findings in several ways. For example, by adding digital advancement to the sampling criteria; by interviewing experts using different kinds of haptic technologies and in immersive environments; by investigating perspectives of decision makers in non-Western locations; and finally, by extending the research to consumer markets. Nonetheless, the authors feel the study provides a substantial contribution to the field of digital fashion and luxury communication, digital business, and haptic technologies, opening new venues of enquiry and research.

3. Conclusion

3.1. Thesis overview

The acceleration of fashion and luxury e-commerce brought about by the COVID-19 pandemic has exacerbated and spotlighted pre-existing problems in the online customer experience. An example of these is product returns, which are driven by size, fit, and the related issue of product feel. When shopping online, products can be seen but cannot be *handled* and *felt on the body*; technology mediates the interaction, and its affordances preclude the material, tactile experience of dress. However, haptics, together with other technologies, might ultimately provide complementary, or alternative ways of dress embodiment in both physical and digital environments. The objective of this thesis is to investigate these phenomena. Specifically, the study focuses on the role of touch in fashion e-commerce, the effects its absence may engender, and the role haptic, or active touch, technologies may have in integrating the online sensorium. The research objectives are articulated in two main questions, discussed in the Introduction (1.2) and reprised below:

RQ1: *what is the relevance of touch sensation - or lack thereof - in digital fashion communication and specifically, in fashion e-commerce?*

RQ2: *what role might haptic technologies play in enriching fashion brands' online sensorium and e-commerce experience?*

The research adopts a qualitative, pragmatic, and descriptive methodology, with sound theoretical grounding. The enquiry is focused on real-life business issues. However, given the multiple perspectives through which the sense of touch can be discussed, this thesis threads together theories from distinct disciplinary fields, from the social to the natural sciences. Hence, a model of fashion practice is developed upon these foundations which conceptualizes stages of dress embodiment, dis-embodiment, and re-embodiment along a physical to virtual continuum, and speculates on the non-neutral role technologies play within each. The empirical research intersects the model at the level which is currently relevant for digital fashion, that is, dis-embodiment and its effects in the domain of fashion communication and e-commerce, from the perspective of businesses and consumers. Following is a summary of the findings.

3.2. Findings

The first two chapters of this thesis illustrate the objectives of the research and lay the theoretical groundwork; this section also includes a discussion of touch and a review of haptic technologies. The third and fourth chapters address RQ1, focusing on two distinct fashion phenomena: the communication of touch in online product descriptions and the growth of virtual try-on (VTO) applications.

The research presented in Ch. 3 builds a semantic framework for the analysis of textual descriptions in fashion product pages. In answer to RQ1, the enquiry points to the (surprising) poverty of tactile perception communication: *touch is ineffectively conveyed* in the texts of most brands analyzed, as if it were, in fact, *irrelevant*. The study elaborates on possible reasons why this may be (including low encoding of the touch sense in the Western languages) and suggests ways to improve on sensory communication (for example, through metaphor, analogy, and other linguistic devices). What emerges is *an opportunity for conveying touch sensation more engagingly* in online fashion communication.

The research presented in Ch. 4 adopts a case study method to explore the VTO phenomena. In answer to RQ 1, and quite unlike the study above, this enquiry points to the *relevance* of touch in e-commerce, specifically with regards to its embodied, kinesthetic dimension: VTOs provide size and fit simulations on digital bodies, including one's own digital twin, or avatar. These platform-driven practices of dress serve customers' hedonic and functional needs (finding one's size and fit) and business interests (reducing returns) but also have worrisome implications in terms of *privacy and inclusivity*; thus, VTOs offer *advantages*, but also present *risks*, to fashion brands and their clients. Nonetheless, in the context of this thesis, VTOs are significant because they provide *three-dimensional, haptic-related information* to online shoppers and represent a trend towards *dress embodiment surrogates in the digital space*.

The fifth chapter provides an overview of the research in progress which now includes the use of two haptic devices as prompts. The sixth and seventh chapter address RQ2, but also provide answers to RQ1. The research presented in Ch. 6 is based on a focus

group. Findings indicate that *young fashion consumers are interested in a haptically enriched online sensorium*. In answer to RQ2, what emerges is that haptics could play a role in the digital fashion experience, if these technologies rendered online garment touch interaction *perceptually engaging and experientially multidimensional*. Flat, two-dimensional surface haptic devices are disappointing in this respect. In fact, insofar as this group can be considered representative, *young fashion consumers have high expectations towards haptic technologies* and in their potential for improving the digital fashion experience.

The research presented in Ch. 7 includes expert interviews with fashion and luxury business executives in marketing, sales, or digital communication functions. This study provides several answers to RQ2. Experts are intrigued by the possibility of acquiring and *leveraging haptic perceptual data* (data on how a product feels, including, but not limited to, tactile feedback) to better serve consumer preferences, optimize production and online product merchandising, and reduce returns. Furthermore, in their view, *haptic enrichment could provide customer engagement value*, both online and in phygital settings. Thus, early adopters of haptic technologies in the fashion and luxury industry might gain a *competitive advantage*.

This thesis includes several studies focused on touch and haptics in fashion e-commerce. Key findings underscore the central role touch plays in the experience of dress and the importance of communicative strategies in conveying touch sensation online – in text or in digital representations of embodiment. They also point to the strategic role haptics might acquire in the fashion and luxury field in the future, if and when such technologies will reach a level of maturity and market readiness adequate enough to be successfully adopted.

3.3. Thesis contribution

Digitization, COVID-19 and the concurrent growth of fashion e-commerce has spotlighted the need to enrich the digital sensorium, including touch sensation in online product interaction. Hence, it has spurred interest regarding the ways touch can be conveyed

online, in both academia and in the industry. This thesis contributes to the discussion in both fields.

The research enriches academic discourse by addressing the topic of touch in digital fashion communication in novel ways. It approaches touch theoretically through the lenses of diverse disciplines, whilst keeping touch-related business and consumer issues in focus. In so doing, it constructs a conceptual model of technologically mediated dress experience variously situated along the physical to virtual continuum (from physical retail to extended reality) and of the embodiment dynamics these positions entail. It draws haptics into digital fashion communication and fosters awareness regarding the impact the current and future state of these technologies may have on the discipline. By discussing touch in e-commerce, this contribution fills a gap and expands the field in fashion studies, sensory marketing, and digital business literatures.

In addition, the research contributes to the industry by pointing out problems and opportunities related to touch in e-commerce, or lack thereof, for different business players. These are, firstly, fashion firms; and secondly, developers of touch surrogate software and hardware, such as VTO applications and haptic devices. For the latter in particular, the research offers precious insights into the practices and needs of online fashion marketing; this could help develop ad-hoc, industry-appropriate solutions for touch in digital fashion.

3.4. Thesis limitations

This thesis has several limitations, which are discussed at the end of each chapter, and listed below by primary area of concern.

With regards to research design and scope:

- The original research design for the study presented in Ch. 6 included three to four focus groups to be conducted in partner universities in Switzerland, Germany, France and Spain. However, due to COVID-19 the plan had to be scrapped entirely. Thus, the topic of touch in e-commerce is presented solely from the perspective of a segment of the original target (“young, technology-savvy

consumers attentive to innovation" from different cultural backgrounds) envisioned for the study. This limits the generalizability of the findings.

- Participants recruited for the study presented in Ch. 7 were experts with, on average, two decades of experience in the textile and apparel industry; their views on haptic perceptual requirements are valuable, but biased by their own expertise. Also, they represent Western brands, and are themselves of European origin. Since expectations regarding touch sensation may vary considerably from culture to culture and in context (Howes & Classen, 2013), the findings are necessarily limited.

With regards to methodology:

- As mentioned, the study presented in Ch. 6 should have included several focus groups and thus, a sizeable enough number of participants to include in the questionnaire. This activity was cancelled together with the focus groups. Thus, the research lacks the quantitative element originally planned.
- The choice of surface haptic devices used during the focus group and the interviews was dictated by availability, cost, and customization issues. Even though care was taken to present the devices as prompts, the technology's affordances inevitably influenced participants' interaction experience, reflections, and projections, thereby circumscribing the reliability of the findings.

These limitations provide opportunities for possible future improvement and development of the research, as discussed below.

3.5. Future research directions

This thesis provides a valuable contribution to academia and industry which could be leveraged for future research. Several main directions could be explored. Firstly, the conceptual model of dress embodiment could be applied to digital fashion in extended reality, particularly to the "metaverse" and the technologies which make this space accessible – including haptics for VR. This could bring to the fore new and exciting possibilities, but also hidden issues regarding digital fashion communication and the role

of ICTs. Secondly, the question of touch, and lack thereof, in fashion e-commerce could be explored from the experiential perspective of the differently abled, including the sight-impaired fashion customer. To this end, a reflection is provided in Appendix A3. Lastly, future enquiries on the sense of touch in fashion e-commerce could be designed to include the haptic developer community, so as to provide concrete outcomes, in terms not only of theoretical, but also of applied research, for the academic community, the fashion industry, and haptics.

4. Appendixes

Appendix 4.1

Chapter 5 – *Poster presented at EuroHaptics 2022*

Università della Svizzera italiana

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SUPSI

Fashion Touch. Surface Haptics in Fashion E-commerce

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Abstract

The sense of touch is an essential part of the fashion experience. In the digital domain, however, consumers cannot perceive tactile garment qualities as they would in a retail store. The acceleration of online commerce during Covid-19 has spotlighted this issue. Thus, surface haptic technologies which enrich visual and textual digital content with touch feedback might be of interest to the fashion sector. The objective of my PhD research[1,2] is to explore this possibility with consumers and industry executives, using two surface haptic devices as prompts. Findings to date: haptic technologies could enhance the fashion digital experience, provided they integrate easily with consumer devices and with firms' legacy systems.

Background

The lack of sensory inputs in the online domain has long held back luxury and fashion brands from pursuing e-commerce strategies. During the Covid-19 lockdowns, however, firms had to shift customer operations to digital channels and try to (audio-visually) simulate the product interaction experience online. Digital acceleration also spotlighted the unsustainable phenomena of returns, which is mostly driven by issues of size and fit as well as on-body feel. Thus, fashion and luxury brands are actively exploring innovative technologies which might address the physical limitations of digital fashion.

PhD Research Objectives

1. To assess in what way the lack of physical interaction is currently addressed by fashion and luxury brands in the online domain[3]
2. To investigate consumer reactions to the introduction of haptic feedback in a fashion e-commerce context[4]
3. To explore executives' opinion on the role these technologies may play in addressing the sensory limits of the online experience[5]

Research Methodology and Device Customization

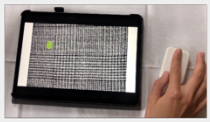
The research is qualitative and pragmatic, involving focus groups and interviews. Two haptic devices were used as prompts: TanvasTouch® and the WeArt Touchkey. The study required simulating a fashion e-commerce website on each device. FashionTouch includes 8 garments with diverse material and surface characteristics, photographed on real models; a homepage which showcases all garments; and a product page for each. The product page features 5 different views of each garment and a detailed image of the corresponding material. The material images were enhanced with haptic feedback.

TanvasTouch

TanvasTouch (https://tanvas.co/) enables precise fingertip tracking and simultaneous surface haptic rendering. It can be programmed to accurately deliver real-time variable-intensity friction and electrostatic haptic feedback within a specific area of the touchscreen. The zoom-in image of each garment material was rendered in black and white, enhanced and uploaded to the software environment of the device, where surface texture characteristics were matched with modulated, ad-hoc haptic feedback effects. When choosing the material images and stroking the display screen, users can experience a simulation of the material's surface effects.

WeArt Touchkey

The WeArt Touchkey (www.weart.it) enables force feedback, texture-based vibrations, and thermal cues. The haptic feedback effects for the WeArt interaction were recorded in the supplier's laboratories directly from the original garments and synched with a graphical video rendition of the stroking gesture. The mock web-site and the interaction simulation for each garment were made accessible on an Apple iPad and paired to the WeArt Touchkey via bluetooth. When users pla-ce a finger on the Touchkey with one hand and choose a garment on the iPad screen with the other, they simultaneously see a pointer moving across the material and feel the corresponding force-feedback effects under their fingertips.



Focus Group and Interviews Findings Summary

The 2D surface limits the gestures habitually adopted to inspect textiles (e.g., grasping, pulling, stretching) with the hand (i.e., more than one finger). There is a disconnect between (high) user expectations regarding material feel and the haptic experience itself.

Young consumers[4] are curious and interested in sensory enrichment via haptic technologies. They don't think showrooming and returns practices will be abandoned even if haptics were introduced. The technology must be inexpensive, portable, easy to use, all-in-one.

Luxury and fashion executives concur that the devices used are not mature for adoption, however they envision[5]:

- Customer experience: haptic feedback could enhance online product promotion, brand engagement, virtual events, runway shows etc.
- Hyper-personalization: customers' haptic preferences could serve as an additional data layer for on-demand production, thereby helping reduce inventory and improve sustainability.
- Phygital experiences: haptic technologies could be used in-store to access inventory or promotions.
- Mixed reality, metaverse: haptic feedback in VR might add interest to fashion events and augmented reality try-ons[6].
- Key issues for technology adoption: legacy system integration firm-side; all-in one, portability, ease of use customer-side.
- Competitive advantage for early adopters.

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EUROHAPTICS 2022

Appendix 4.2

Chapter 7 - *Code Book*

Phase	Topics (Opening Questions)	Codes	Code-related concepts	Emerging Themes (Digital Transformation)				
I - Contextualization	COVID-19 business impact. Digital challenges. Digital strategy and tactics during COVID-19.	Company culture	Shift in mindset, attitudes, and expectations. Cultural resistance to change vs. willingness to learn. Resilience. Leadership.	Company-wide shift towards a more customer-oriented culture.	Cross-functional digital acceleration.	Digital leadership role of the marketing function.	Innovative practices of digital product representation.	Managerial challenges raised by digital innovation.
		Customer experience	Better identifying customer needs. Providing personalized services. Curating ad-hoc journeys. Fine-tuning marketing initiatives. Revising communication approaches, etc.					
		Digitalization	Rendering physical assets into digital assets. Translating analogue content to digital content. Reproducing the retail and show-room experience via available or new technological tools.					
		Digital commerce	Innovation in e-commerce, social and mobile shopping. Customer-facing or back-end rehaul. Introduction of new functionalities (including virtual try-on applications).					
		Employee experience	Initiatives to support employees during lockdown. Factors affecting employee satisfaction and dissatisfaction. Personal experience of interviewee as an employee.					
		Phygitization	Changing role of physical store. Channel integration. Acceleration of in-store digital technology use.					

Phase	Topics (Research Question 1)	Codes	Code-related concepts	Emerging Themes (Digitizing Touch)		
II - Problematization	Touch sensation in product interaction. Business issues related to lack of touch in e-commerce.	Online touch experience	Presence / absence of material touch in digital vs. physical domains. Strategic relevance and tactical implications for online operations.	Digital vs material touch - an unsurmountable gap.	Evocative audio-visuals acceptable in lieu of physical interaction.	Tactical workarounds to address customer expectations.
		Product attributes	Product qualities which can or cannot be reproduced digitally, such as surface texture, but also garment drape, flow, etc.			
		Product expectations	Expert vs. customer material knowledge. Customer need for touch. Expectations regarding products (touch and feel, quality).			
		Size and fit	Issues related to communicating sizing and fitting information online.			
		Returns	Motives prompting returns. Business challenges raised by returns. Sustainability issues.			

Phase	Topics (Research Question 2)	Codes	Code-related concepts	Emerging Themes (Future Potential of Haptic Technologies)				
III - Elicitation	Haptic feedback experience. Haptics potential role in digital fashon. Haptic technology adoption.	Interaction experience	Qualities of the interaction experience with haptic devices. Aspects of manual product exploration included or excluded. User expectation gap. Overall value of the interaction.	Haptic touch requirements.	Haptic data integration within the value chain.	Potential for customer-brand engagement.	Haptic technology evolution beyond screens.	Haptics as competitive advantage.
		Product attributes	Garment characteristics perceived or not through haptic mediation. Comparison between attributes or products. Attribute enrichment.					
		Value to Customer	Role and possible value of haptic interaction and haptic information delivery within the customer journey.					
		Haptic content	Haptic data management issues. Delivering and extracting information from haptic feedback / touch effects. User experience issues.					
		Challenges	Factors affecting the adoption of haptic technology firm side (scalability, technology costs, interoperability etc.) and consumer side.					
		Opportunities	Technological innovation. Potential use-case scenarios and business impact of haptic technologies.					

Appendix 4.3

Lost in delivery. Touch and fashion's inconsistent communication to the visually impaired

Originally published as guest blog post:

Ornati, M. (2021, February 24). Lost in delivery. Touch, and fashion's inconsistent communication to the visually impaired. *InTouch: Digital Touch Communication*. https://in-touch-digital.com/2021/02/24/lost-in-delivery-touch-fashions-inconsistent-communication-to-the-visually-impaired/

About a year into my new PhD program at the Università della Svizzera italiana, Switzerland, I began losing my eyesight. I have been myopic since adolescence, so not seeing well has always been the norm for me. But this was different. The decline was marked, and what was worse, my vision became increasingly fuzzy, in a way stronger correction would not solve. The hours spent in front of a screen lecturing and doing research increased exponentially because of the pandemic. As my eyes started to fail me, I decided to undergo surgery. But while waiting for one eye and then the other to be operated on, I had to adapt.

Coincidentally, my doctoral research focuses on another sense – not vision, but touch. More specifically, I study touch in the context of digital fashion[1], and the role haptics– active touch simulation technologies – might one day play in the online fashion experience (Ornati & Cantoni, 2020). If you have ever bought a fashion garment from an e-commerce website and waited for it to be delivered so you could finally touch it, try it on, and feel it on your body, you might also have wondered, like I do, about the quality of the overall sensory experience of digital retail, and what might be done about it. (There is hope).

[1] http://www.digitalfashion.ch/

But let us return to vision. As I was struggling to keep staring at a screen, I discovered a host of tools that I, as a sighted person – albeit with artificial correction – had not known existed. I realized my iMac's operating system included functionalities such as voice recognition and text reading functions, keyboard enhancements, and so forth. I also became more aware of developments in haptic technologies serving the visually impaired, such as the work of Sile O'Modhrain[2]. And as I was doing my online research on fashion e-commerce websites, I started noticing assistive navigation add-ons that I had previously glossed over – additional services provided by third-party applications[3] such as EqualWeb (https://www.equalweb.com/) or Facil'iti (https://www.facil-iti.com/).

By activating the features provided in the add-on's contextual menu, I could enlarge text and image, have it read to me, or adapt the screen for different visual impairment conditions. As I continued my research, I purposefully began looking for these added services within fashion websites, but gradually I realized they were more the exception than the rule (only two out of thirteen websites featured them). It seemed fashion brands – or at least the ones I was analyzing – were not that interested in investing in online inclusivity. This struck me as odd, given the industry is in the spotlight with regards to sustainability issues, both environmental and social.

Mindful that doctoral research requires focus - tempting as it is to meander onto the fascinating ramifications of one's topic - I would not have given the issue much further thought. But part of my inquiry included - in addition to scrutinizing garment pages - actually placing an order and having the garment delivered to my house. After a few orders had been placed, packages delivered and unboxed, and items unfolded, inspected, tried on and considered, I started realizing something was amiss.

"KEEP AWAY FROM FIRE"!

[2] http://www.somodhrain.com/palpable/default.html
[3] https://www.inclusionhub.com/web-accessibility

Fig. A1. H&M's warning in two languages is clear for the fully sighted only.

All the boxes and bags I received were decorated with bold logos, and many featured inspirational phrases extolling the virtues of recycling. Inside the boxes, I found the clothes folded inside cellophane bags, sealed or zipped, or wrapped in paper. Some packages included return slips and labels. All the garments featured the customary cardboard labels, attached to the items with pins or strings; and inside the clothes I found the usual assortment of cloth labels sewn into the side seams or on the back of the collar. A label attached to a sweater ominously read "KEEP AWAY FROM FIRE" implying I could expose myself to great danger were I to wear it by the fireplace. And that's when it struck me. I could read the label – but what about those who could not?

In the book *The Senses: Design Beyond Vision* (Lupton & Lipps, 2018) published in conjunction with the 2018 exhibit[4] by the same name at Cooper Hewitt, Smithsonian Design Museum, contributing author Karen Kraskow describes the experience of two

[4] https://www.cooperhewitt.org/channel/senses/

visually impaired professional women as they go about shopping for clothes, and the strategies they use to access their purchases, such as eliminating, modifying or otherwise adjusting clothing tags to distinguish different garment colors. One of them asks: "Could we not have a system of differently textured or shaped tags to represent the color range? How about tags to identify clothes that fit me when I'm above my normal weight, and different ones to identify those that fit me when my weight is in the normal range?" (Kraskow, 2018, p. 198). Well… What about tags that would warn her to "KEEP AWAY FROM FIRE"?

The Cooper Hewitt book is fascinating in its treatment of design solutions going beyond the affordances of vision. As it were, the minimum standards for the rights of people with disabilities are set by the UN Convention on the Rights of Persons with Disabilities (UNCRPD)[5] an international, legally binding instrument. In the USA, the Americans with Disabilities Act (ADA) Standards for Accessible Design[6] state that all electronic and information technology must be accessible to people with disabilities. In Europe, the European Accessibility act[7] seeks to guarantee accessibility to products and services, including e-commerce platforms, across member states. Notwithstanding this, in my limited but significant personal experience, many US- and EU-based fashion brands operating online did not seem to respect standards guaranteeing right to website access for the visually impaired, nor, for that matter, access to important (life saving?) information for the product they delivered.

Perhaps fashion brands should follow the example of Selina Peyer, a young Swiss designer. Although her website does not yet have an add-on inclusivity features (let's give her a chance – she just started out!), her knitwear brand, Feel A Fil (https://feelafil.com/), produces "haptic" knits delivered with regular and Braille-annotated garment description and care labels. It should not be that difficult, nor that onerous, to ensure inclusivity in the fashion e-commerce customer experience is not lost in delivery.

[5] https://ec.europa.eu/social/main.jsp?catId=1138&langId=en
[6] https://www.ada.gov/2010ADAstandards_index.htm
[7] https://ec.europa.eu/social/main.jsp?catId=1202

Fig. A2. The Swiss brand *Feel A Fil* produces "haptic" knits delivered with regular *and* Braille-annotated garment description and care labels. *Image credit*: Selina Peyer, Feel A Fil.

Figure A3. The Swiss brand *Feel A Fil* produces "haptic" knits delivered with regular *and* Braille-annotated garment description and care labels. *Image credit*: Selina Peyer, Feel A Fil.

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