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Wearing Technology

When Fashion and Technology Entwine

Lianne Toussaint
Wearing Technology

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Lianne Toussaint
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Wearing Technology

When Fashion and Technology Entwine

Lianne Toussaint

Doctoral Thesis
to obtain the degree of doctor from Radboud University Nijmegen on the authority of the Rector Magnificus prof. dr. J.H.J.M. van Krieken, according to the decision of the Council of Deans to be defended in public on Thursday, September 6, 2018 at 14.30 hours by

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Acknowledgments

Can one wear a Ph.D. thesis? It certainly feels as if I constantly carried the ideas, inspiration, thoughts, deadlines, workload and arguments leading up to this dissertation with me over the past four years. In a way, this Ph.D. became like a permanent appendage to me that went with me wherever I went. But doing a Ph.D. would not have been bearable (and wearable!) if it weren’t for the many people supporting me and lifting my spirits along the way.

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Introduction

You think there’s been hype in the technology world? Wait until the fashion people get involved (Davies 2014).

When we spy our technological faith in the distance, we should not reel back in horror of its inevitability; rather, we should lurch forward in preparation (Kelly 2011: 173).

Like many, one of the first things I do on an average morning is to reach for my smartphone. Still barely awake, I turn off the alarm clock and check the weather forecast, latest news, personal messages, and my agenda for the day. After reluctantly getting out of bed and shuffling towards the wardrobe, I try to pick an outfit that fits best with the daily schedule that my precious technological assistant had just displayed; including all of my activities, social engagements and the context in which I will have to perform them. Nothing new so far, but now let’s return to the beginning of this scene and imagine an alternative scenario. What would this scene look like if fashion and technology – the two ‘things’ that already so constantly and closely surround us – would become one?

Slowly waking to the subtly increasing light in the neckline of my nightgown, I press the side of my right sleeve to activate the ‘snooze mode’ of the music player, which is connected to the tiny speakers in my shoulders pads. As I step out of bed and put on my slippers, my nightwear senses the sudden temperature drop and gradually starts to warm the surface of my skin. After pressing an indicator twice, my left sleeve transforms into a screen and displays two new messages from my mum. I carry on with my morning routine. While I brush my teeth, speakers play the latest news in accordance with my personal news feed settings. Standing in front of the wardrobe my left sleeve shows today’s agenda; commute in a poorly heated train, a number of formal meetings at work, a few immobile writing hours behind a computer screen, and finally an informal dinner with friends. Best to wear my posture-correcting thermostat jacket today and combine it with the trousers that I can switch to ‘jeans look’ and ‘bicycle lighting mode’ tonight.
The wearable gadgets in this fictional wake-up scene may still sound far-fetched and futuristic. Until a few years ago such technologically enhanced clothing indeed merely existed in the imagined worlds of science fiction, fantasy, and superheroes. Think of Harry Potter’s invisibility cloak, Marty McFly’s auto-adjusting and auto-drying jacket in sci-fi classic *Back to the Future II* (1989), Batman’s flying cape, or the light suits in action movie *Tron* (1982). The recent rise of a brand-new generation of ‘techno-fashion’, however, proves that the idea of weaving technology and clothing together has slowly but steadily left the realm of fiction.

**Techno-Fashion on the Rise**

*Wearing Technology: When Fashion and Technology Entwine* focuses on the emerging phenomenon of ‘techno-fashion’. The entwinement of fashion and technology no longer exclusively belongs to a fantasy world rather it has become the focus of a new wave of innovators eager to change the course of fashion. Flexible solar cells that turn a coat into a sustainable battery charger, a jacket that warns against air pollution, a shirt that sends hugs over distance, or trousers that help to correct your posture: they now all exist in real life. A growing number of designers, companies, and technology developers are experimenting with the integration of sensors, solar cells, responsive materials, and numerous other technologies into fabrics and clothing. Flourishing in the slipstream of the up-and-coming market for ‘wearable technology’ and ‘wearables’, their designs are rapidly gaining ground at fashion weeks (e.g. Zac Posen’s LED dress, CuteCircuit’s F/W 2014 collection [Figure 1] and Richard Nicoll’s S/S 2015 ‘Tinkerbell Dress’ at the NYFW; the 2017 TECH Fashion Week in San Francisco; and the ‘Ghost in
the Shell’ show at Paris Fashion Week 2017) and at conferences and festivals (e.g. South by Southwest 2015 and 2017 in Austin; the FashionTech and Wear It festival in Berlin; the Wearable Festival in Paris; Fashioning Technology in Perth; and the Fashiontech Festival in Montréal). Over the past few years, techno-fashion also gradually found its way into museum exhibitions (e.g. The Future of Fashion is Now in Rotterdam, Pretty Smart Textiles in Belgium and Denmark, #techstyle at the Museum of Fine Arts Boston, and Fashioning Technology in Perth), was embraced by major technology and sportswear companies (e.g. the Nokia ‘Smartphone Skirt’, Microsoft’s ‘Printing Dress’ [Figure 2] and ‘Lightwear’, and UnderArmour’s ‘E93 Biometric Compression Shirt’ [Figure 3]), and even attracted the attention of several mainstream fashion chains (see, for example, Topshop’s Top Pitch competition, Ralph Lauren’s ‘PoloTech Shirt’ [Figure 4], the H&M x Google ‘Coded Couture’ project and ‘Project Jacquard’ by Levi’s and Google).

Although health and fitness ‘wearables’ such as the Apple Smart Watch or the recently introduced Samsung Gear Fit are still more common and well-known than the fashion-oriented developments within the wearable technology field, there are plenty of signs that the industries for sports and fitness apparel, work or safety wear, and fashion design are also warming to the specific potential of integrating fashion and technology (Quinn 2002; Smelik 2017). Testifying to the growing visibility of designs that combine fashion and technology as well as to the latest market reports and forecasts, there is no doubt about it: techno-fashion is here to stay (see, for example, Beecham Research 2013; Hayward 2017; Hunn 2015: 33; Svetlik 2014; Visiongain 2014).

The long-term implications of colliding technology and fashion are expected to go as far as “change how we use clothing, what we expect of our garments and how we relate to fashion” (Brunstein 2011: 89). Yet, there is little academic research focusing on this specific fashion-focused subfield of wearable technology. Previous studies of techno-fashion predominantly addressed the technicalities of its design and practical applications (e.g. Berglin 2013; Cho ed. 2010; Dunne 2004; Guler et al. 2016; Kettley 2016; Mattila ed. 2006; McCann and Bryson 2009; Pailes-Friedman 2016; Watkins and Dunne 2015), or provided an overview of the different developments and actors at play in the field (e.g. Amitai and Seymour 2014; Braddock Clarke and O’Mahony eds 2008; Lee 2005; O’Mahony 2011; Quinn 2002, 2010, 2012, 2013a; Seymour 2009, 2010). Scholarly attention to the broader social and cultural implications of integrating fashion and technology, however, has so far been relatively sparse (e.g., Dunne 2004; Dunne et al. 2014; Lamontagne 2017; Ryan 2014).
Techno-fashion is an interdisciplinary and heterogeneous field in flux. New technological developments, materials, and designs appear in rapid succession, making it challenging to demarcate the boundaries of this elusive thing. Understandably, the dominant way to study techno-fashion has been through design practice. Such practice-based and design-driven research is important and relevant because plenty of work still has to be done before the integration of fashion and technology will become truly seamless, wearable, acceptable, and (commercially) successful (Dunne 2010a). To get a better grip on the broader implications of this development, however, it is important to also delve into the theoretical and critical reflection that techno-fashion invites. As Anne Cranny-Francis notes, “smart textiles and smart clothing developments are very exciting, if not without some concerns” (2013: 170). Like all new technologies, she writes, “wearables offer not only great possibilities but also require critical assessment by those whose lives they affect” (ibid.).

Scholars and market forecasts seem to agree that this relatively new cultural phenomenon is likely to affect us on a personal as well as societal level. Yet little has been written on how and why techno-fashion could affect our perceptions, interactions, and physical experiences. How can techno-fashion transform our behavior and experience, given that we do not just carry it with us but on us as well (Brunstein 2011: 98, original emphasis)? In what ways does the incorporation of new technologies and materials change the matter and meaning of fashion? How may techno-fashion influence the ways we relate to and communicate through fashion and technology? To what extent can it help us to enhance and empower ourselves or, conversely, allow others to monitor and control us? These are the main issues that Wearing Technology explores and reflects on.

Before I outline the set-up of this dissertation, I will first discuss the position of this study within the overarching research project it originates from Crafting Wearables (2013-2018). Second, I will address the central research questions and problems, and introduce the key themes and notions in my research. The third section outlines my theoretical and methodological approach, serving as a prelude to Chapter one. The final section of the introduction provides an overview of the chapters and structure of this dissertation.
three areas: they are not tested through the entire production chain; the aesthetics of the design are not integrated into the technology; or they remain a gadget without taking into account the wearer’s body, identity or performance. The underlying idea of this hypothesis is that wearable technology offers exciting opportunities and an endless array of potential applications and functionalities but has so far failed to live up to the expectations. As Lucy Dunne writes, wearables and smart clothes are “attractive and interesting, but futuristic and remote—something out of science fiction, not everyday life” (Dunne 2010a: 42). The initial aim of Crafting Wearables², therefore, was to overcome the main challenges in designing wearable technology by (1) exploring how to craft wearables that are robust and fashionable, as well as commercially viable, and (2) researching how wearables change the relation between fashion, body, performance, and identity.

The first aim (i.e., explore how to craft wearables that are robust, fashionable, and commercially viable) served as the starting point for the Ph.D. trajectory of fashion designer Pauline van Dongen, who focuses on developing a ‘material aesthetic’ design methodology that advances wearable technology towards more fashionable and everyday applications (Van Dongen forthcoming). Through her material aesthetics analyses, she seeks to reveal the need to move our understanding of technology in fashion past functionality and instrumentality. The second aim of Crafting Wearables (i.e., research how wearables change the relation between fashion, body, performance, and identity) prompted the more theoretical meta-perspective of my Ph.D. research. Whereas Van Dongen’s research aims to identify and overcome some of the design challenges that techno-fashion still faces, I treat the existence and future success of techno-fashion as a given and attempt to think through the broader social and cultural implications beyond its infant stage. The two Ph.D. projects thus complement each other by facilitating a dialogue between practice and theory, design and reflection.

Both this dissertation and Van Dongen’s Ph.D. research are characterized by a theoretical and methodological focus on the role of the body, materiality, and the relations

² Crafting Wearables (2013-2018) is funded by the ‘Creative Industries’ programme of the Netherlands Organisation for Scientific Research (NWO). The project entails collaboration between prof. Anneke Smelik from Radboud University Nijmegen (project leader); prof. Ron Wakkary, dr. Stephan Wensveen and prof. Oscar Tomico Plasencia of the ‘Wearable Senses’ group at Eindhoven University of Technology; and professor José Teunissen (now affiliated to London College of Fashion) and Lucie Huiskens of ArTEZ Institute of the Arts in Arnhem. It involves two Ph.D. positions (held by Lianne Toussaint and Pauline van Dongen) and five short embedded research positions (held by Ralph Zoontjens and Paola Tagnozzi, Maartje Couwenberg, Marina Toeters, and Sif Drua Albrechtsen). The research project was supported with the in-kind contribution of several private and public partners, including Philips Research, Textile Museum|Textile Lab Tilburg, MODINT, 3D Systems, Solar Fiber, Inntex, and Xsens.
between humans and technology that techno-fashion fosters. By focusing on these specific aspects of techno-fashion within our research, we both build upon and bridge the work of the Industrial Design and Fashion Studies scholars involved in the Crafting Wearables project (Brand & Teunissen eds. 2006, 2009; Kuusk, Wensveen, & Tomico 2016; Mackey et al. 2017; Ross & Wensveen 2010; Smelik 2016, 2017; Teunissen & Brand eds. 2014; Tomico et al. 2013; Tomico & Wilde 2015, 2016; Wakkary et al. 2016; Wensveen 2010; Zhang & Wakkary 2014).

If mobile and portable technology such as smartphones and tablets already radically transformed our ways of navigating, perceiving, communicating, eating, learning, and living over the past few decades (see, for example, Goggin and Hjorth eds. 2014), then the consequences of integrating technology into the things we wear are likely to be equally far-reaching. Despite a growing interest in techno-fashion as “the next generation of wearables” (Beloff and Seymour 2008), little research has covered the fact that it “also introduces new social concerns, as it can radically alter the ways in which an individual is perceived by and interacts with others and manages his/her own physical space” (Dunne 2004: i). As Lucy Dunne notes, “[t]he dominant design culture in current wearable technology research, that of electrical engineering and computer science, is unused to addressing variables related to the human body, mind, and social interaction” (ibid.).

By bridging the fields of cultural studies, fashion studies, and the philosophy of technology, this dissertation aims to complement and advance scholarly studies of techno-fashion. I combine cultural-critical, philosophical, and sociological theories with empirical investigation, in order to take a step back from the whirlwind of ongoing technological developments and to theorize some of the broader socio-cultural implications of techno-fashion.

Understanding Techno-Fashion: Research Question and Aims
Since the turn of the twenty-first century, numerous scholars have identified techno-fashion as a phenomenon of significant cultural and societal impact. In Fashionable Technology, Sabine Seymour emphasizes the expressive and creative possibilities of what she calls ‘fashionable technology’: “fashionable wearables have great expressive potential that is amplified through the use of technology” she writes (Seymour 2009: 12). Bradley Quinn argues that techno-fashion is “real enough to revolutionize the meaning and function of fashion” and will “have profound implications for
our experience of body and mind, our communication abilities, healthcare and lifestyle” (2002: 1). Some even believe that techno-fashion will transform the world of fashion to such an extent that it can be called a ‘disruptive’ innovation (DisruptFashion 2012-2016; Guler et al. 2016; Petruziello 2016): an innovation that has the potential to disrupt the established fashion industry, ultimately displacing it for an entirely new market and value network (Christensen 2012).

Multiple scholars thus anticipate that techno-fashion will have profound social and cultural effects, but often without providing the critical and theoretical tools to think them through systematically. Firstly, as Ryan points out, the problem is that the existing literature is mostly “untouched by historical and cultural examination” and characterized by a “consistently affirmative and advocative tone” (Ryan 2014: 5-6). The latter is understandable, considering that the majority of authors are personally involved in designing, developing, or promoting techno-fashion. Secondly, there is little research that explores the impact of techno-fashion on everyday life, which is partly due to the fact that it is still “not something that many of us have actually experienced” (Ryan 2014: 3). As a result, our understanding of the possibilities and effects of techno-fashion on a socio-cultural level is still limited. Knowing little about what kind of experiences, material relations, forms of communication, and power relations techno-fashion brings about, we are currently ill-prepared for its definite breakthrough. We thus still grope in the dark when it comes to identifying desirable or undesirable directions for the future use and implementation of techno-fashion.

Visiting events and design studios, speaking to experts, and directly observing examples from the field during the early explorative phases of my Ph.D., I experienced that the mere material presence of techno-fashion on a body or even a static mannequin does something to people and their behavior. It was striking to see how wearers and spectators approached or interacted with techno-fashion designs, often responding with a mix of fascination, awe, and reservation. It appeared that these design objects strongly affect how people communicate, behave and relate to themselves and to others. As I acknowledge the importance of a better and deeper understanding of these effects, my research aims to investigate how techno-fashion transforms relations between the human body, technology, and fashion. The scope, aims and central question are based on the hypothesis that techno-fashion mediates people’s relations to themselves and to the world in a material way (Verbeek 2005a: 209). This informs the following central research question:
How can we understand the ways in which techno-fashion materially mediates the relations between the human body, technology, and fashion?

The focus on how techno-fashion affects connections between body, technology, and fashion emerged from my empirical explorations of the field. It is also grounded in the existing literature that offers four different thematic perspectives from which the effects of integrating fashion and technology can be investigated.

Firstly, my thematic approach and research methodology are inspired by the possibility of techno-fashion to enhance human sensory capacities and transform the wearer’s embodied experience. As Anne Cranny-Francis stresses, it is important to explore techno-fashion’s effect “on how we experience the world and ourselves” (2013: 195-196). Similarly, Anneke Smelik argues that wearing technological objects and materials directly on our bodies will “have an impact on how we experience our bodies and ourselves” (2017: 259). These insights inspired me to use phenomenological and postphenomenological approaches as the backbone of my research methodology, as they are tailored to analyzing our embodied experience of material artifacts. As I will elaborately address in chapter one on ‘Thinking through Techno-Fashion,’ phenomenology and postphenomenology offer both the theoretical and methodological tools to inquire into what it is like to wear techno-fashion. I use the typically phenomenological research method of in-depth interviews, for example, to explore how techno-fashion affects wearer’s embodied experiences and actions (Bloor and Wood 2006 eds.: 128-130).

Secondly, several scholars have raised the thought-provoking idea that techno-fashion equips garments with the material capacity to “act” (Cranny-Francis 2013: 162, see also Küchler 2005; O’Connor 2005). “What makes smart fabrics revolutionary,” Rebeccah Pailes-Friedman writes, “is that they have the ability to do many things that traditional fabrics cannot, including communicate, transform, conduct energy, and grow” (2016: 14). The self-acting, self-transforming and responsive capacities of techno-fashion confront us with a non-human form material agency that has yet to be explored (Smelik 2018). The ‘agentive’ matter of techno-fashion, I will argue in chapter three, not only requires new conceptual and theoretical tools for understanding such ‘material agency’ but also necessitates the further development and updating of object-based research methods.

The third thematic pillar within this research is rooted in the scholarly literature that connects techno-fashion to issues of communication and self-expression, thereby
acknowledging the broader socio-cultural context in which it is, and might be, worn. Susan Elizabeth Ryan states that “to wear technological enhancements or devices is to advance the language of dress in specific ways that converge with the cultural dimensions of technology, and, as a result, to become ‘culturally seen’ within a technologically literate environment” (Ryan 2014: 1). Indeed, Smelik predicts, if our clothes of the future will measure our bodily signals, sense movement, and position, or have new expressive qualities, “they will change the relation of the wearers to themselves as well as transform the communication to and with others” (Smelik 2017: 268). Wearing technology, as Valérie Lamontagne notes, implies a "reinventing [of] our relationships to our bodies, our experiences of spaces, social interactions, and self-representation" (2017: 1). These insights informed my particular theoretical focus on social interaction, subjectivity, and communication in chapter four. Moreover, they inspired me to address topics such as social relationships and personal expression within my interviews with makers and wearers. The different meanings and interpretations that garments evoke in different wearers and environments, I will show, reveal that experiences of techno-fashion are always socially and culturally situated.

The fourth and final source of inspiration for my approach is the awareness that the bio-monitoring and tracking practices involved in techno-fashion have a sympathetic as well as a sinister side (Quinn 2002: 57; Lupton 2013). Jane McCann and David Bryson, amongst others, identify the risk that monitoring becomes subsumed by surveillance, and relate this to “the issue of consent and freedom of the individual where the use of technology may limit or curtail the freedom of the wearer” (2009: 337). These more political and ethical considerations are central to chapter five on ‘wearable surveillance,’ in which I connect the experiential, material, and social levels on which techno-fashion operates to the broader socio-political issues of power, safety, and control.

Clustering the aforementioned themes, it follows that techno-fashion can be expected to have an impact on four different levels of experience: it operates on a physical, material, interpersonal, and socio-political level. Techno-fashion shapes new experiences of body and self, transforms and ‘activates’ the material capacities of fashion, changes our ways of communicating to and with others, and may even have an impact on our sense of freedom and autonomy. Combined with my empirical findings on how techno-fashion affects people and their behavior, four interconnected themes become apparent: embodied experience, new materiality, communication and self-expression, and surveillance and biomonitoring. Each of these themes informs one of the sub-aims of this dissertation: (1) to understand the ways in which techno-fashion
shapes and reshapes embodied experiences and fosters intimate relations between
body and technology; (2) to explore how techno-fashion transforms and activates
the matter of fashion; (3) to gain insight into how techno-fashion affects processes
of embodied communication, social interaction and self-presentation through fash-

Within this dissertation, I strive to achieve the four sub-aims by analyzing four respec-
tive case studies from the field of techno-fashion: (1) the robotic ‘Spider Dress 1.0’ and
‘Spider Dress 2.0’ by Anouk Wipprecht [Figure 5, 6]; (2) Sensoree’s responsive ‘AWE
Goosebumps’ dress [Figure 7, 8]; (3) the illuminated running wear project ‘Phototrope’
by Pauline van Dongen [Figure 9]; and (4) Byborre’s biomonitoring ‘BB. Suit 0.3’ [Figure
10]. These four case studies serve as the empirical tools with which I will assess as
well as propose various theoretical and conceptual approaches to techno-fashion.
In addition, the selected designers and designs function as primary research sourc-
es from which to deduct insights that contribute to the development of a theoretical
framework for understanding how techno-fashion materially mediates the relations
between the human body, technology, and fashion. As my analysis of the case studies
will show, a dialogue between the two currently separated theoretical fields of post-
phenomenology and new materialisms, helps to elucidate the impact of techno-fash-
ion in terms of the embodied experiences, new materials, expressive modes, and sur-
veillance practices it yields. This is reflected in the two theoretical arguments central
to the dissertation, which I will now briefly introduce.

Wearing Technology: The Central Arguments
Two theoretical pillars form the backbone of this dissertation: postphenomenology and
new materialisms. The choice for these two theoretical perspectives is informed by
the four case studies and the four corresponding aims of my research. In one way or
another, all case studies affect the relation between the wearer’s body and the world
around her: the robotic limbs of the ‘Spider Dress 1.0’ and ‘Spider Dress 2.0’ demarcate and extend the boundaries of the human body, alerting both the wearer and her surroundings of the issue of personal space; the inflatable silicones in Sensoree’s ‘AWE Goosebumps’ externalize and amplify the wearer’s physical sensation of goosebumps; the LED strings in Pauline van Dongen’s illuminated running shirts affect the visibility of their wearers, both literally and metaphorically; and the biosensors in Byborre’s ‘BB. Suit 0.3’ drastically change the way in which the wearer presents himself to the outside world. Techno-fashion, in other words, materially mediates the embodied actions, perceptions and experiences of its wearer. Throughout my dissertation, I therefore use, fuse, and further develop two arguments for understanding techno-fashion in terms of (1) embodiment and (2) new materiality. These two arguments jointly represent my theoretical and methodological approach to techno-fashion.

**Embodiment: Addressing the Body in Technology**

The first argument concerns the extension of postphenomenological theory into the realm of wearable, rather than just instrumental, technological artifacts. Postphenomenology is grounded in phenomenology and draws particular attention to the topic of technological embodiment (Ihde 1990, 2002, 2009, 2010; Friis and Berg eds. 2016; Rosenberger and Verbeek eds. 2015). Technological objects are inextricably connected to and co-constitute human existence, as we experience the world through or by means of these objects. This dissertation adopts a postphenomenological perspective to show how techno-fashion shapes and reshapes embodied experiences and fosters intimate relations between body and technology. I argue that techno-fashion is not just a bodily phenomenon that involves bodily sensations, but also an embodied phenomenon that influences our subjectivity and ways of being in the world. This implies that studying techno-fashion should involve attention to its embodied dimensions on both a theoretical and methodological level. In addition to a literature study focused on the embodiment of technology and/or fashion, I, therefore, conduct semi-structured in-depth interviews with wearers and designers to provide insight into how people actually experience and physically relate to techno-fashion.
Using Anouk Wipprecht’s ‘Spider Dresses’ as a case study, chapter two discusses why techno-fashion has to be considered as an embodied practice of dressing (Entwistle 2015) and illuminates why the postphenomenological concept of technological embodiment is vital for understanding the difference between using and wearing technology. Combining theoretical reflections on technological embodiment with insights gained from interviews with Wipprecht (Interview AW 2016) and one of her models (Interview WH 2017), I contend that techno-fashion must be defined and understood for its intimate and particular connection to the body. This argument for a theoretical and methodological focus on embodiment is further developed in the fourth chapter, where I analyze Pauline van Dongen’s illuminated running shirt (named ‘Phototrope’) as an illustrative example of how techno-fashion allows wearers to communicate directly through, about, and on their body. Techno-fashion revitalizes and extends the communicative and performative roles of fashion, I argue, adding another layer to the already complex communicative and interpretative social dynamics of dress. Precisely because techno-fashion is worn on and by the body, I maintain, it has the potential to radically alter as well as complicate the ways we ‘speak’ through and identify with what we wear.

New Materiality: Giving Materiality its Due

The second central argument starts from the insight that techno-fashion involves a distinctly new generation of smart, interactive, self-organizing and responsive materials. Taking the case of Sensoree’s ‘AWE Goosebumps’ as an example, chapter three demonstrates how the new materials of techno-fashion seemingly equip garments with the material capacity (or ‘agency’) to self-transform their shape and appearance. This both invites and requires a rethinking of the materiality and matter of fashion. We do not just relate to techno-fashion in terms of its technological functionality and use. The ‘animate’ character of its materials allows techno-fashion to become our companion rather than a servant. Again, this argument is both theoretical and methodological in scope. Pointing out that the ‘new’ and ‘agentive’ materiality of techno-fashion necessitates an extension of the theories and methods of materiality scholarship, I extend the object-based approach from material culture research into the realm of so-called new materialisms. The new materials of techno-fashion, I argue, ‘unmute’ the matter of fashion in the sense that they are non-human agents that actively respond to and interfere with wearers and their environment (Barad 2007; Barrett and Bolt 2012; Dolphijn and Van der Tuin 2012).

The fifth chapter, then, uses the combined framework of new materialisms and post-phenomenology to discuss how different material entities (e.g., fashion, body, and technology) entwine in the cultural practice of wearing technology and jointly become the
medium for socio-political control. Analyzing the biomonitoring ‘BB Suit 0.3’ developed by Byborre, I show how techno-fashion literally brings surveillance closer than ever before. On the one hand, techno-fashion’s agentive materiality and close proximity to the body allow for it to have particularly positive and/or negative effects on how we think of, care for, and control ourselves and our environment. On the other hand, techno-fashion can also have deeply positive and/or negative consequences for the ways in which others may think of, care for, and control us.

**Outline and Structure**

Combining theoretical reflection with empirical findings, *Wearing Technology* aims to value and recognize techno-fashion as an object of academic research. Elaborating on four themes (i.e., embodied experience, new materials, communication and self-expression, and surveillance and biomonitoring), I hope to contribute to an interdisciplinary framework for studying, analyzing, and understanding the phenomenon of techno-fashion. The structure of this dissertation mirrors the four different yet related thematic dimensions central to my research, moving from the micro levels of embodied experience and human-object relationships to the macro levels of social interaction and socio-political discourses.

Chapter one, ‘Thinking through Techno-Fashion: Theories and Methods,’ elaborates on the particular theoretical and methodological approach that I employ to explore the material mediations of techno-fashion. I start by providing my definition of techno-fashion, explaining its position within the broader and heterogeneous field of wearable technology. Based on this terminological discussion, I then present the notions of embodiment and material agency as the theoretical lens through which I think techno-fashion. After an introduction of the theoretical framework follows a discussion of the research methodology, which is characterized by a combination of literature study with four intersecting types of qualitative analysis (i.e., semi-structured in-depth interviews, fitting sessions, object-based analyses, and discourse analyses of visual and textual representations). The chapter concludes with a series of meta-reflections on the importance of facilitating a dialogue between practice and theory when studying techno-fashion.

In chapter two, ‘From User to Wearer: On Technological Embodiment,’ I further develop and deepen the postphenomenological approach introduced in the first chapter, using Anouk Wipprecht’s ‘Spider Dress 1.0’ and ‘Spider Dress 2.0’ as my case study. Taking the fact that techno-fashion is worn rather than just used as a starting point, I address
how techno-fashion transforms and mediates embodied experiences. Building upon the work of Merleau-Ponty and the value of his insights for fashion studies, the chapter elaborates on the embodied practice and experience of dressing. I then redirect these reflections towards the work of Don Ihde, exploring the relevance and limitations of the postphenomenological notions of technological mediation and ‘embodiment relations’ for the study of techno-fashion.

Chapter three, entitled ‘Flashy and Fleshy: The New Materials of Techno-Fashion’ focuses on the materials, material capacities, and materiality of techno-fashion. I argue that techno-fashion demands an object-based approach that moves beyond the notion of material artifacts as static and mute entities. Using the ‘AWE Goosebumps’ dress designed by Sensoree as a case study, I unravel how techno-fashion transforms and activates the matter of fashion. The chapter starts with a discussion of how, and to what extent, material culture studies or relational approaches to materiality may help to map the material aspects of techno-fashion. Based on the data collected through object-based analysis and interviews I will then argue for developing a theoretical and methodological framework that combines postphenomenological and new materialist ways of thinking materiality. Analyzing ‘AWE Goosebumps’ in light of ongoing debates on the material agency of objects, I will show that techno-fashion challenges the a priori distinction between human and nonhuman matter, blurring the boundaries between the flesh and skin of the human body and the ‘animate’ matter of techno-fashion.

In the fourth chapter, ‘Talking Techno-Fashion: Why Meaning Matters,’ I build upon the combination of postphenomenological and new materialist theory unfolded in the previous two chapters and connected them to the communicative and performative roles of techno-fashion. The chapter uses the illuminated ‘Phototrope’ running shirt by Pauline van Dongen to explore the ways in which techno-fashion materially mediates the meaning of fashion. I first investigate the extent to which traditional communication models can explain how people communicate through, interpret and give meaning to techno-fashion in an everyday context. In addition, the chapter discusses the question if techno-fashion can ‘say’ something about the wearer that regular fashion cannot express and shows that meaning and matter are always inevitably entangled in the act of wearing technology. Finally, the chapter introduces the notion of performativity to address how the material and embodied character of techno-fashion co-constitutes and expresses the wearer’s subjectivity in relation to others.
The fifth chapter, ‘Creepy or Comforting? Wearable Surveillance and the Quantified Wearer’, addresses the broader socio-political and biopolitical aspects of power relations involved in wearing technology. This chapter offers a more critical perspective, connecting techno-fashion’s embodied, material, and performative dimensions to the topics of ‘wearable surveillance,’ privacy, and social control. The ‘BB. Suit 0.3’ designed by Byborre will act as the case study with which to assess what particularly promising or problematic possibilities techno-fashion offers for tracking, quantifying, sharing, and commodifying all kinds of information about ourselves or our environment. What makes the project ‘BB. Suit 0.3’ a unique case study is that it combines the real-time tracking of the wearer’s biosignals with the large-scale monitoring of an audience. This will enable me to analyze how the tracking and exchange of data through techno-fashion affects the power relations between people, fashion, and technology. Moreover, the chapter reflects on the desirable and well as undesirable directions for the implementation of techno-fashion in our everyday lives, connecting practices of wearable surveillance to current debates on the Quantified Self, self-tracking, and human control over technology.

In the ‘Conclusion,’ finally, I will reflect upon the key findings of this research in light of its four sub-aims. Synthesizing the insights from each chapter, I will draw conclusions as to how techno-fashion transforms fashion from the micro levels of embodied experience and materiality to the macro levels of interpersonal communication and social control. Through connecting the main arguments and insights from this dissertation, I look to address how techno-fashion mediates embodied experiences, transforms the matter of fashion, impacts social interaction and communication, and instigates new ways of controlling and monitoring the body. Weaving these research findings together, I conclude with an answer to the central question; How does techno-fashion materially mediate the relations between the human body, technology, and fashion?
1. Thinking Through Techno-Fashion: Theories and Methods

To theorize fashion means to develop propositions and arguments that advance the understanding of its logic and manifestations (Rocamora and Smelik 2016: 3).

In order to develop a full understanding of processes of mediation, we should not only study ‘what things do’ (...) but also how humans give meaning to these mediations – both empirically and conceptually (Verbeek 2015: 190).

To understand what is at stake in thinking through techno-fashion, it helps to start with a concrete example. In order to counteract the lack of physical contact in a digital and globalized world, London-based wearable technology company CuteCircuit developed the ‘Hug Shirt’ [Figure 11]: a shirt that allows wearers to send hugs over distance through a combination of sensors, actuators, and a Bluetooth enabled smartphone app (CuteCircuit 2002). The shirt registers the strength, duration, and location of touch from one wearer, as well as his or her skin temperature and heart rate. Actuators located in the shirt of the ‘receiver’ then translate these data into a sensation that recreates the physical touch, warmth, and emotion of the hug from the sender. The communicative and expressive impact of this shirt is determined by the congruence between the material sensations of the wearers’ bodies (e.g., temperature and touch), and the material properties of the shirt (e.g., the shirt’s technological “squeeze” and warmth, and the type of fabric used).

CuteCircuit’s ‘Hug Shirt’ mediates the physical and material sensation of a hug and wirelessly communicates it to another wearer by translating that sensation into a technological hug. The garment allows the wearer to physically interact with and relate to the second wearer beyond and outside the material boundaries of his or her body. Whether

the receiving wearer actually experiences comfort in the ‘technological hug’ depends on how well it manages to register, communicate, and recreate the original hug. If the shirt can have the desirable effect of reinforcing the relationship of two geographically separated wearers also depends on permission from the receivers, who can control if they want to engage in the hug or not (Cranny-Francis 2013: 157). If the origin, timing, setting, or nature of the garment’s behavior is not mitigated by consent and therefore uncontrollable, the receiving wearer would probably experience and interpret the technological hug as invasive, unwanted, or even threatening.

The example of the ‘Hug Shirt’ represents some of the most important issues at stake in the development of techno-fashion. It indicates that techno-fashion will influence the embodied experience, meaning, and function of fashion in a radically material way. It shows how technology-infused garments may instigate new forms of embodied interaction, personal expression, and communication. Yet it also signals that techno-fashion, precisely because of its physical proximity to the body, can have both desirable and undesirable implications for our physical privacy, social interactions, and autonomy. As described in the introduction, the four aims of this research each focus on one of these key themes:

1. to understand the ways in which techno-fashion shapes and reshapes embodied experiences and fosters intimate relations between body and technology;
2. to explore how techno-fashion transforms and activates the matter of fashion;
3. to gain insight into how techno-fashion affects processes of embodied communication, social interaction and self-presentation through fashion; and
4. to investigate how techno-fashion instigates new ways of controlling and monitoring the body.

This chapter discusses my theoretical and methodological approach to these themes. First, I will develop a definition of techno-fashion and elaborate on other terminologies circulating within this field of study. This discussion of definitions and terms helps to
set the stage for this dissertation and further explains my focus on techno-fashion as a form of technological and material mediation (Verbeek 2016). Next, I will further introduce the subject of techno-fashion by briefly sketching its background and historical development in relation to the broader field of wearable technology. Subsequently, I will present the theoretical framework by introducing the academic literature and concepts that form the basis of my research. The themes of embodiment and material agency will be presented as the two major threads running throughout my study of techno-fashion. Finally, I will elaborate on the research methodology, which combines literature study with four intersecting types of qualitative analysis: semi-structured in-depth interviews, fitting sessions, object-based analyses, and discourse analyses of visual and textual representations. The chapter ends with reflections on the intersection between the practice and theory of studying techno-fashion.

Navigating a Terminological Minefield: Definitions and Case Studies

Within this dissertation, I use the term techno-fashion to refer to a subfield within the broader field of wearable technology. Although wearable technology is the most common and well-known umbrella term to describe the integration of clothing and technology, it is also an ambiguous, debatable and elusive concept. Moreover, wearable technology has become “contested ground, claimed by diverse groups from industry to art” (Ryan 2014: 6; cf. Thompson 2007). Over the years, many different and often partially overlapping terms were invented to describe the field: from techno-fashion (Quinn 2002), cybercouture (Quinn 2002; Smelik 2012, 2017), fashionable technology (Seymour 2009), and computational fashion (Amitai and Seymour eds. 2014) to smart clothing or smart textiles (Cho ed. 2010; Kettley 2016; Mattila 2006; Schneegass and Amft eds. 2017), e-textiles (De Rossi 2007), soft wearables (Tomico and Wilde 2015), and advanced textiles (O’Mahony 2011). Amid this heterogeneous maze of terms, technologies, disciplines, and discourses it is challenging to come up with a solid definition of the phenomenon. In the words of Wired columnist Russell M. Davies (2014): “[a]ctually, just what is the domain of ‘wearable technology’? What are we talking about here?”

This wide array of concepts used to describe the combination or integration of fashion and technology reflects serious confusion about the very nature of the phenomenon (Ryan 2014: 6). As Suzanne Lee notes, “‘smart clothing,’ ‘wearables,’ and ‘wearable computing’ are somewhat equivocal terms describing a genre of clothing that functions on a whole new level – electronic” (Lee 2005: 43). In light of the field’s ever-increasing heterogeneity, such conceptual confusion is understandable. The domain of wearable
technology nowadays includes countless body-worn technologies, ranging from smart watches and activity trackers to medical devices and responsive clothing.

In order to demarcate the scope of my research and clarify the terminology related to this phenomenon, I will first explain my use and definition of the concept of techno-fashion. Secondly, some of the terminological confusion surrounding wearable technology will be solved through a discussion and explanation of the most commonly applied terms within the field.

**Techno-Fashion**

The term wearable technology is a broad and all-encompassing label that does not express the social, cultural and aesthetic dimensions of a specific, more fashion-oriented subgroup of wearables. It includes examples varying from haute couture outfits, outdoor apparel, and functional workwear to wearable accessories and gadgets such as jewelry, wearable cameras (‘wearcams’), smart watches, medical devices, and an abundance of health and activity trackers. To be able to refer to a particular subcategory of wearable technology that is more explicitly connected to the realms of fashion, dress, and clothing, I will adopt Bradley Quinn’s notion of ‘techno-fashion’ (Quinn 2002). What distinguishes techno-fashion from the broader field of wearable technology is that it specifically concerns garments and accessories (as distinct from tools, instruments, or devices) that combine the functionalities of technology with the aesthetic, expressive, critical and/or communicative role of fashion.

Depending on “various discourses of technology, fashion, and dress on the one hand and historical narratives in science fiction, media, and culture on the other,” techno-fashion notably merges the functional with the fashionable (Ryan 2014: 4). To a certain extent, even mobile phones may be considered fashion items in the sense that they give “miniature aesthetic statements” about their owners and have “decorative, expressive, and symbolic functions” in ways similar to a watch or piece of clothing (Castells et al. 2009: 112; cf. Juhlin and Zhang 2011). Just like activity trackers such as the Fitbit, Apple Watch, or Nike FuelBand, however, these mobile technologies predominantly fulfill a practical function: their main purpose is communication and information, or (in the case of activity trackers) to monitor the health, activity, and fitness of the wearer. What I consider techno-fashion, however, describes designs that notably balance practical functions with the aesthetic (e.g., art, craftsmanship, creativity, design), expressive (e.g. of emotion, identity, thoughts, meaning), critical (e.g., political, ethical), and communicative (e.g., social, informative, interactive) dimensions of fashion. As designer Anouk Wipprecht, the case study in chapter two formulates it:
It is often wrongly assumed that clothing and fashion are one and the same thing. There is clothing, and there is fashion. Clothing is what protects, conceals, and shelters your body, whereas fashion is a form of personal expression and communication (Interview AW 2016).

This also explains why the specific subgroup of wearable technology here defined as techno-fashion concerns ‘fashion’ in the broadest sense of the word: it is (1) an industry concerned with the consumption and production of commodities; (2) a socio-cultural phenomenon caught up in the dynamics of modernity and post-modernity; and (3) an immaterial system of signification inextricably connected to the material and tangible objects at its heart (cf. Bruggeman 2014; Kawamura 2005; Rocamora and Smelik 2016). As Rocamora and Smelik explain: “[fashion] is thus made of things and signs, as well as individual and collective agents, which all coalesce through practices of production, consumption, distribution, and representation” (2016: 2).
Although I am aware that my definition of techno-fashion may open up yet another debate on what aesthetic, expressive, and communicative exactly mean, and when these aspects are notable enough to speak of techno-fashion, I believe it at least helps to overcome some of the terminological confusion and to set the stage for future research on the topic within the fields of fashion studies and cultural studies specifically. In addition, the term techno-fashion in my view most adequately describes the specific subcategory of wearable technology that creatively stretches “the boundaries between clothing, body, and machine, forever transforming the ethics and lifestyles traditionally designated by codes of dress” (Quinn 2002: 1).

In 2014, the British technology market research, analysis and consulting firm Beecham Research provided an overview of the field of wearable technology in its entirety [Figure 12]. Although this chart makes no mention of fashion – the sectors for embellishment, decoration, personal applications and physical expression are referred to as ‘glamor’ and ‘communication’ – it does help to clarify where I position techno-fashion within the overarching field of wearable technology. The chart visualizes a spectrum from the functional and applied applications for wearable technology (work and safety wear, medical, and wellness), to the more fashion-oriented applications (sports/fitness, lifestyle computing, communication, and glamour). Most techno-fashion falls within the latter category of wearable technology applications, where its expressiveness is equally as important as, or perhaps even more important than, functionality (Seymour 2009: 14). The downside of Beecham’s chart is that it categorizes products based on a strict separation of sectors, applications, and functions. For example, it gives the impression that wearable technology is either glamorous and decorative (sector glamor), or personal and expressive (sector communication), or sporty and performance-enhancing (sector sport and fitness). The kind of wearables serving as my case studies, however, concern designers and designs that fuse technological functionality (e.g., medical, security/safety, wellness, sport/fitness functions) with the aesthetic, communicative, and expressive role of fashion.

Case Studies
Any study of a heterogeneous phenomenon like techno-fashion necessarily has to be selective in order to be thorough and interpretative (Ryan 2014: 4). I, therefore, focus my analysis on four in-depth case studies: the ‘Spider Dress 1.0’ and ‘Spider Dress 2.0’ by Anouk Wipprecht (chapter two), ‘AWE Goosebumps’ by Sensoree (chapter three), ‘Phototrope’ by Pauline van Dongen (chapter four), and finally the ‘BB Suit 0.3’ by Byborre (chapter five). These case studies all fall within reach of the specific subdomain of techno-fashion as defined above. The case studies concern garments (rather than
wearable objects such as small devices, wristbands, or accessories) that incorporate technology for practical and artistic reasons. Although the developments and research experiments in techno-fashion span across disciplines ranging from industrial design and design studies, to information technology, physics, material science, medicine, social science, fashion studies, arts and artificial intelligence; I have chosen to focus on techno-fashion “that is as serious about aesthetics as about functionality” (Brunstein 2011: 89-90). This implies that the design of garments for primarily medical or military purposes, for example, falls outside the scope of this research.

Each of my chapters starts from one of the four case studies, simultaneously using them as empirical tools that raise specific research questions, and as test cases that help to assess my theoretical and conceptual approaches to these questions. In addition, the case studies function as primary research sources from which to deduct insights that contribute to the development of a theoretical framework for understanding how techno-fashion materially mediates the relations between the human body, technology, and fashion.

The criteria that inform the rationale for my selection of case studies are based on my preliminary empirical investigations, my network, and the set-up of the research project Crafting Wearables. Most importantly, the four case studies were chosen for their firm position at the intersection of fashion and technology, and for their relevance in light of the central research question and aims of this study. Not only do they represent the fashion-oriented segment of the wearable technology spectrum, they (1) help to gain a thorough understanding of how techno-fashion shapes and reshapes the embodied experience of fashion and technology; (2) are representative of how techno-fashion transforms and activates the matter of fashion; (3) are exemplary of how techno-fashion affects communication and social interaction; and (4) serve to critically reflect on the impact of techno-fashion in terms of surveillance, power and control. Using ‘purposeful sampling’ rather than a statistical sampling of a large population, I decided to select only information-rich case studies that can illuminate the questions under study (Patton 2002: 230).

For the sake of comparing, understanding, and analyzing this subgroup in relation to the broader field of wearable technology, however, I will occasionally also mention examples from the more functional segments of the wearable technology landscape, such as smartwatches and activity trackers. When addressing themes such as embodied experience or body monitoring, for example, it is valuable to also reflect on the differences and similarities between wearing a wearable device around the wrist and wearing a technologically enhanced garment.
Wearable Technology

Now that the phenomenon of techno-fashion has been defined, it is important also to discuss how it relates to the broader field of wearable technology from which it originates. In *Computational Fashion* Sabine Seymour notes that she would refrain from using the term wearable technology because she writes, “[i]t just so happens that my bra includes a heart rate sensor, my ring is a notification actuator, my workout pants have an integrated muscle stimulator, and my T-shirt lights up when I dance. It is still just clothing” (Seymour 2014: 2). Yet although I acknowledge wearable technology’s inextricable link to clothing and agree that the many attempts to pinpoint its features have created a terminological minefield, I believe that refusing or sidestepping definitions altogether will not help to get a grip on the development in question. As outlined in the introduction, wearable technology has been omnipresent in both the technology and fashion sector over the past few years. It is now time to more clearly define this phenomenon, precisely because the process of defining can help to gain a better understanding of its characteristics and implications, also in comparison to other related domains such as smart textiles and wearable computing.

Within this dissertation, I use the term ‘wearable technology,’ often shortened to ‘wearables,’ as a general and overarching label that refers to *clothes, accessories, and wearable items incorporating technologies or technological processes for practical, functional and/or aesthetic purposes*. There are multiple reasons why I chose to employ this general descriptor and definition. First of all, ‘wearable technology’ has become the most well-known, widely circulating and commonly accepted term to describe the field as a whole. It is also a relatively neutral term that is used and understood in all the disciplines and sectors involved, from the fashion and textiles industry to the world of healthcare and information technology. Secondly, using a broad term allows for the inclusion of garments involving technologies or technological processes other than electronics – such as 3D printing, thermochromic ink, or smart materials. Such an inclusive definition makes it possible to also address the increasing links between fashion and technology in general. Thirdly, my decision to use the blanket term wearable technology is a strategic one that hints at the field’s origins in wearable computation as well as stresses the core importance of ‘wearability.’

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2 Thermochromic ink or dye can change color in response to a change in temperature. ‘Smart material’ is a generic term used in material science to describe materials that can radically change their shape due to external influences, such as temperature, stress, and moisture.

3 Wearable computing is the study or practice of inventing, designing, building, or using miniature body-borne computational devices. Wearables pioneer Steve Mann often uses the term ‘Body-Borne Computing’ or ‘Bearable Computing’ as a substitute for ‘Wearable Computing’ so as to include all manner of technology that is on or in the body, e.g. implantable devices as well as portable devices like smartphones. Wearable computers may be worn under, over, or in clothing, or may also be themselves clothes (Mann 1996, 2013). Today, wearable computers can be considered a segment of the larger classification of wearable technology (Dunne 2004: 6).
The development of portable and wearable devices – such as the wristwatch, Walkman, and portable radio – is generally driven by a desire for continuous access and technological innovation (Dunne 2004: 5-6). The current wearable technology trend is consistent with this urge for non-stop communication and information access. However, Susan Ryan notes, early portable and wearable computers “were not actually worn, they were carried or held, or placed out of sight” and “ultimately have little to do with the bodily display that is the nature of dressing” (Ryan 2014: 95). While some of the precursors of today’s wearable tech could be deemed “wearable” in the sense that they are small and lightweight enough to be mounted onto the body, most of them were not designed for wear-ability (Gemperle et al. 1998: 1, original emphasis).

As Francine Gemperle et al. argue, “[t]he word wearable implies the use of the human body as a support environment for the product. (...) However, simply shrinking down computing tools from the desktop paradigm to a more portable scale only makes them into mini PC’s. It does not take advantage of the opportunities presented by a whole new context of use. It does not regard the human body as a context” (Ibid: 1). Generally ignoring the cultural connotations of fashion and clothing, early wearable computing tends to subordinate the physical body to pure functionality (Ryan 2014: 95). Yet unless the design accounts for and accommodates the active relationship of wearables to the human body, wearable technology is not nearly as wear-able as the term suggests.

Using the term wearable technology helps me to express the vital role of the human body and to think through the differences and similarities between carrying and wearing technology. Nonetheless, this broad and common term also has one major downside: it does not make explicit the vital role of design, aesthetics, and style in developing or wearing wearable tech specifically, nor its close connection to the realms of fashion and clothing. Several scholars have also pointed to this shortcoming, noting that the label wearable technology does not adequately describe a specific, more fashion-oriented subgroup of wearable technologies that makes its way into fashion by notably merging functionality with aesthetics (see, for example, Seymour 2009, 2010; Smelik 2017). As explained, this is the main reason why I use the term techno-fashion alongside the notion of wearable technology, so as to more adequately and explicitly capture the role of fashion design within a specific segment of the field.

4 Although a distinction between items that can be carried (portable technology) and items that can be worn (wearable technology) can be made in English, some other languages do not allow for this. In Dutch, for example, the words portable and wearable are both translated as ‘draagbaar’, whereas ‘portable’ or ‘portatif’ is the only translation in French and German solely offers the word ‘tragbar’.
When Fashion and Technology Entwine: Two Theoretical Approaches

As discussed in the introduction to this dissertation, my research started with my explorative empirical investigations of the field of techno-fashion. Visiting events and design studios, speaking to experts and designers, and directly observing many different designs during the early stages of my Ph.D. trajectory, I noticed that the mere material presence of techno-fashion on a body, or even on a static mannequin, does something to people and their behavior. This led to the hypothesis that techno-fashion not only strongly affects the experience and material properties of fashion but may also radically transform how people communicate and behave, and relate to themselves as well as to others. It also informed the central question research question: How can we understand the ways in which techno-fashion materially mediates the relations between the human body, technology, and fashion?

Within this dissertation, two theoretical approaches help to find an answer to the central research question, namely postphenomenology and new materialisms. The choice for these two theoretical strands is informed by the four case studies and the four corresponding aims of my research. In one way or another, all case studies affect the relation between the wearer’s body and the world around her: the robotic limbs of the ‘Spider Dress 1.0’ and ‘Spider Dress 2.0’ demarcate and extend the boundaries of the human body, alerting both the wearer and her surroundings of the issue of personal space; the inflatable silicones in Sensoree’s ‘AWE Goosebumps’ externalize and amplify the wearer’s physical sensation of goosebumps; the LED strings in Pauline van Dongen’s illuminated running shirts affect the visibility of their wearers, both literally and metaphorically; and the biosensors in Byborre’s ‘BB. Suit 0.3’ drastically change the way in which the wearer presents himself to the outside world. Techno-fashion, in sum, does something to the embodied experience and matter of fashion.

There is sufficient literature available that specifically addresses either fashion or technology in terms of embodied experience or material agency, such as Joanne Entwistle’s The Fashioned Body (2015) and Küchler and Miller’s Clothing as Material Culture (2005); or Don Ihde’s Bodies in Technology (2002) and Peter-Paul Verbeek’s What Things Do (2005a). As techno-fashion has rarely been studied from a socio-cultural perspective, however, there is no coherent theoretical framework or solid body of literature that unites the fields of fashion studies and the philosophy of technology. Whereby developers and designers of techno-fashion have found fertile ground in combining the practices of fashion and technology, I will attempt to interweave these domains theoretically.
By developing a theoretical framework for the study of how techno-fashion materially mediates the relations between the human body, fashion, and technology, this research brings four different fields of study together: fashion studies, design studies (particularly interaction design and industrial design), cultural studies, and the philosophy of technology. To combine these in themselves already interdisciplinary fields, I unite two contemporary philosophical approaches specifically concerned with embodied experience and the material dimensions of culture and society: (1) phenomenology (Husserl 1952/1993; Merleau-Ponty 1945/2002, 1968) and its recent successor postphenomenology (Ihde 1990, 2002, 2003b, 2009, 2016; Verbeek 2005a, 2011; Rosenberger and Verbeek eds. 2015); and (2) new materialisms (Barad 2003; Barrett and Bolt 2013; Bennet 2004, 2010; Braidotti 1994, 2013; Bruggeman 2014; Coole and Frost 2010; Dolphijn and Van der Tuin 2012; Rocamora and Smelik 2016; Smelik 2018; St. Pierre, Jackson, and Mazzei 2016). Before, I further address how a combination of these two theoretical lenses help to research techno-fashion from a socio-cultural perspective as well as to analyze it in terms of performance, embodied experience, materiality, and surveillance, I will first explain what each of them entails.

1. Phenomenology and Postphenomenology

Phenomenology: Embodied Experience

Phenomenology has always played a central role in the philosophy of technology (Verbeek 2001: 120). Fashion scholars, also, have increasingly turned to phenomenology to research and emphasize the embodied aspects of fashion and dressing (see for example Entwistle 2015; Negrin 2013, 2016). One of the central arguments of phenomenology is that the classical Cartesian dichotomy between subject and object – in later phenomenology this becomes ‘human beings’ and ‘world’ – does not hold. From a phenomenological standpoint, humans and world can only be thought of as always already related and constituting each other in this relation (Verbeek 2001: 120-121). Embodied experience and the perceiving body as “a physical thing that is able to entertain a system of sensations,” are key topics in phenomenological thought (Heinämaa, 2012: 226, original emphasis).

These topics are of particular relevance in relation to techno-fashion because technology-infused garments often involve various sensorial sensations such as touch or vision, as well as technological forms of ‘sensing’ in the form of sensors. Phenomenology provides the conceptual and methodological tools to reflect on the relationship between the human body and techno-fashion and helps to address the ways in which techno-fashion affects the wearer’s bodily experience of self and environment.
The work of phenomenologist Maurice Merleau-Ponty notably illuminates how human beings relate to the world “through objects” and how artifacts may consequently become instruments with which we perceive the world (Merleau-Ponty 1945/2002: 176, original emphasis). He illustrates this point with the example of a blind man’s cane: “Once the stick has become a familiar instrument, the world of feelable things recedes and now begins, not at the outer skin of the hand, but at the end of the stick” (ibid.). This insight is of specific significance for research on and wearable technology in general because wearables are often envisioned as “a bodily auxiliary, an extension of the bodily synthesis” as well (1945/2002: 176; cf. Smelik 2012: 133). In itself, clothing is already “an essential tool for people to define their space,” yet techno-fashion may amplify this function by allowing wearers to extend the spatiality and capacities of their bodies (Quinn 2002: 16; cf. Verbeek 2001: 126). A clear example that illustrates how techno-fashion extends the wearer’s body is ‘Navigate’ [Figure 13, 14], an “urban way-finding jacket” developed by the company Wearable Experiments (Wearable X). Using haptic vibrations to indicate when to turn left or right, ‘Navigate’ subtly helps the wearer to explore the city without looking at a screen or map. Whereas our bodily capacity to navigate is normally largely confined to vision, ‘Navigate’ extends this capacity to the sense of touch. The way in which techno-fashion extends and supplements the human body is discussed in chapter two.

Another reason for discussing techno-fashion in light of the phenomenal body – the body as “existence or being in the world through a body” (Merleau-Ponty 1945/2002: 360) – is that one of the main trends in the overarching field of wearable technology concerns the tracking and registration of physiological signals, such as heart rate, posture, temperature, movement or activity. By permitting the wearer to technologically bear witness and sometimes even manage bodily states and processes, such techno-fashion amplifies the wearer’s body awareness and promote a kind of “self-conscious self-surveillance,” something I will further address in chapter five on ‘wearable surveillance’ (Balsamo 1995: 216). Finally, phenomenology helps to see how techno-fashion is inclined to bring with it a new body consciousness because it combines the technologically acquired data with fashion’s capacity to communicate and express something about the wearer (Quinn 2002: 16; cf. Verbeek 2001: 126).
2002: 33). As chapter four will explain, techno-fashion can communicate all kinds of information about the wearer to the outside world by translating certain inputs (such as physiological data) into visible output (such as light, color, sound, or vibration).

To sum up, phenomenology is a valuable approach to techno-fashion for three reasons. First, it contributes to a description and better understanding of the possibilities and effects of techno-fashion in relation to the wearer’s “body-in-the-world” (Merleau-Ponty, 1945/2002: 164). Techno-fashion, it highlights, has implications for the spatial and physical situatedness of wearers. Second, phenomenology is helpful in understanding how some wearables direct attention to and help to monitor phenomena normally taken for granted or even unperceived, such as our body posture, vital signs, or the feel of clothing on our body. Some wearable technologies, therefore, have the capacity to aid the wearer’s embodied experience, enabling a heightened and new form of body consciousness (Ryan 2014: 96). Third, phenomenology illuminates that humans and
the world are inseparably connected and elucidates how human beings can not only extend the perceptual range of their lived bodies through wearable technologies but may perceive with them as well (Verbeek 2001: 126, original emphasis).

Postphenomenology: Technological Mediation

Within the philosophy of technology, phenomenology is an important starting point for investigating human-technology relations. Yet the instrumental role that early phenomenologists like Merleau-Ponty ascribe to objects does not account for the active and ‘non-neutral’ (Ihde 1990; Verbeek 2005a) way in which today’s complex technologies shape human perception and experience. The objects that Merleau-Ponty describes are motionless and passive artifacts that have to be activated by their user: without the intervention of the blind man, for example, the cane will not and cannot ‘act’ as an instrument by itself. Techno-fashion, however, often includes programmed or self-acting technological garments that can be activated independently or even beyond the control of the wearer (Chin 2010: 42; Dunne 2011: 614). Garments containing robotic components (e.g. Anouk Wipprecht’s ‘Spider Dress 2.0’ [Figure 15] and Hussein Chalayan’s ‘111’ collection or smart and responsive materials (e.g. the ‘Skorpions’ collection by XSLabs [Figure 16] or NEFFA’s mood, light and temperature-reactive ‘Chameleon Mood Scarf’ [Figure 17]), may therefore seem uncannily yet fascinatingly ‘alive’.

Rather than passively and neutrally mediating between the wearer and the world, technology-infused garments often possess an “apparent autonomy” and extraordinary power (2005a: 127); they move and change color or shape of their own accord. In order to give a thorough account of how techno-fashion alters the wearer’s embodied experience and affects relationships between fashion, technology and the human body, a theory that specifies and extensively analyses such complex interrelations are needed. A suitable theoretical framework for this perspective can be provided by the reinterpretation of phenomenology coined by the American philosopher Don Ihde: post-phenomenology (Ihde 2002, 2009; Verbeek 2005a, 2011; Selinger ed. 2006; Rosenberger and Verbeek eds. 2015).
Postphenomenological studies typically study technology in terms of the relations between human beings and technological artifacts and combine philosophical analysis with the empirical investigation (Verbeek 2015: 190). They do not approach technologies as merely functional and instrumental objects but as mediators of human experiences and practices (ibid.). The term postphenomenology was coined by Don Ihde, who defines his philosophy of technology as follows:

Postphenomenology is a philosophical style of analysis which deals with science and technology studies. It is a recent comer to a series of twentieth and twenty-first-century interpretive upheavals regarding science, technology, studies, cultural studies, and technoscience (Ihde 2015: vii).

Much like Husserl and Merleau-Ponty, Ihde views human beings and their world, subjects, and objects, as mutually constituting each other. However, he takes the phenomenological premise one step further by focusing on what happens when the relationship between human beings and the world is technologically mediated (Ihde 2009: 57, original emphasis). I will further discuss and explain this notion of technological mediation in the second chapter. Through exploration of the exact structure of these technological mediations, Ihde differentiates between four types of human-technology
relations: embodied relations (the technology is incorporated into the users bodily synthesis), hermeneutic relations (the technology has to be “read” or interpreted in order to be meaningful), alterity relations (the technology is experienced as a “quasi-other” that seems to possess a certain autonomy), and background relations (the technology withdraws from the user’s perceptual awareness) (1990; 2009). This focus on the specific and variational structure of mediation explains why Ihde describes postphenomenology as “a modified, hybrid phenomenology” (Ihde 2009: 23); he appropriates and ‘updates’ some key ideas from the phenomenological tradition and brings them to the philosophy of technology (Cerbone 2009). Offering “a way to probe and analyze the role of technologies in social, personal and cultural life” it is an invaluable resource for my analysis of techno-fashion (Ihde 2009: 23).

A postphenomenological approach to techno-fashion is helpful because it highlights that techno-fashion not only changes what the wearer experiences (the object of experience itself) but also affects how that experience comes about. The ‘Aegis Parka’ [Figure 18] by designer duo Nieuwe Heren, for example, simultaneously functions as an instrument and as a garment: it registers the air quality and warns the wearer when the level of hazardous molecules becomes too high by translating the intensity of air pollution into the intensity of the LED lights on the jacket. The Aegis Parka allows the wearer to “see” the air quality, a phenomenon that normally escapes our sensory perception. This active technological mediation changes the wearer’s experience of a specific space or environment, in this case possibly causing the wearer to avoid or prefer certain locations. Ihde’s postphenomenological perspective thus aligns with the hypothesis that the techno-fashion can modify – sometimes modestly, sometimes radically – both what and how the wearer experiences the world (Cerbone 2009).

2. Renewed Materialisms: From Material Culture Studies to New Materialism
It is against the background of phenomenology and post-phenomenology, that the second theoretical pillar of my approach to techno-fashion will be used: new materialisms (Braidotti 1994, 2013, 2014; Coole and Frost 2010; Barrett and Bolt 2012; Bruggeman 2014;
Dolphijn and Van der Tuin 2012; Rocamora and Smelik 2016; Smelik 2018). Garments and accessories are distinctly different in material form and character from other objects of material culture, in that objects of dress bear some relationship to the body that wore them. Typically made of cloth, a garment can serve to protect, adorn, mark or obscure the body (Mida and Kim 2015: 27). With the advent of techno-fashion, however, clothing suddenly becomes the vehicle of innovative design and technology (Küchler 2005: 212). Rosi Braidotti, one of the founders of the neo-materialist feminism that inspired the strand that has come to be known as new materialisms, considers the new materialist endeavor as an attempt to update post-structuralist theories of the subject in order to acknowledge the material conditions of subjectivity (Braidotti 2014). To her, a philosophical reappraisal of materiality should be about the appreciation of matter and attention to the materiality of life, especially the non- or not-yet-human matter (ibid.).

‘New materialisms’ refer to a group of relatively new “bodies of thought” (St. Pierre, Jackson, and Mazzei 2016: 99) that argue for a reconceptualization and revaluation of matter. Although I am aware that the development of new materialisms as a strand of thought is still work in progress (ibid.: 99), its perspective allows me to think bodily experience and human-technology relations – as they are respectively theorized by phenomenology and post-phenomenology – in tandem with the distinct materiality and agency of techno-fashion.

New materialisms focus on materiality from within different disciplines, such as feminism, cultural studies, and political theory (Coole and Frost 2010: 2; Bruggeman 2014: 43). As Coole and Frost (2010) point out, new materialists “are (...) aware of the emergence of novel if still diffuse ways of conceptualizing and investigating material reality” (Coole and Frost 2010: 2). I prefer to address the strand in its plural form, as new materialisms, because they arise from attempts to rethink matter within different disciplines and therefore, in my view, cannot (yet) be seen as a coherent strand. On this point, I agree with Coole and Frost stating that the initiatives from different disciplines are still distinctive attempts reflecting “on various levels of materialization” (ibid.: 4).

The first reason for me to turn to new materialisms for my analysis of techno-fashion is their notable attention to ‘material agency.’ Rather than thinking of matter as passive and mute ‘stuff’ on which humans exert power, new materialist theories understand matter as being an active and meaningful actor in the world (Barrett and Bolt 2012: 3, 5). This helps to understand how technology brings “agentic” materials into the realm of fashion. In the twentieth century, “soft” fabrics like silk, satin and also fur were already...
supplanted by ‘modern’ materials, such as leather, PVC, silicone, and rubber (Entwistle 2001: 144). With the emergence of techno-fashion, a distinctly new generation of smart, interactive, self-organizing and responsive materials enters the scene (cf. Quinn 2002, 2010, 2012; Braddock Clarke and O’Mahony 2008; Seymour 2009, 2010). Dyes, buttons, ribbons, textiles, zippers, fabrics and thread are supplemented with materials such as optic fibers, solar cells [figure 19], sensors, microcontrollers et cetera. Rather than knitted, woven, sewn, manufactured or stitched, techno-fashion is engineered, constructed, printed, laser-cut, processed, installed, soldered or even grown (Quinn 2002: 2). Many of these new materials it incorporates have the capacity to actively change the shape, appearance, feel and/or meaning of a garment.

The second reason why new materialist theory is of particular relevance to my study of techno-fashion is its specific attention to the inextricable entanglement of matter and meaning (Dolphijn and Van der Tuin 2012: 91). “Matter and meaning are not separate elements,” Karen Barad highlights, “[t]hey are inextricably fused together, and no event, no matter how energetic, can tear them asunder” (Barad 2007: 3). As numerous fashion scholars have noted, however, one of the most dominant academic ways to study fashion has long been to think and study fashion in terms of signification and representation rather than materiality (e.g., Entwistle 2000; Sykas 2013; Bruggeman 2014; Rocamora and Smelik 2016). Such merely semiotic or discursive approaches help to analyze and deconstruct how fashion acts as a site of signification – a garment represents something else – yet devote little attention to the physical substrate of garments (Sykas 2013: 235). A traditional material culture approach to fashion, on the contrary, focuses on the material from which garments are made and “the infinite possibilities it holds as an embodiment of value and meaning” (De la Haye 2013: 231, original emphasis). As I will argue in chapter three ‘Flashy and Fleshy: The New Materials of Techno-Fashion,’ such an object-based analysis of materiality provides insight into how material artifacts are embedded in social relationships but does not yet account for the ‘agency’ of such complex material phenomena as techno-fashion.

The complex way in which the materiality of techno-fashion also actively invokes meaning and exerts material power requires an approach that helps to “rediscover older materialist traditions while pushing them in novel, and sometimes experimental, directions or towards fresh applications” (Coole and Frost 2010: 4). New materialism does not necessarily distance itself from the “crude” materialist or linguistic interpretations of matter, but “works through” and rejuvenates them (Dolphijn and Van der Tuin 2012: 89-91; cf. Bruggeman 2014: 162). In other words, new materialism is not ‘new’ or exclusive
in its attention to materiality, but in its refreshing co-thinking of materiality and meaning (cf. Rocamora and Smelik 2016: 13). Rick Dolphijn and Iris van der Tuin formulate this new materialist conception of matter/meaning entanglement as follows: “[a]n object is no longer passive matter that has to be re-presented; meaning-making takes place on a two-way track” (Dolphijn and Van der Tuin 2012: 110). I will further discuss the importance and relevance of thinking the entanglement of matter and meaning in chapter four, which focuses on the communicative and interpretive aspects of techno-fashion.

**Combining Phenomenology, Postphenomenology, and New Materialisms**

Although new materialism’s exact relation to phenomenology is yet under researched (Dolphijn and van der Tuin 2012: 114n9), it is clear that they have a “predilection for a more phenomenological approach to embodiment” in common (Coole and Frost 2010: 19). In *New Materialisms: Ontology, Agency, Politics*, Diana Coole and Samantha Frost describe the phenomenological emphasis on corporeality as one of the pillars onto which new materialisms are built:

In addition to focusing on the way power constitutes and is reproduced by bodies, phenomenological studies emphasize the active, self-transformative, practical aspects of corporeality as it participates in relationships of power. They find bodies exhibiting agentic capacities in the way they structure or stylize their perceptual milieu, where they discover, organize, and respond to patterns that are corporeally significant. Such theories (...) give materiality its due (2010: 19-20).

I believe this new materialist attention to the materiality and re-materialization of the body fits with phenomenological and postphenomenological approaches that help to address fashion’s inextricable link to the body, as well as to highlight the haptic and embodied experience of techno-fashion (Negrin 2013, 2016). Yet there are more ways in which phenomenology, postphenomenology, and new materialisms seem to resonate.

In addition to their emphasis on the agentic capacities and materiality of the body, they share an endeavor to surpass the classic subject/object dichotomy. The early roots for this can be found in Merleau-Ponty’s unfinished *The Visible and the Invisible* (1968):

_Flesh of the world – Flesh of the body – Being. (...) That means that my body is made of the same flesh as the world (it is a_
perceived), and moreover that this flesh of my body is shared by the world, the world reflects it, encroaches upon it and it encroaches upon the world (the felt [senti] at the same time the culmination of subjectivity and the culmination of materiality), they are in a relation of transgression or of overlapping (248).

What Merleau-Ponty describes here as ‘the world encroaching upon the body’ is similar to what new materialisms term material agency. As Jane Bennett explains, new materialism “attempts a more radical displacement of the human subject than phenomenology has done” (2010: 30). Whereas phenomenology does not account for how specific objects may exert material power outside or beyond the control of the human subject, new materialisms help to explore the material, non-human agency of techno-fashion and its powerful effects on those who wear or encounter it (Latour 2005; Barrett and Bolt 2012: 6). This also aligns with the postphenomenological mediation theory that sees technologies as the ‘non-neutral’ mediators of human-world relations, rather than treating them as material objects opposed to human subjects (Ihde 1990; Verbeek 2005a). Moreover, it is interesting to compare the new materialist conceptualization of ‘material agency’ to what postphenomenology terms ‘alterity relations’: human-technology encounters in which a technical artifact presents itself as something “other.”

As addressed in the introduction, my research explores the ways in which techno-fashion materially mediates the relations between the human body, technology, and fashion by focusing on embodied experience, new materiality, communication and self-expression, and surveillance and biomonitoring. Phenomenology offers the tools to reflect on relations between the human body and objects. Postphenomenology addresses what happens when these relations are technologically mediated. New materialisms attend to the material basis of such interrelations, challenging merely human-centered understandings of material agency. When combined, these theoretical perspectives help to understand techno-fashion “not only as a signifying system but also as an embodied practice that takes place in a collectively shared social space” (Rocamora and Smelik 2016: 12). Using and connecting these different strands of theory throughout this dissertation, I will gradually develop a theoretical and methodological approach for studying the material mediations of techno-fashion.

**Research Design and Methods**

Techno-fashion is a relatively new research topic that asks for an explorative research
Qualitative methods best fit with an explorative research process because they are designed to understand a phenomenon in terms of the meanings people bring to it and describe persons’ experiences, behaviors, interactions and social contexts (Fossey et al. 2002: 717). As noted in the introduction, there is a need for a thorough understanding of the (real and anticipated) implications of techno-fashion. This requires research methods that help to gain better insight into the point of view, thoughts, expressions and embodied experiences of the several actors in the field.

A study of theoretical texts from the fields of fashion studies, cultural studies and the philosophy of technology forms the basis for my research methods. In accordance with the phenomenological, postphenomenological, and new materialist theories described in the previous section, my qualitative research method is informed by a combination of the interpretative and critical research paradigm (Fossey et al. 2002: 718-720). While an interpretative approach focuses primarily on understanding and accounting for meanings inherent in human experience and action, a critical methodology is directed not towards understanding for its own sake, but towards understanding as a tool to critique and transform current structures and relationships (ibid.: 720). A synthesis of interpretative and critical methods resonates with the purpose of my research: I not only intend to gain a better understanding of how techno-fashion materially mediates the relations between the human body, technology, and fashion, but also aim to critically reflect on the development and socio-cultural implications of this phenomenon.

Qualitative research methods are relatively flexible, enabling contact with the people involved in the continued development and experience of techno-fashion, and produces rich and descriptive data that can contribute to theoretical knowledge and practical use (Boeije 2010: 11). My research, therefore, combines literature study and theoretical reflection with several qualitative research methods: semi-structured in-depth interviews with wearers (1) and designers (2) (Boeije 2010; Jenss 2016; Kawamura 2011; Piercy 2004; Saukko 2013; Travers 2001), and object-analyses (3) based on the direct observation of the material properties and media representations of techno-fashion (Granata 2012; Prown 1982; Steele 1998; Mida and Kim 2015).

**The Wearers: In-depth Interviews and Fitting Sessions**

52(510,973),(571,996)

The first research method that I apply to understand better the ways in which techno-fashion materially mediates the relations between human body, technology, and fashion is the typically phenomenological method of the in-depth interview (Bloor and Wood eds. 2006: 129). Although the vital role of the body in designing or studying techno-fashion is
increasingly acknowledged (e.g., Smelik, Toussaint and Van Dongen 2016; Tomico and Wilde 2015; Toussaint and Smelik 2017), the physical wearing experience still often remains hidden from view in both research and design practice. As most techno-fashion never gets past the prototype phase and is almost exclusively presented within the context of catwalk shows, research labs, conferences or museum exhibitions, however, it is not surprising that the lived, the experiential body easily fades from view. Apart from models and a small group of high-profile early adopters like pop stars, few people have access to and actually experience what it is like to wear techno-fashion. Previous studies of techno-fashion therefore mostly rely on visual or textual representations of techno-fashion for their analysis of the role of the body and hence provide little insight into the embodied experiences it evokes. To gain more insight into this matter, I attempted to gather additional qualitative data from the second group of respondents: wearers.

For one of the selected case studies, Pauline van Dongen’s illuminated running shirt (called ‘Phototrope’), I acquired data on wearer experiences by organizing so-called ‘fitting sessions’ with two respondents. These sessions had the purpose of gathering information on embodied experiences of three designs by Van Dongen (chapter four). The fittings consisted of in-depth semi-structured interviews with two respondents while they were subsequently wearing several designs of by-wire.net⁵ and Pauline van Dongen (see the list of interviews in the appendix). During the fittings, wearers were asked about their views, interpretation and bodily experience of each specific design, which allowed me to gain a better understanding of the embodied and experiential aspects of wearing techno-fashion (Kawamura 2011: 45-80). The semi-structured interviews offered respondents the opportunity to describe their vision on techno-fashion in their own words, which ensures that different wearer perspectives and experiences are represented in my research findings (see the topic list for wearers in the appendix). In addition to the in-depth interviews, I was able to access the qualitative data that other members Crafting Wearables research team gathered during several tests with Pauline van Dongen’s ‘Phototrope’ in 2015⁶. After all, the best way to explore the actual rather than just the anticipated impact of techno-fashion, and wearable technology in general, is through gaining insight into the points of view, expressions and lived experiences of their (potential) wearers.

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⁵ Although by-wire.net did not end up being a case study in this research, the data gathered on wearer experiences of the ‘Spine Dress’ during the fittings do serve as comparative material in chapter two.

⁶ Within the context of the Crafting Wearables research project, designer Pauline van Dongen and research assistant Marina Toeters organized several user tests with Van Dongen’s illuminated runwear project ‘Phototrope’, including a series of tests during the weekly training sessions of a running team in a public park. The data gathered during these ‘Phototrope Test Sessions’ (2015) have been used for my case study analysis in Chapter four. A complete and detailed overview of these user tests can be found in the list of interviews in the appendix.
For the three remaining case studies, I collected data on first-hand wearer experiences by interviewing models in relation to case studies Anouk Wipprecht (chapter two) and Sensoree (chapter three). For the case study of chapter five (Byborre), I interviewed designer Borre Akkersdijk himself as he is the only person that has worn the design under investigation. The reason for these diverging methods is mainly practical, as it was unfortunately not feasible to organize a fitting session with the designs of Byborre, Sensoree, and Wipprecht. Although this obviously implies that the data were collected under different circumstances than those from the fitting sessions (it concerns individual respondents who have a personal interest in the designs under investigation and reflect on their wearing experience in retrospect), they do offer unique and vital insight into embodied experiences of techno-fashion. The model I interviewed for my case study analysis of Anouk Wipprecht’s ‘Spider Dress 2.0’ (chapter two), for example, repeatedly worked with the designer and has a commercial interest in being booked for modeling jobs again. Nonetheless, her first-hand experiences of the dress are of value to my research because she is one of very few who have worn the ‘Spider Dress 2.0’ on several occasions and in various public settings. Her descriptions of what it is like to wear the dress may thus be after-the-fact and subjective, but they are also telling and uniquely insightful.

The Designers: In-depth Interviews

Besides collecting qualitative data on wearer experiences, I conducted a series of semi-structured in-depth interviews with several designers from the field of techno-fashion. The respondents for these interviews were selected on the basis of the Crafting Wearables project plan, my central research aims, practical and logistic considerations, and snowball sampling strategies (Fossey et al. 2002: 726). All interviewees have given their written consent to the inclusion of their name and reflections in this dissertation.

Throughout the four years of my Ph.D. research, I interviewed a total of ten designers (see the list of interviews in the appendix). Four of these interviews relate directly to my case studies (e.g., Anouk Wipprecht, Sensoree, Pauline van Dongen, and Byborre), the other six have served as background information and additional or comparative research material. The qualitative data gained from the six additional interviews with designers merely serve as background information that helps me to explain, compare, illustrate, and support information and arguments about the field at large. All interview transcripts are available upon request from the author.

The in-depth interviews are based on a topic list, including a series of open questions with accompanying queries that ask the respondent for more detailed and contextual
data (see the topic list for designer interviews in the appendix). Such a method is an ideal way to collect a considerable, in-depth and rich amount of data (Piercy 2004: 1). Working with topic lists with relatively broad questions, allows respondents to openly “express views, give words to their experiences and describe events and situations,” making sure that “[t]he information gained is not limited to preconceived questions and categories” (Boeije 2010: 32). At the same time, the insights and experiences of these techno-fashion practitioners helped me to identify the common threads in the field, as well as to continuously refine, inspire, adjust and assess my own theoretical reflections, interpretations, and analyses.

The Artifacts: Object-Based Analysis

In addition to literature study and semi-structured in-depth interviews, I used an object-based research method specifically attuned to dress artifacts (Mida and Kim 2015). This methodological approach involves a systematic process of observation, reflection, and interpretation (ibid.). Inspired by the phenomenological attention to embodied human-object relations, and the postphenomenological approach that takes actual technologies and technological developments as a starting point for philosophical analysis, I start my research from actual techno-fashion designs. By visiting museum archives and exhibitions7, attending events with techno-fashion on display8, going to design labs9 and designer studios10, and organizing fittings sessions with actual designs, I was able to directly observe the material and intrinsic characteristics of techno-fashion artifacts. Such empirical investigations offered me “a way to build and test theories against examples of actual garments and accessories” (Granata 2012: 70).

In addition to direct observation, my object-based research method involved the gathering and analysis of “other sources of contextual material” (Mida and Kim 2015: 31), including textual and visual representations such as videos, captions, photographs, press releases, magazine or newspaper articles, and exhibition catalogues. This reflective phase allows for an exploration of the ways in which techno-fashion artifacts are received, framed, and discussed within a broader, socio-cultural context, and offers insight into the topics

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9 E.g. the Wearable Senses Lab at Eindhoven University of Technology and the TextileLab in Tilburg.
10 E.g. the studios of Pauline van Dongen, by-wire.net, Despina Papadopoulos, Byborre and Anja Hertenberger.
and views surfacing in relation to this relatively new phenomenon. For two case studies – Wipprecht’s ‘Spider Dress 2.0’ and Sensoree’s ‘AWE Goosebumps’ – the online videos fortunately also provided some extra qualitative data on wearer experiences, as they cover conversations or short interviews with wearers of these two designs. The final step in my object-based approach concerned linking the observations and contextual material to theory (Mida and Kim 2015: 76-81). This is where I further interpret my observations and experiences and analyze the collected data with the help of theory (ibid.).

Theory Meets Practice

In the introduction to this dissertation, I described how my initial empirical investigations of techno-fashion prompted me to inquire into the ways in which it materially mediates people’s experiences. While observing how wearers and spectators approached or interacted with these technological artifacts, I noticed that techno-fashion has the potential to strongly affect how people communicate and behave, and how they relate to themselves as well as to others. Although these observations align with the bulk of literature that ascribes all kinds of revolutionary and disruptive qualities to techno-fashion, I became aware of the gap between the theory and practice of techno-fashion. Most literature assumes that techno-fashion will have a profound influence on our lives in the foreseeable future but refrains from testing this hypothesis by bringing the observations or experiences of the actual objects, makers, and wearers of techno-fashion into focus. To gain a better and deeper understanding of how techno-fashion concretely and materially mediates people’s relations to themselves and to the world, I realized, it has to be investigated both theoretically and empirically.

The qualitative research methods employed here, reflect this dialogue between abstract (philosophical) theory and the empirical matter of techno-fashion. Fusing theoretical with artifact-based approaches, I work from the object into theory as well as back from theory into the object (Taylor 2002: 85). Additionally, the main purpose of conducting interviews with designers and wearers is to help understand techno-fashion “in terms of the meaning people bring to [it]” (Boeije 2010: 11). Getting in direct contact with designers of techno-fashion and gathering data on how their designs are experienced by wearers, produces rich descriptive data on both the embodied experiences and subjective meanings attributed to the phenomenon (ibid.). The generation of qualitative data through in-depth interviews and fitting sessions allows me to be sensitive to the particular experiences and ideas of those people actually engaged in the field, which is crucial in getting a sense of how they think and feel that techno-fashion impacts relations between the human body, fashion, and technology.
To conclude, the research methodology for this dissertation combines theoretical reflection with object-analyses and qualitative data analyses in order to develop a solid theoretical basis for the critical analysis of wearable technology and, ultimately, a basic knowledge of the socio-cultural implications of techno-fashion. The theoretical framework is developed in close cooperation with the designers and partners involved in Crafting Wearables, and further refined in response to the data gathered during the research. The practices, views and experiences of designers and wearers inspired and co-shaped my theoretical framework and conceptual thinking. The adaptation of post-phenomenology for the study of techno-fashion, for example, is informed by an increasing interest in designing from and with the body among the designers in the project team. Conversely, my postphenomenological reflection and analysis of techno-fashion, inspired these designers to more consciously think about the hermeneutic, material, and embodied effects of their design. The research is thus characterized by a combination of theoretical reflection and qualitative data analysis that allows for a research practice that includes designer, wearer (body-in-context), object, and representations as valuable sources of information.
2. From User to Wearer: On Technological Embodiment

Case Study: Anouk Wipprecht, ‘Spider Dress 1.0 and 2.0’

My body is the fabric into which all objects are woven, and it is, at least in relation to the perceived world, the general instrument of my ‘comprehension’ (Merleau-Ponty, 1945/2002: 273).

We are bodies – but in that very basic notion one also discovers that our bodies have an amazing plasticity and polymorphism that is often brought out precisely in our relations with technologies. We are bodies in technologies (Ihde 2002: 138).

As a bystander creeps up on the wearer, the robotic limbs slowly retract, like a spider intently tracking each and every movement of its prey. Suddenly, the dress attacks. The limbs threateningly claw at the approaching subject, protecting the wearer from anyone intruding her personal space. This scene describes an encounter with the robotic ‘Spider Dress 1.0’ (2012) designed by Dutch ‘fashion-tech designer’ Anouk Wipprecht in collaboration with Austrian software engineer Daniel Schatzmayr [Figure 21]. Equipped with proximity sensors, actuators, and controllers that steer a set of six robotic ‘limbs’ on top of the wearer’s shoulders, the dress registers and responds to any movement within the range of ten to eighty centimeters of the wearer. Establishing a complex interaction between body, garment and environment this performative techno-fashion playfully questions the sensorial limits and personal space of the wearer.

Designer, artist, and techno-fashion pioneer Anouk Wipprecht is fascinated by the idea of having both a physical and a psychological relationship with a garment (Interview AW 2016). Schooled in engineering and interaction design as well as fashion design, she represents an emerging generation of designers determined to bring the realms of fashion and technology closer together. Her work encompasses biomechanic cocktail making...
dresses ‘Daredroid’ (2010/11) [Figure 22], an interactive 3D printed ‘Smoke Dress’ (2012) [Figure 23], a ‘mood-logging’ camera dress reacting to brain waves called ‘Synapse’ (2014) [Figure 24], and a series of 3D printed ‘Audi A4’ Dresses (2015) with embedded LEDs and virtual reality projections [Figure 25]. Her clientele includes big names like the Black Eyed Peas, Cirque du Soleil, Intel, and Audi. Taking the emotional, intellectual, and sensorial experience of fashion and technology as a starting point, Wipprecht creatively explores how techno-fashion may accomplish a higher state of connectivity between the body and our clothing (V2_Institute for the Unstable Media 2013).

Wipprecht’s work is not only interesting in showing how techno-fashion can change the functionalities of clothing (clothing can suddenly defend the wearer’s personal space, display virtual reality, or make cocktails) and technology (technology as a form of visual expression and adornment), it also playfully explores the implications of techno-fashion for the wearer’s experience of her body-in-the-world. “Clothing is capable of changing the body’s posture, sensitivity and self-perception,” Elke Bippus writes in *Fashion Body Cult*, “[i]t is not only a hull but can also be a condition for physical experience and consciousness raising” (Bippus 2007: 14). Whenever clothes are worn — either with integrated technologies or without — they inevitably intervene between the wearer’s body and the surrounding material world.

The previous chapter explained why techno-fashion, due to its intimate relation to the human body, mediates experience in a material way. Using Wipprecht’s ‘Spider Dress 1.0’ and ‘Spider Dress 2.0’ as case study, this chapter will further develop and deepen the postphenomenological approach introduced in the first chapter and zoom in on the effects of techno-fashion in terms of embodiment. In what ways does techno-fashion transform and mediate embodied experiences, considering the fact that it is worn on and by the body? First, I expand on embodiment and embodied experiences of fashion, by discussing the work of Merleau-Ponty and his influence on fashion studies. Second, I will apply Merleau-Ponty’s insights on human-objects relations to the case of techno-fashion, and Anouk Wipprecht’s ‘Spider Dress 1.0’ (2012) and ‘Spider Dress 2.0’
(2015) in particular. The chapter subsequently delves into the work of Don Ihde, who redirects phenomenology towards a postphenomenology of human-technology relations.

Exploring the relevance and limitations of the postphenomenological notion of ‘embodiment relations’ for the study of techno-fashion, I will try to unravel and theorize the embodied experiences that Wipprecht’s experimental robotic dress evokes. To investigate how the effects of this particularly performative example of techno-fashion differ from those of a more introvert example, by-wire.net’s ‘Spine Dress’ [Figure 26] will then serve as a comparative example. Before I address how the postphenomenological notion of technological mediation can help to understand the ways in which wearing technology differs from using it, I will first discuss the relationship between clothing and technology as theorized within postphenomenology. The final section of the chapter is devoted to a postphenomenology of techno-fashion, which adopts the notion of embodiment relations and technological mediation to elucidate further why wearing technology is a different experience from using it.

**Addressing the Body: A Phenomenological Approach**

When I interviewed model Whitney Heleker¹ about what it was like to wear Wipprecht’s ‘Spider Dress 2.0,’ she responded that the legs were so delicate that for her to easily move around without damaging the dress the room would first have to be cleared (Interview WH 2017). This wearing experience resonates loudly with Merleau-Ponty’s influential analysis of a woman with a feather in her hat. In his seminal *Phenomenology of Perception* (1945/2002), Merleau-Ponty addresses the close connection between human experience and artifacts, illuminating how human beings relate to the world through objects. Using the hat with a feather as an example, he describes how the clothing item becomes an extension of the woman’s area of sensitivity, to the point where she may “without any calculation, keep a safe distance between the feather in her hat and things

¹ This was written digital interview conducted with model Whitney Heleker through Facebook messenger (Utrecht/San Francisco, 26 June 2017).
which might break it off. She feels where the feather is just as we feel where our hand is” (1945/2002: 165). The example of a feathered hat helps to explain that we grasp space, and our position within space, through movement and embodied encounters with the world around us and – importantly – clothing contributes to and co-shapes that spatial awareness (Entwistle 2015: 29). Clothes closely relate to how we navigate and move in space because they support our body movements (e.g., sports shoes), limit them (e.g., high heels, tube skirt or corset), or provide access to certain social or geographical spaces (e.g., a headscarf or thermo jacket). Fashion, in other words, is to be understood as an embodied discourse and practice that is situated within specific spatial and social contexts (Entwistle 2015: 246). Model Heleker’s memory of how the room would have to be cleared to prevent her movements from doing any harm to the dress’ robotic limbs, signals that the experience of techno-fashion is a deeply embodied experience, as well.

In addition to his analysis of how a feathered hat influences the spatiality and motility of the wearer’s body, Merleau-Ponty reflects on how we tend to experience clothes as an inherent part of our ‘natural’ physique: “If I did not take off my clothes I could never see the inside of them, and it will, in fact, be seen that my clothes may become appendages of my body” (1945/2002: 104). Noting that clothes are like permanent appendages to us, he highlights how the almost continuous proximity of garments generally causes them to be incorporated into the “original structure” of our body (ibid.). We generally walk, cycle, eat, socialize and work while dressed and therefore barely, if at all, know what these activities would feel like if we were not wearing clothes. As we spend most of our lives clothed and hardly ever experience or encounter the world undressed, clothing has become merged with the basic organization of our body.

Another passage in Phenomenology of Perception that is of particular interest for studying embodied experiences of fashion and dress, addresses the ways in which objects (a hat, a car, a stick, a typewriter) can become familiar instruments that we can habitually “transplant ourselves into” and “incorporate (…) into the bulk of our own body” (Merleau-Ponty 1945/2002: 166). Merleau-Ponty then takes his analysis of bodily space a step further by discussing the example of a blind man’s cane:

The blind man’s stick has ceased to be an object for him, and is no longer perceived for itself; its point has become an area of sensitivity, extending the scope and active radius of touch, and providing a parallel to sight. (…) Once the stick has become a familiar instrument, the world of feelable things recedes and now begins, not at the outer skin of the
hand, but at the end of the stick. (...) The pressures on the hand and the stick are no longer given; the stick is no longer an object perceived by the blind man, but an instrument with which he perceives. It is a bodily auxiliary, an extension of the bodily synthesis (1945/2002: 165, 175-176).

The example of the blind man’s stick, Peter-Paul Verbeek explains, allows Merleau-Ponty to demonstrate that the intentional relation between human beings and the world is not only “extended or stretched out” through artifacts spatially (Verbeek 2005a: 125). It makes clear that human beings cannot only extend the spatiality of their lived bodies through artifacts such as a hat but can perceive with them as well (ibid.: 124-125, original emphasis). The intentional relationship between the human body and artifacts thus goes beyond extending bodily space: once the objects have become a familiar instrument, they can be incorporated into the ‘body schema’ as a whole (Merleau-Ponty 1945/2002: 239).

The Clothed, Extended and Lived Body
Merleau-Ponty’s work has proven of great relevance for studying the embodied dimensions of fashion. Since the 1990’s, several fashion scholars have convincingly introduced his phenomenology as a helpful theory for analyzing the interrelations between body and clothing (see for example Craik 1993; Hollander 1994; Sweetman 1999, 2001; Entwistle and Wilson eds. 2001; Young 2005; Woodward 2007; Bruggeman 2014; Entwistle 2015; Negrin 2016; Smelik, Toussaint and Van Dongen 2016). In The Fashioned Body (2015), Joanne Entwistle, most notably, uses Merleau-Ponty’s idea of the body as the locus of experience to bring embodiment to the fore, arguing that any analysis of dress should include the body and explore the dynamic relationship between fabric and flesh (Entwistle 2003: 148). Inspired by Merleau-Ponty’s attention to embodiment, Entwistle develops the notion of dress as a ‘situated bodily practice’ (2015). Ones clothing is always located spatially and temporally and involves the practical and embodied experience of getting dressed. “When getting dressed,” she writes, “one orientates oneself to the situation, acting in particular ways upon the body” (ibid.: 29). Entwistle also regrets that scholars who have written about fashion or dress have tended to leave the body out, ‘disembodying’ fashion by concentrating on representations such as magazines, texts, paintings or photography (2015: 4). Even literature that does account for the body, she remarks, tends to ignore “the lived, experiential body that is articulated through practices of dress” (2015: 5).

Drawing on Merleau-Ponty’s analysis of embodiment as well, Llewellyn Negrin embraces Merleau-Ponty’s phenomenology as a theoretical framework “with which to address
fashion not simply as an aesthetic or symbolic phenomenon but as a haptic experience” (Negrin 2016: 1). Connecting the phenomenological premise to the fashion-focused studies of Iris Marion Young (2005), Entwistle (2001, 2015) and Sweetman (2001), she argues that the embodied aspect of body adornment is, in fact, paramount to the experience of fashion (Negrin 2016: 10). She writes: “our attire becomes an integral part of our corporeal schema, influencing the ways in which we comport ourselves in space” (ibid.: 14).

Merleau-Ponty’s reflections on how items of clothing can become like an appendage to the body help scholars to explore the dynamics between fashion and flesh. The importance of this perspective is famously illustrated by Umberto Eco’s description of wearing tight jeans:

I discovered that my movements, my way of walking, turning, sitting, hurrying, were different. (...) As a result, I lived in the knowledge that I had jeans on, whereas normally we live forgetting that we’re wearing undershorts or trousers. I lived for my jeans, and as a result, I assumed the exterior behavior of one who wears jeans. In any case, I assumed a demeanor (Eco 1986: 192, original emphasis).

Noting how the jeans affected his embodied behavior and experiences, Eco highlights that we are normally unaware of our clothes, but that garments may make their presence felt by provoking an unusual or surprising physical sensation (ibid.). When a garment is notably present due to, for example, its fit or silhouette it can “impinge upon our experience of the body and make us aware of the ‘edges,’ the limits and boundaries of our body” (Entwistle 2003: 145). Eco demonstrates that the physical sensation of a garment touching, clutching or adhering to body and flesh not only determines our sensorial perception of the outside world but also informs a “spatial awareness that derives from interoceptive (i.e., inward-oriented) senses of bodily position, movement and balance” (Paterson 2007: 3-4). By limiting certain movements while inviting others, “dress and fashion regulate the body and thereby produce particular ways of being” (Parkins 2016: 84). Moreover, Eco notes how the pants turned him into “one who wears jeans” (Eco 1986: 192), thereby pointing to the ways in which embodied experiences of fashion are also connected to our sense of self and identity. I will further elaborate on the topic of self-expression and identity in the fourth chapter.

Merleau-Ponty’s phenomenology highlights the potential of fashion to influence how we move, position, and interact with others via our bodies. Interestingly, this embodied
dimension lies at the basis of many techno-fashion designs, and Wipprecht’s work in particular. As mentioned, the delicate robotic limbs of the ‘Spider Dress 2.0’ caused model Heleker to move around more carefully and consciously. Ironically, the “self-defense” (Kaplan 2015) dress turned her into a vulnerable creature that was constantly accompanied by a team of Intel employees in order to protect her spider limbs from damage (Interview WH 2017). “My ability to turn my head was limited by the legs as well,” Heleker also recalled, “so I’d have to turn my body more to look behind me” (ibid.). A positive side effect of the robotic legs, she mentioned, is that they force the wearer to correct her posture: “[b]ecause if I did slouch or put weight on one hip, the added weight would start to wear on some part of my body in compensation for the imbalanced posture” (ibid.).

The ‘Spider Dress 2.0’ impinges upon the wearer’s experience of the body, particularly because of its technological protrusions. The inherently intimate relation between clothes and the body thus becomes even more salient with the advent of techno-fashion. As Anneke Smelik convincingly observes:

> The fact that technology is worn on the body heightens the urgency of taking the body’s materiality into account. Designs from the field of techno-fashion and cybercouture reveal how tactility and sensibility are foregrounded and enhanced in futuristic clothing (Smelik 2012: 154, my translation).

The very idea of wearing technology thus causes the fleshy, phenomenological body to come to the fore. Even more so than garments without integrated technologies, techno-fashion has the power to affect both our internal body awareness and outward bearing (Ryan 2014: 8). The vital role of sensorial and bodily perception in many techno-fashion designs therefore requires a particularly strong and critical awareness of the perceptual, sensorial and physical impacts of techno-fashion. Merleau-Ponty’s phenomenological reflections on clothing and bodily extensions are particularly suited for this purpose.

Merleau-Ponty discusses the experiences of wearing a feathered hat or using a blind man’s stick to show how human beings can extend their bodily space through artifacts and, in some cases, even the perceptual range of their bodies. This phenomenological approach to spatiality and primacy of embodied experience is valuable for studying fashion and techno-fashion because of three reasons (cf. Smelik, Toussaint and Van Dongen 2016). Firstly, phenomenology turns its attention to the lived, experiential body.
Merleau-Ponty describes his philosophy as a “return to the world of actual experience which is prior to the objective world,” and considers it his task ‘to rediscover phenomena, the layer of living experience through which other people and things are first given to us’ (Merleau-Ponty 1945/2002: 66).

Secondly, Merleau-Ponty’s analyses of the feathered hat and blind man’s stick help to understand the deeply embodied nature of clothing, and to analyze how artifacts can become ‘appendages’ of the body (Merleau-Ponty 1945/2002: 104). Moreover, his phenomenological analysis of clothing reveals that the almost continuous proximity of garments generally causes them to become incorporated into our basic bodily experience of the world, pointing out that humans do not just act in the world as bodies, but as clothed bodies (Negrin 2016: 130, original emphasis).

Thirdly, phenomenology directs the attention to the body as the locus of our experiences and thereby inspires a theoretical focus on how garments can rearrange and even extend the spatial awareness and experience of the wearer. On an analytical level, this approach helps to understand how and why techno-fashion affect the wearer’s spatial and physical awareness. On a methodological level, the phenomenological attention to embodied experience also points to the importance of including what phenomenologists call the first-person point of view in research on techno-fashion (Smith 2016). Studying garments from the standpoint of the wearer is important and indispensable for elucidating its effects in terms of embodiment. In fact, phenomenologists emphasize that this first-person perspective is the only way such embodied experiences can be given to us in the first place (Zahavi 2005: 125).

The following section of this chapter will further explore the benefits of a phenomenological approach to techno-fashion. I will apply Merleau-Ponty’s insights on bodily space and extended perception to Anouk Wipprecht’s robotic ‘Spider Dress 1.0’ and ‘Spider Dress 2.0’, assessing how his phenomenology might contribute to a better understanding of the embodied experiences techno-fashion evokes.

**Like a Spider in a Web: Sensing Spatial Proximity**

Although Merleau-Ponty’s reflections on human-artifact relations are not primarily concerned with technological artifacts (Brey 2000: 5), they are very helpful in taking the first step towards understanding the effects of techno-fashion on the wearer’s experience and awareness of the body. Wipprecht’s first Plexiglas prototype of the robotic ‘Spider Dress 1.0’ (2012) [Figure 27] is equipped with proximity sensors that detect
movement within a distance of ten to eighty centimeters from the wearer, causing the robotic spider limbs to “coyly” dance around the wearer’s body while at the same time protecting her if someone approaches too fast or comes too close (Pakhchyan 2013). Seeing this dress in light of Merleau-Ponty’s work, it exemplifies the concept of stretching the wearer’s bodily spatiality through techno-fashion. Not unlike the feathered hat, the out-thrust spider limbs change the outlines and spatiality of the wearer’s body. They not only literally extend the wearer’s body by expanding it into the surrounding space, but also inevitably influence how she navigates and comports herself in space (Negrin 2016: 14). Like Merleau-Ponty’s hatted woman has “a tacit knowledge of the location of her feather,” the wearer of ‘Spider Dress 1.0’ implicitly knows the location and dimensions of the prosthetic spider limbs (Brey 2000: 4).

With her second version of the dress, Wipprecht went even further in trying to create “an extension of the wearer’s intuition” (ibid.) or, as it would be described in phenomenological terms, “an extension of the [wearer’s] bodily synthesis” (Merleau-Ponty 2002 [1945]: 176). Like the 1.0 version, the ‘Spider Dress 2.0’ (2015) [Figure 28] is equipped with
two proximity sensors and twenty servomotors\(^2\) that allow it to monitor and defend the wearer’s personal space. This more intricate 3D-printed version of the dress additionally contains embedded respiration sensors in the chest piece and learned threat detection to control the defensive behavior of the robotic limbs (Kaplan 2015). It combines data on the behavior of people within a seven-meter proximity, with real-time biometric signals on the wearer’s breathing. Based on pre-programmed social norms and violations the system is able to detect exactly when someone is violating the wearer’s personal space and will respond accordingly by showing twelve different states of defensive behavior. Encroachers approaching the wearer too quickly or closely are met with violently moving robotic spider limbs, that clearly tell them to “back-off” (Heleker 2015a).

Applying Merleau-Ponty’s phenomenological analysis of the feathered hat and blind man’s cane to Wipprecht’s ‘Spider Dress 2.0’ provides further insight into how techno-fashion may affect the wearer’s embodied experiences. When asked what it feels like to wear the attention-grabbing robotic spider limbs at the Consumer Electronics Show in 2015, model Whitney Heleker responded: “I feel like it is really a part of me (…) I don’t feel any pressure points of the weight, so it’s pretty spread out and honestly pretty comfortable” (Heleker 2015b). When I asked her to elaborate on the wearability of the design, she explained that the dress was such a perfect fit because it was 3D-scanned to her body (Interview WH 2017). Firstly, this indicates how the model’s body was incorporated the dress (Merleau-Ponty 1945/2002: 239). Rather than experiencing the 3D-printed robotic limbs as something detached and separate from her body, Heleker became so familiar with wearing them that they have started to feel like a part of her. For Wipprecht, this idea of the technology merging with the body is actually what techno-fashion is all about: “[i]f you wear a design that you partly control, and it partly extends your agency through its autonomous actions, you start to question where you end, and my system begins” (Wipprecht 2014).

Secondly, Wipprecht’s techno-fashion epitomizes the phenomenological idea of artifacts through which the user’s scope of sensorial perception is extended (Merleau-Ponty 1945/2002: 165). Enabling the wearer to perceive more than she could do in a non-technological garment, the dress demonstrates that “[t]he experience of the corporeal schema is not fixed or delimited but extendable to the various tools and technologies which may be embodied” (Broadhurst 2012: 168). The embodied experience of the

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\(^2\) A servomotor, often abbreviated as servo, is a small device that allows for a precise automatic control of a mechanic system (Reed 2016). The servomotor is a popular and inexpensive method for motion and position control within robotics and wearable technology design.
‘Spider Dress 2.0’, one could even say, is somewhat similar to that of a spider in her web. The lines of the spider web, as Tim Ingold puts it in his playful philosophical dialogue between an ant and a spider\(^3\), are an extension of the spider’s “very being as it trails into the environment” and comprise the lines along which the spider lives and conducts perception and action in the world (Ingold 2008: 211). Like spiders know when a fly has landed in their web because they can feel the vibrations in the lines through their spindly legs (ibid.), wearers of the ‘Spider Dress 2.0’ know when a person is entering their personal space because they can perceive the intruder’s presence through the robotic spider legs.

Thirdly, phenomenology calls attention to the lived experiences of ‘Spider Dress 2.0’, which helps to discover how the “symbiosis between body and machine (...) brings with it a new body consciousness” (Quinn 2002: 33). As Eco’s reflection on tight-fitting jeans elucidates, clothes can stimulate and heighten the wearer’s self-awareness:

> Not only did the garment impose a demeanor on me; by focusing my attention on demeanor, *it obliged me to live towards the exterior world* (...) Well, with my new jeans my life was entirely exterior: I thought about the relationship between me and my pants, and the relationship between my pants and me and the society we live in. I had achieved hetero-consciousness, that is to say, an epidermic self-awareness (1986: 193-194, original emphasis).

In the case of ‘Spider Dress 2.0’ this epidermic self-awareness is not so much invoked by the tight fit of the garment – wearers describe it as “lightweight” (Sam 2015), “honestly quite pleasant to wear” (ibid.), and “pretty comfortable” (Heleker 2015b) because it was 3D-scanned to fit the model’s body perfectly (Interview WH 2017) – as by the way in which the attention-grabbing technology makes wearers conscious of the distance between their skin and those around them.

As Wipprecht explained in an interview\(^4\), the robotic dress is inspired by Edward T. Hall’s (1966/1990) idea of different zones of spatial perception around the human body, also referred to as ‘proxemics’ (Interview AW 2016). Hall divides the ways in which humans

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\(^3\) Ingold tells the tale of an ANT and a SPIDER that debate each other’s perspectives on material agency. ANT represents the Actor Network Theory notion of material agency as distributed around a network within the story, while the SPIDER defends Ingold’s own take on material agency as emerging from “the interplay of forces that are conducted along the lines of the meshwork” (Ingold 2008: 212; cf. Ingold 2011: 89-94). I will get back to this philosophical insect tale in the next chapter, chapter three, where I elaborate on material agency as the subject of heated scholarly debate.

\(^4\) This was a Skype interview I conducted with Anouk Wipprecht while she was in San Francisco (Utrecht/San Francisco, 16 February 2016).
manage the distance between themselves and others into four different zones: intimate, personal, social, and public (1966/1990: 113-129). The ultrasonic range finders and proximity sensors located in the black “eyeballs” of ‘Spider Dress 2.0’ record where people around the wearer are standing and how fast they approach (Wipprecht 2017). Based on Hall’s zones of spatial experience, Wipprecht has pre-programmed the robotic spider limbs to react to these data with twelve states of behavior (i.e., three for each zone) [Figure 29]. On the one hand, the dress thus alerts wearers to the behavior of those approaching, making wearers (more) conscious of their own position and of what is happening around them. On the other hand, the ‘instinctive’ reaction of the spider limbs also sends a clear signal to those within the personal space of the wearer. The closer and faster someone moves towards the intimate space of the wearer; the more aggressive and fast the limbs will move. This animalistic way of responding to intruders is unmistakable, even for someone lacking any basic understanding of technology (Interview AW 2016).

The ‘Spider Dress 1.0’ is a fully automated system that continuously responds to proximity. “It’s a self-defending mechanism,” “a human-arachnid hybrid” that transforms the wearer’s body “into a stage where the garment becomes the leading actor” (Wipprecht 2013). The ‘Spider Dress 2.0’ (2015) has a similar set-up but with the added possibility for the wearer to co-control the movements of the spider limbs. Due to the respiration sensors in the “kidneys” on both sides of the bodice, wearers can calm the dress down by slowing down and deepening their respiration or amplify the aggressiveness by increasing their breathing rate. “If my legs are overactive” model Heleker explains, “I can take a deep breath to kind of let them relax a little so that I can have a conversation with someone when they are in my personal space” (2015a). Instead of the “spider” controlling the situation, constantly attacking anyone in the direct vicinity of the dress, the wearer can now influence the intensity of the robotic movements by managing his or her own respiration (Interview AW 2016). As Sabine Seymour points out, techno-fashion should be careful not to turn human bodies into extensions for technological advances, rather than the other way around (Seymour 2009: 14).

The respiration sensors incorporated in the second version of the spider dress add another dimension to the wearer’s self-awareness. The spider’s reaction to the environment and the wearer’s embodied control of that reaction become enmeshed, causing the wearer to feel like the limbs are “really a part of [her]” (Heleker 2015b). The respiration sensors directed Heleker’s attention to her respiration, as well as to the relation between her breathing, the dress’s behavior, and the environment. The dress is not meant to be like an automatic weapon or unmanned drone that will fire as soon as it detects a
threat. The dress makes both the wearer and the environment aware of personal space, but not without “asking” the wearer if it indeed feels the need to be protected, offering the possibility to take control of the situation (Interview AW 2016). This results in what Wipprecht calls “an interesting interplay between co-control and education of your own body and mind” (Kaplan 2015). Adding the possibility to physically control the dress’ behavior thus not only stimulates the wearer’s body awareness but also connects the question of personal space and privacy to the issue of control. “When people were too close, my legs would start getting too crazy and lost their sensitivity to the movement towards me because there was so much going on,” model Heleker recalls (Interview WH 2017). This loss of control and sensitivity on the side of the technology made her want to take control over the technology, “[s]o it was good to have the respiration band to relax the legs and basically reset them” (ibid.). The importance of control in relation to techno-fashion is more extensively explored in chapter five.

My phenomenological approach to Wipprecht’s spider dresses demonstrates that techno-fashion offers the potential to, on several levels, increase wearers’ awareness of their “body-in-the-world” (Merleau-Ponty 1945/2002: 164). Whereas the first, outward-oriented version of the spider dress only concerns a more conscious experience of the spatiality and position of the wearer’s body in relation to the surroundings, the ‘Spider Dress 2.0’ shows that techno-fashion has the capacity also to raise awareness of internal and normally unconsciously experienced body signals (e.g., as breathing or heart rate). The ‘Spider Dress 2.0’ amplifies already existing but unconsciously perceived body signals by bringing them to the attention of the wearer. This case study indicates that techno-fashion can, as it were, function like a spider’s web: the dress affects the way wearers position and move their body in space, tells them what is happening in their environment, and extends their perceptual scope beyond the boundaries of their bodies.

Outward versus Inward, Subtle versus Strong
Wipprecht’s ‘Spider Dress 2.0’ is not exactly a subtle way to raise the issue of personal space and protect the wearer from unwanted attention. On the contrary, model Heleker describes:

Many people wanted pictures. And a lot of people were in awe of the dress. Many people almost found it very funny, maybe because it’s just so bizarre. The average person seemed blown away by the concept of the dress, while the Techy people seemed more interested in the “nuts and bolts” of the dress” (Interview WH 2017).
The ‘Spider Dress 2.0’ is a particularly interesting case study because it exemplifies a provocative and outward-oriented experiment with how techno-fashion can play with and extend embodied experiences. Like the majority of techno-fashion, this dress combines sensor technology and actuators to register and respond to information about the environment and/or the wearer’s body. Although the technology embedded in Wipprecht’s robotic outfit is representative for the field at large, the visual appearance of her work is somewhat peculiar and extreme. Wipprecht’s techno-fashion is performative, provocative, and futuristic rather than applied. She deliberately designs one-off prototypes and presents them during shows and exhibitions as an artistic proposition for future human-technology relations. She claims that her interest mainly goes out to intimate one-on-one interactions between technology and the human body rather than spectacular theatrical performances (Interview AW 2016), but it is undeniable that her ‘technological couture’ is all about attracting attention to craft and design, and openly displaying the aesthetics and nuts and bolts of the technology as well.

When considering the extrovert and artistic nature of the ‘Spider Dress 2.0’, it is little surprising that her dresses heighten the wearer’s body awareness, as well as remind the environment to be aware of the wearer’s personal space. As model Heleker notes, the dress, in fact, attracts so much attention that its seem to achieve the opposite of what it was designed to do: “Wearing the spider dress put so much attention on me. It was ironic how the dress was meant to keep people away but actually attracted them more towards me” (Interview WH 2017). Designs that occupy the other, more utilitarian end of the techno-fashion spectrum integrate technology in a more subtle, unobtrusive, and hidden way. When researching the embodied experience of techno-fashion, therefore, it is important to take into account that the extent and intensity of the effects will differ from design to design, from the wearer to wearer, and from moment to moment. To illustrate these variations, I will briefly compare the physical effects of Wipprecht’s ‘Spider Dress 2.0’ to those of a design that integrates technology in a more introvert and inward-oriented way: the ‘Spine Dress.’

The ‘Spine Dress’ [Figure 30] is a creation of by-wire.net, a design and research company in fashion technology founded and led by Marina Toeters (by-wire.net). The dress contains a band of conductive copper on the back, which gradually warms up when a current is run through the copper wires. Hidden inside the band on the back, the technology embedded in this dress is hardly noticeable to the wearer. As Toeters mentions in the interview I conducted with her:\footnote{This was a face-to-face interview with Marina Toeters (founder and owner of bywire.net), that took place in Utrecht on December 3, 2014.} she prefers to bring techno-fashion closer to
30. By-wire.net x CRiSP, ‘Spine Dress’ (2011/15)
Photography by Wetzer & Berends (Studio Huid & Haar) © Wetzer & Berends
everyday clothing, designing intimate personal experiences rather than eye-candy (Interview MT 2014). Tellingly, one of the respondents wearing the ‘Spine Dress’ at one of our fitting sessions\(^6\) described the temperature rise caused by the dress as “so gradual that you are hardly aware of it until you realize your entire body actually feels warmer after a while” (wearer 2, fitting 2). This indicates that even though the more applied and subtle types of techno-fashion may evoke less striking or immediately noticed transformations, their effect on the embodied experience of the wearer may still be strong. After all, making the wearer feel warm and comfortable in everyday life can be just as powerful or important an effect, as making her feel safe and protected.

Towards a Postphenomenology of Techno-Fashion

Clearly, there is a difference between wearing a feathered hat or using a blind man’s cane and wearing Wipprecht’s bold ‘Spider Dress 2.0’. Although Merleau-Ponty’s account of embodiment is highly insightful for studying how techno-fashion alters our being-in-the-world, it also has its limitations. Merleau-Ponty describes embodiment only in relation to artifacts and instruments that do not ‘act’ without or beyond interaction with a human subject. Yet even though a dress with sensors only makes sense when interacting with an audience (Hoogervorst 2016: 6), techno-fashion can often also act or react without human intervention. Wipprecht’s ‘Spider Dress 2.0’ has been programmed to automatically respond and adapt to specific stimuli (movement, proximity, respiration), and by-wire.net’s ‘Spine Dress’ warms of its own accord. To a certain extent, techno-fashion such as the ‘Spider Dress 2.0’ almost seems to have a ‘life’ of its own: at times acting as if it is an autonomous entity that is sensitive and responds to certain circumstances (for a more elaborate discussion of how technology ‘animates’ fashion, see my discussion of material agency in chapter three).

Fittingly, Wipprecht describes her designs as “‘host’ systems on the human body” that move, breathe, and react to the environment around them (Wipprecht n.d.). As phenomenology does not account for such self-acting objects, there is a need for a “non-subjective” and “interrelational” kind of phenomenology that resists “the transcendental

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\(^6\) As explained in the methodology section of the first chapter, our research methodology included fitting sessions during which we gathered interview data on how wearers actually experience, use and evaluate specific techno-fashion designs. Inspired by the phenomenological attention to embodied experience, we asked respondents about their physical and psychological experience of the designs, addressing aspects such as freedom of movement, body awareness, spatiality, and comfort as well as visual appearance, style, taste and social context. Fittings are numbered in chronological order, and the different respondents are labelled anonymously (see list of wearer interviews in appendix).
perspective of the major phenomenologists of the twentieth century” (De Preester 2010: 340). This is where I encounter the particular merit of postphenomenology, which takes the interrelations and mutual constitution of objects and subjects, technologies and human beings as its starting point.

As explained in the first chapter, postphenomenology is a relatively new framework of analysis that uses some of the cornerstones of phenomenology to build a theory of contemporary human-technology relations (Ihde 1990, 2009; Selinger 2006; Verbeek 2005a, 2011; Rosenberger and Verbeek eds. 2015). Much like the phenomenologies of Husserl and Merleau-Ponty, postphenomenology views human beings and their world as mutually constituting each other. Revising this phenomenological premise for his analysis of the highly industrialized and high-technology society in which we now live Don Ihde, the founding father of postphenomenology, focuses on what happens when the relationship between human beings and the world is technologically mediated (Ihde 2009: 57, original emphasis). Verbeek defines this phenomenological take on human-technology relations as follows: “[t]hings – and in our current culture especially technological artifacts – mediate how human beings are present in their world and how the world is present to them; they shape both subjectivity and objectivity” (Verbeek 2005a: 235).

According to Verbeek, Ihde’s postphenomenological work has been pioneering in two respects: it made technology the subject of philosophical reflection and applied the tools of the phenomenological tradition to the study of technology “at a time when it was far out of the philosophical mainstream” (Verbeek 2001: 119-146). Often considered Ihde’s most renowned and influential book (Selinger 2006: 5; Verbeek 2001: 119), Technology and the Lifeworld (1990) set out to develop “a philosophy [that] can provide a framework or ‘paradigm’ for understanding” human-technology relations (Ihde 1990: 9). Through a departure away from traditional phenomenological analyses of technology, postphenomenology redirects phenomenology towards a philosophy of technology. A philosophy that addresses the role of technologies in contemporary life, and the diverse ways in which technologies are culturally embedded. Before I address how the postphenomenological notion of technological mediation brings us one step closer to understanding the ways in which wearing technology differs from using it, I will first discuss the relationship between clothing and technology as theorized within postphenomenology.

**Why Clothing is a Technology**

Ihde begins his analysis of human-technology relations by focusing on the perceptual and bodily experience of the world. He enters phenomenology through an exploration
of the “[q]uality of our mediated relation to the world and its difference from our naked relation to the world” (Ihde 1990: 46). Interestingly, he uses clothing as an example of how technology may mediate, and on some levels even substitute bodily experiences:

As long as I experience at all, I do so in bodily-perceptual ways, and this is the case inside any technologies I may occupy. In a cold environment, I could tactilely experience the wind and chill; but if I have ‘chosen’ to mediate that cold by wearing down clothing, I now substitute feeling the wind for feeling the warmth of what I am wearing. In this case, the “environment” is simply brought close, and itself has the texture of one of the many cocoons humans employ in all non-Garden situations. The technology (clothing), however, transforms this immediately experienced environment; and it is that transformation which must be investigated (Ihde 1990: 17, original emphasis).

Not unlike several fashion scholars inspired by Merleau-Ponty (cf. Entwistle 2015; Negrin 2016), Ihde here recognizes that our embodied experience of the world is continuously mediated by clothing: we generally substitute the experience of our body-in-the-world for the experience of our clothed body-in-the-world. We are so used to clothing that it feels like a pervasive “cocoon” from which we constantly perceive our environment (Ihde 1990: 17). As an example, Ihde explains how the bodily-perceptual experience of coldness can be replaced by the sensation of warmth through clothing. Although Ihde does not mention this himself, his example of clothing as a medium that mediates our bodily experiences strongly resonates with Marshall McLuhan’s well-known description of clothing as an extension of the skin (McLuhan 1964/2002: 129-132; also see Smelik 2017: 258). McLuhan writes:

Clothing, as an extension of the skin, can be seen both as a heat-control mechanism and as a means of denning the self socially. In these respects, clothing and housing are near twins, though clothing is both nearer and elder; for housing extends the inner heat-control mechanisms of our organism, while clothing is a more direct extension of the outer surface of the body (1964/2002: 129-130).

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7 In Technology and the Lifeworld, Ihde uses the idea of a “New Garden” – an “imaginative” and “abstract variation” of the biblical Garden of Eden – to investigate and question the possibility of non-technological human existence (1990: 11-15).
As a direct appendage to the skin, clothing replaces our organic “protective buffer” with one that envelopes, yet is external from, the body (ibid.: 43). To McLuhan, clothing is therefore only one of the many technologies that extend the human body. Taking this idea of technology as an extension of the body a step further, Smelik notes that “[w]e have now entered an age in which technology is not only an extension, but also an improvement, enhancement, and expression of the body. We use technology with the idea that we can control, improve and enhance our life and even our own body” (Smelik 2017: 258). Techno-fashion is exemplary of this development, as it combines the domains of clothing and technology, directly extending the human body in order to improve, enhance, support, protect, or assist it. As we have seen, by-wire.net’s ‘Spine Dress’ extends the body’s inner heat control mechanism, while Anouk Wipprecht’s ‘Spider Dress 2.0’ extends its perceptual range and stimulates the wearer’s body consciousness. In fact, it could be said that the robotic spider limbs equip the wearer with an additional “protective buffer” (McLuhan 1964/2002: 43) or defensive “cocoon” (Ihde 1990: 17) around the body that warns off any intruders.

Like McLuhan, Ihde considers clothing a technology. According to Ihde, clothing is almost synonymous to technology in the sense that it mediates and transforms the bulk of our encounters with the world and has always had both a practical and a cultural purpose. Both technology and clothes are human-made artifacts that mediate our lives on a personal as well as societal level. As anthropologist Daniel Miller writes, “[c]lothes are among our most personal possessions,” “[t]hey are the main medium between our sense of our bodies and our sense of the external world” (2010: 23). From a postphenomenological point of view, a garment equipped with robotic arms or sensors is no more ‘technological’ than any other garment; it inevitably mediates the wearer’s embodied experience of the world. Moreover, technology and textiles are closely linked linguistically, as the origins of the two words can be traced back to the Indo-European word teks (to weave or fabricate) and the ancient Greek word techné (an art, craft or skill) (Hughes 2004: 3). What clothing, fashion, and textiles have in common with computers, telephones, tools, or instruments is that they are material artifacts that stem from “the creative activities, individual and collective, of craftsmen, mechanics, inventors, engineers, designers, and scientists” (ibid.: 4). It follows that the realms of fashion design and technology are not as far removed from each other as one might think. The novelty of techno-fashion, then, is not so much its technological nature as the fact that it requires craftsmen, mechanics, inventors, engineers, designers, and scientists to join forces.
Ihde initially adopts an unbounded and inclusive definition of technology because it permits him to emphasize that “the technological form of life is part and parcel of culture, just as culture in the human sense invariably implies technologies” (1990: 20). Notwithstanding cultural or historical differences and in spite of many variations, “human activity from immemorial time and across the diversity of cultures has always been technologically embodied” (ibid., original emphasis). Technologies, from the very basic and traditional (e.g., primitive clothing or weaponry) to the advanced and intricate (e.g., wearables or drones), are an inextricable part of embodied human existence.

From Ihde’s perspective, technologies belong to our cultures in such an intimate way that a life completely devoid of technology has become almost unthinkable: “Not much of my life is lived nakedly; when it is so lived, it is never far from the material clothing that is our technological embodiment” (1990: 46). There is no sharp division between the clothed body and the naked body, between the body adorned with techno-fashion and the body adorned in ‘mere’ clothes. In other words, as Lars Svendsen concludes in *Fashion: A Philosophy*: “If you remove all the clothes, you will not find a ‘natural’ body but a body that is shaped by fashion: the body is no more ‘natural’ than the clothes it wears” (Svendsen 2006: 79). Ihde shows that the same argument applies to technology in general: even if our bodies and lives would be stripped bare of technology (including clothing) altogether, the technological form of life that comes so natural to us would still be present in our embodied experience of the world.

*Understanding Technological Mediation*

Ihde’s approach to human-technology relations highlights that techno-fashion, from a phenomenological perspective, is no more technological than clothing. Whether it concerns plain technology, techno-fashion, or clothing; they all mediate human experiences of the world in one way or another. Yet the experience of wearing an ordinary sweater or jeans is obviously different from wearing a robotic, self-moving dress or even a regular sweater with integrated sensors. The crux of this difference lies in the extent to which the object – be it a garment, a technology, or a combination of both – transforms our embodied experience. It is in this domain that Ihde’s postphenomenology becomes particularly valuable, because of its preoccupation with the human experience of technologies, and the *structure* of that experience specifically (ibid.: 23, original emphasis; cf. Verbeek 2001: 123).

The first step in Ihde’s analysis of the different structures of human-technology relations is to identify two, closely linked and intertwined, modes of *perception*:
microperception and macroperception (1990: 29). The first defines what is “usually taken as sensory perception (what is immediate and focused bodily in actual seeing, hearing, etc.),” whereas the latter refers to “a cultural, or hermeneutic, perception” (ibid.). Applied to Wipprecht’s ‘Spider Dress 2.0’, this implies that wearers and their environment perceive this garment in two, interconnected ways. The specific movements of the robotic limbs can be perceived visually; the microperceptual experience of the dress involves ‘seeing’ their movement. Yet, that visual stimulus does not become meaningful unless it is placed within a cultural framework. On the macroperceptual level, the movement of the limbs will first have to be recognized and understood as a form of defense or attack in order for the dress to effectively warn off those entering the personal space of the wearer uninvited. As the wearing experiences of model Heleker point out, however, the intended relationship between the microperceptual and macroperceptual experience of the ‘Spider Dress 2.0’ does not exactly match with the actual responses of most spectators (Interview WH 2017). Heleker notes how many people were in awe of the dress and constantly wanted to take pictures, while others thought it was mainly funny or bizarre (ibid.). “The average person seemed blown away by the concept of the dress,” she remarks, “while the techy people seemed more interested in the ‘nuts and bolts’ of the dress” (ibid.). The responses to the dress thus differed from spectator to spectator, but overall it tended to attract people towards the wearer rather than send them off (Heleker 2015b).

In addition to differing from individual to individual, macroperceptual experiences of the ‘Spider Dress 2.0’ turn out to also differ from culture to culture. When showcasing the dress in the Netherlands, Wipprecht noticed, the audience is much more curious and daring in approaching the dress which often causes the spider limbs to totally “freak out” (Wipprecht 2017). Within this specific cultural context, people did not seem to feel intimidated or threatened by the dress at all. In the United States or Asian countries, on the contrary, spectators were generally much more restrained in their interaction with the dress, almost to the point where Wipprecht had to “push these polite people into coming closer to the dress” (ibid.). The showcasing and testing the ‘Spider Dress 2.0’ in various cultures and settings, thus reveals that the microperceptual experience of techno-fashion differs depending on the specific cultural, social and historical context within which that experience becomes meaningful.

Verbeek, who uses Ihde’s work as a point of departure for his own philosophy of technological artifacts, explains Ihde’s distinction between micro- and macroperception as the difference between the “bodily dimension of sensory perception” as theorized
by Husserl and Merleau-Ponty, and the “contextual dimension of experience” (Verbeek 2005a: 122). Both Ihde and Verbeek emphasize that although these two dimensions of perception can be distinguished, they are always intertwined and interdependent (Ihde 1990: 29; Verbeek 2005a: 123). There is no microperception without macroperception and vice versa, because “a bodily perception can no more exist without being interpreted than an interpretation can exist without something to be interpreted” (ibid.). This intertwining and interdependency of micro- and macroperception also come to the fore in the experience of techno-fashion.

Wipprecht’s ‘Spider Dress 2.0’ is designed to respond to proximity by showing twelve different states of behavior varying from “territorial attack mode” to “friendly fire mode” (Wipprecht 2015), which presupposes that both wearer and spectators will manage to interpret their visual perception of the spider arms (microperception) as either defensive and aggressive, or friendly and inviting (macroperception). As Verbeek explains, Ihde’s bipartite analysis of technological mediation not only provides insight to different types of perception but also shows “how transformations of micro perception affect macroperceptual ways of seeing” (2005: 131). This insight allows for a better understanding of how techno-fashion can invite and alter specific embodied experiences. It helps to see that the function of techno-fashion such as Wipprecht’s robotic dress, is predicated upon the intertwinement of microperception and macroperception. The dress is pre-programmed to adapt its movement to stimuli in the wearer’s body and the environment, allowing it to alternate between showing movements (microperception) that represent territorial defense versus those that invite playful interaction (macroperception).

Moreover, acknowledging the interrelation between micro- and macroperception contributes to a better understanding of how the wearer’s embodied experience of an environment might change because of techno-fashion. “[B]eing in front of everyone and representing the spider dress’ powerful energy,” model Whitney Heleker experienced, she “kept a strong posture almost the entire time” (Interview WH 2017). Wearing ‘Spider Dress 2.0’ made her assume a strong posture and embody the strong appearance of the dress. Interpreting the dress’ behavior and look as powerful and protective, the Heleker’s overall experience of interpersonal interactions and the environment was also transformed. “I definitely felt more confidence with the dress,” Heleker describes, “simply because it is a fashion statement of power” (ibid.). Wearing this particular example of techno-fashion thus made her feel more confident and comfortable than she would have been without it: “[p]eople’s natural interest in the dress is almost like an ego boost lol” (ibid.). In fact, most examples of techno-fashion are based on this idea that
a change in microperception (a different posture, a warmer spine, a visual perception of the air quality, et cetera) will positively affect the wearer’s macroperception as well (feeling less stressed, more comfortable, empowered, healthier, safer, et cetera).

Attention to how microperceptions affect macroperceptions helps explain why the effects of the ‘Spider Dress 2.0’ may even transcend the embodied experiences of wearers and those approaching them. Wipprecht regularly receives “fan mail” for the dress from victims of sexual abuse or violence that have never actually seen or worn the dress in real life. Apparently, even just the concept and visual representations of this dress (online photo and video footage) already speak to these victims in such powerful ways, that it gives them a feeling of recognition and empowerment (Interview AW 2016).

Ihde’s emphasis on the distinction and interrelation between micro- and macroperception shows that technological mediation transforms human experience and that this transformational character is “one root of their non-neutrality” (Ihde 1990: 49, original emphasis). By focusing on relations between human beings and technological artifacts, postphenomenology provides us with the tools to study the various ways in which techno-fashion helps to shape relations between humans and the world. In addition, the postphenomenologists’ attention to human-technology relations elucidates why techno-fashion can never be merely functional or instrumental because it inevitably mediates human experiences and practices, be it in spectacular or in subtle ways (Verbeek 2015: 190). Techno-fashion, it follows, is non-neutral in that it mediates the wearer’s bodily-sensory and cultural-hermeneutic experience of the world, no matter how subtle that transformation might be. This insight is of vital importance for the development, study, and implementation of techno-fashion. Acknowledging that each type of bodily-sensory output (e.g., sound, light, smell, movement, visual display or touch) presupposes a specific cultural-hermeneutic experience of that output, allows for a better understanding of how techno-fashion affects the ways in which wearers experience their bodies and environment.

Depending on the context, the movements shown by the ‘Spider Dress 2.0’ may cause the wearer to feel safe, confident and attractive or, on the contrary, scared and suspicious. Moreover, people encountering the wearer may consider the moving spider limbs threatening and scary or, on the contrary, attractive and fascinating. The same applies to any kind of touching, seeing, hearing or feelings elicited by other techno-fashion: in order to understand the structure of the embodied experiences evoked by techno-fashion, the reflexive relation between bodily sensations and their cultural-hermeneutic context has to be taken into account.
Variations of Human-Technology Relations
Paying attention to what Ihde has termed micro- and macroperception provides insight into how techno-fashion transforms perceptions on both a bodily-sensory and cultural-hermeneutic level of experience, while it also helps to understand the inextricable intertwining of both modes of perception. This is the first step in Ihde’s account of human-technology relations, which makes clear that the possibilities and the constraints of techno-fashion “are not derivable from simple material properties, nor is one directly aware of them” (DePreester 2010: 343). Whether the ‘Spider Dress 2.0’ can effectively give the wearer a sense of empowerment and protect his or her personal space, is only partially determined by its movement and appearance yet has everything to do with the embedded, situated, and embodied ways in which it is experienced (ibid.: 343-344).

The second step in Ihde’s phenomenology of human-technology relations is to inquire into the various ways in which humans interact with their environment by means of technologies (Ihde 1990: 72). He develops a continuum of four different variations of human-technology relations: embodiment relations, hermeneutic relations, alterity relations, and background relations (1990: 72-112; 2009: 41-44). Connecting these relations to the ‘Spider Dress 2.0’ helps to explain how they manifest themselves in the case of techno-fashion, as well as illuminates why it concerns a continuum of human-technology relations rather than a strict distinction.

At one extreme of the continuum of human-technology relations lie the embodiment relations, which in this case means that ‘Spider Dress 2.0’ withdraws from the wearers’ attention and is temporarily incorporated into their bodily experience of the environment. This is the kind of relationship that occurs when wearers feel as if the garment is really a part of their bodily synthesis. The next moment, the spider dress can enter into a hermeneutic relation, in which the wearer or spectator attends to the behavior of the dress and interprets it as referential to personal space. Another type of relationship that techno-fashion can occupy are background relations. When techno-fashion becomes part of a background relation, it functions as a kind of “absent presence” (Ihde 1990:111; cf. Verbeek 2005a: 128), as the mere context or backdrop against which the wearer or spectator experiences the world. Although the wearers and/or spectators of ‘Spider Dress 2.0’ may at a certain point become so familiar with the dress that it no longer constantly catches their attention, it seems unlikely that it will ever become “barely detectable background presence” that merely “textures” in the environment (Ihde 1990: 109). Chances are small, therefore, that this particular technological artifact will easily engage in background relations.
At the other extreme of the continuum lie alterity relationship wherein the robotic spider dress is experienced as a quasi-other to which the wearer or spectator can relate almost as if it is an animate creature, a “human-arachnid hybrid” (Wipprecht 2013). I will come back to alterity relations and hermeneutic relations in chapter three and four respectively. The remainder of this chapter will focus on embodiment relations, analyzing the ‘Spider Dress 2.0’ in terms of technological embodiment and explore the differences between using and wearing technology.

**Embodiment Relations**

What Ihde terms embodiment relations refers to relations that “incorporate material technologies that we experience as taken into our very bodily experience (Ihde 2009: 42, original emphasis). In the case of techno-fashion, embodiment relations imply that the design enters into the wearer’s bodily, actional, and perceptual relationship with the environment (ibid.). The wearer’s perceptual and bodily abilities are transformed through the techno-fashion (Ihde 1990: 72, original emphasis). The examples Ihde gives of such embodied technologies are instruments and perceptual aids such as telescopes, glasses and the blind man’s cane (ibid.: 73-74). As for the latter, Ihde refers to Merleau-Ponty’s discussion of the blind man’s cane: “(…) Merleau-Ponty discerns that perception may be materially extended through the ‘body’ of an artifact. Perceptual extension is not limited by the outline of my body or the surface of my skin” (ibid.: 40). This chapter already addressed how Wipprecht’s ‘Spider Dress 2.0’ acts in a way similar to the blind man’s cane: it functions as an instrument through which the wearer experiences something in the world (Ihde 2002: xi). As wearers take the dress into the experience of their body and the world around them, an embodiment relation between body and techno-fashion occurs. A schematic representation of such embodiment relations to techno-fashion, looks as follows (Ihde 1990: 73; cf. Verbeek 2005a: 125):

(Wearer – techno-fashion) → world

Together, the wearer and garment form the perceptual and embodied entity through which the wearer experiences the world. Wearers form a unity with the techno-fashion (hence the brackets) as they incorporate the technology into their “perceptual and body sense” (Ihde 1990: 72). Techno-fashion is positioned as the mediator in-between the wearer and the world because it is via the garment that the world is perceived.

Embodiment relations, as defined by Ihde, are applicable to the ‘Spider Dress 2.0’ to the extent that wearers may, at specific moments, experience the techno-fashion as taken
into their very bodily experience (Ihde 2009: 42). As long as the wearer consciously attends to the spider dress, the will remain “object-like” (ibid.), but as soon as the dress withdraws from explicit attention, it has the potential to enter into an embodiment relation with the wearer. Model Heleker’s description of how the ‘Spider Dress 2.0’ made her feel “like it is really a part of me” (Heleker 2015b) suggests that the robotic spider limbs, despite their attention-grabbing look and behavior, did at a certain point withdraw from her attention, so she incorporates the dress into her bodily experience. It follows that the ‘Spider Dress 2.0’ is capable of engaging in ‘symbiotic’ relationships with the wearer, acting as an “interface” between the body and the world (Interview AW 2016). As we have seen earlier in this chapter, however, Wipprecht’s ‘Spider Dress 2.0’ does more than merely mediate between the wearer and the world by extending the body outward (spatially and perceptually) into the environment: it transforms the wearer’s experience of his or her own body in various ways, as well as changes how others perceive the wearer. This makes the question of embodiment much more complex and multi-directional than in the simple instrumental cases that Ihde discusses. Studying embodiment relations in isolation from the individual subject and the social and cultural context in which these relations occur, thus overlooks the kind of multi-directional, complex and elusive material mediations effectuated by techno-fashion.

**Between Transparency and Transformation**

A determining factor for identifying different human-technology relations is the degree to which our experience of the technology is transparent. Postphenomenological thinkers emphasize that technologies have to meet specific conditions to become part of an embodiment relation. Using glasses as a representative case, Ihde observes that technology must, first of all, have the technical capability – the right physical characteristics – to become ‘transparent’ (ibid.: 73, original emphasis). Verbeek further explains the ‘withdrawal’ and transparency of technologies as the capacity to “call attention, not to themselves, but to (aspects of) the world given through them” (2005: 126). A pair of glasses can only enter into an embodiment relation with its wearer if it is transparent and ‘fitting’ enough. Glasses that are smudged, broken, misty, pinching or of incorrect power become an object of perception themselves, hence hindering the wearer from properly seeing through them. The question is then, to which extent this also applies to techno-fashion and to the ‘Spider Dress 2.0’ in particular.

As noted in the first chapter of this dissertation, the Crafting Wearables project in which this research is embedded is premised upon the hypothesis that wearable technologies are
not yet robust, fashionable, comfortable, and practical enough. Postphenomenological attention to the notion of ‘withdrawal’ makes clear that this problem is due to a lack of transparency on multiple levels: if techno-fashion does not fit, look, feel, or function well it hinders wearers from using it as an instrument through which they experience (aspects of) the world. Techno-fashion that constrains the body, breaks, falters or restricts movement calls attention to itself, making it less likely for the garment to be embodied by the wearer. I will again use my case study, the ‘Spider Dress 2.0’, and the comparative example of the ‘Spine Dress’ to demonstrate this.

As argued earlier, Wipprecht’s ‘Spider Dress 2.0’ meets Ihde’s description of an embodiment relation in the sense that it involves “experiencing something in the world through an artifact, a technology” (Ihde 2002: xi). In theory, wearers of the ‘Spider Dress 2.0’ can perceive any approaching subjects, as well as their own bodily signals (e.g., respiration) by taking the dress into their embodied experience. But being a bold statement rather than a subtle instrument, the ‘Spider Dress 2.0’ is not exactly a technological device that easily withdraws itself from the wearer’s attention. On the contrary, the visibility, futuristic and robotic shape, and prominent sound and movement of the integrated technologies are likely to attract, rather than withdraw from, the attention of wearers and their environment. If the dress was designed with the intention to enhance the wearer’s perceptual capabilities, this thus seems at odds with its physical characteristics.

In comparison, by-wire.net’s ‘Spine Dress’ illustrates how a high level of transparency facilitates the occurrence of an embodiment relation between wearer and techno-fashion. In this case, the physical characteristics of the dress contribute to the highest possible level of transparency. The dress looks like any other dress, and the integrated heat-control technology functions so subtly that wearers hardly notice the way it gradually yet effectively changes their body temperature (wearer 2, fitting 2). The ‘Spine Dress,’ in other words, is much more inclined to occupy a background relation or embodiment relations because it withdraws itself from the wearer’s attention relatively easily. The look and feel of Wipprecht’s ‘Spider Dress 2.0’, on the other hand, is so transformative that it is much more likely to attain an alterity or hermeneutic relation to the wearer.

If techno-fashion achieves an embodiment relation between the wearer and the garment thus mostly depends on the (experiential and visual) transparency of the design (Rosenberger and Verbeek 2015: 15). Addressing the issue of transparency and use context, Ihde goes so far as to argue that the key to designing embodied technologies is not the technology alone but the harmonization of human and technology. “Design
perfection,” he writes, “is not one related to the machine alone, but to the combination of machine and human” (Ihde 1990: 74). Following this line of thought, he emphasizes the importance of designing and developing technology along “bodily vector, molded to the perceptions and actions of humans” (ibid.). The better the technology is tailored to the bodily and perceptual processes we are already familiar with, the easier it is for wearers to take the technology into their bodily synthesis.

Ihde also touches upon the contradictory side of our embodiment relations to technology by connecting the double purpose of clothing to technology in general. On the one hand, he notes, we wish for the technology to become totally transparent and embodied, to “truly ‘become me’” while on the other hand, we desire “to have the power, the transformation that the technology makes available” (ibid.: 74). To illustrate this point he comes up with a variation upon the emperor’s invisible clothing:

Imagine the invention of perfectly transparent clothing through which we might technologically experience the world. We could see through it, breathe through it, smell and hear through it, touch through it. Indeed, it affects no changes of any kind, since it is perfectly invisible. Who would bother pick up such clothing (even if the presumptive wearer could find it)? Only by losing some invisibility—say, with translucent coloring—would the garment begin to be usable and interesting. For here, at least, fashion would have been invented—but at the price of losing total transparency—by becoming that through which we relate to an environment (ibid., original emphasis).

With this alternative take on the tale of the emperor’s invisible clothes, Ihde discusses the notion of transparency in a literal as well as metaphorical sense. If clothing were literally transparent, he notes, it would fail to fulfill its protective, social and cultural purpose. Revealing the naked body, it is supposed to cover and adorn, perfectly transparent clothing would be useless (cf. Barthes 1967/1983: 128-129). Similarly, it is futile to develop technology that is perfectly transparent in a metaphorical sense. There is no point in developing technology that allows us to experience the world in the exact same way our naked (i.e., non-technical) body does.

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8 The Emperor’s New Clothes is a famous short fairy tale written by Danish author Hans Christian Andersen. It was first published in 1837 and tells the story of two weavers who promise a vain emperor a new suit made of a fabric that would become invisible to anyone who was either unfit for his position or “unusually stupid”. When the emperor parades in his new clothes in front of the townsfolk, no one dares to admit he looks bare naked until a young child finally cries out: “But he hasn’t got anything on!” (Andersen 1837).
What remains unexplained in Ihde’s discussion of transparent versus opaque forms of technological mediations, is how he connects the idea of literally transparent clothing to the metaphorical transparency of technology in general. As I understand it, he is attempting to acknowledge how "wearing" rather than just "using" technology connects it to the social visibility aspect of fashion. Like we choose our clothing to adorn and present our bodies in certain ways, our technology is ideally also expected to have a visible and fashionable character. After all, when we encounter people in daily life, we do not just look at their clothes, but also look through the clothes towards the person behind them. When wearing technology, we thus want it to work well and look good at the same time. We expect technology to transform our appearance in an optimal way, and at the same time wish it to be as non-obtrusive and experientially transparent as possible. Continued analysis of the ‘Spider Dress 2.0’ helps to explain this argument.

Wipprecht’s ‘Spider Dress 2.0’ is, first and foremost, an artistic and experimental design created “to give more power and ‘psychological thrill’ to the sugar sweet character that performative wearables often have” (Wipprecht 2015). At first glance, this robotic and futuristic techno-fashion allows the wearer to experience the world in a transformative rather than transparent way. The audible movements of the robotic technology, the openly displayed technology, and the clearly visible cameras and unusual 3D printed material; in no way does this dress seem to withdraw itself from the visual or experiential attention of the wearer, let alone from the attention of the environment. Yet, to a certain extent, even Wipprecht’s performative techno-fashion is transparent.

While programming the central module that controls and interconnects all the technological components, for example, Wipprecht has to make sure everything functions fluidly and without delays because “when [the] mechanics are responding a few seconds too late, it does not convey an engaging message” (Wipprecht 2015). Moreover, she has used social studies and environmental psychology to create “an intelligent system” that is autonomous, but at the same time “assistive and adaptive to the owner’s emotions and desires” (ibid.). Many of the technological processes behind and inside the ‘Spider Dress 2.0’, such as the wireless interaction between the data from the sensors or cameras and the actuators that generate the movement, are thus certainly designed to function as transparently as possible. For techno-fashion to effectively extend the perceptual and bodily scope of the wearer requires a design that can, at least partially, take on a degree of experiential transparency (Rosenberger and Verbeek: 14). Although Wipprecht’s techno-fashion is designed to be bold and thought-provoking rather than subtle she, too, has to strike a delicate balance between transparency and
transformation; between moments of subtle background and embodiment relations on the one hand, and those of bold hermeneutic or alterity relations on the other. While Ihde could only fantasize about the possibility of invisible clothes, techno-fashion can oscillate between being almost “perfectly invisible” and “usable and interesting,” between escaping and attracting the attention (Ihde 1990: 76).

Ihde’s version of the emperor’s clothes reveals one of the biggest success criteria for techno-fashion: its balance between transparency and transformation. In order for techno-fashion to become functional and fashionable at the same time, it has to strike a delicate balance between its degree of literal and metaphorical transformation, and its level of both literal and metaphorical transparency (ibid.: 79). Not only is this issue something that designers can play with depending on their design intentions; (potential) wearers, too, can use this insight to critically assess the benefits and constraints of specific forms of techno-fashion. As Gemperlé et al. elucidate, the degree to which techno-fashion can become transparent is dependent on a complex set of criteria that determine how ‘wearable’ a design truly is (1998: 118). While Ihde’s mediation theory helps to analyze the aspects of wearability that have to do with experiential transparency, it overlooks the aesthetic, expressive, or communicative roles that fashion fulfills.

Postphenomenology points to how designers may intentionally develop techno-fashion that acts as an instrument through which the wearer experiences (certain aspects of) the world in different, new or better ways. If they succeed in doing so, the techno-fashion can reach a high level of experiential transparency (and hence physical wearability). As Verbeek states, transparency “here is a form of perceptual ‘neutrality’; technologies function as a perspicuous interface between humans and world” (2012: 394). To reach the level of experiential transparency, a garment will have to be carefully attuned to wearability criteria such as placement, shape, comfort, durability, and weight of the garment (Gemperlé et al. 1998: 117). Yet, if a techno-fashion designer hopes to attract attention with the design object, then a cognitive or contextual form of transparency would be undesirable (ibid.; cf. Van den Eede 2011). In that case, designers should still strive for experiential transparency but while keeping up a contextual and socially visible opacity (ibid.).

Similarly, potential wearers or consumers of techno-fashion can assess whether the transparency level of a specific design meets their expectations and requirements. When one wants to buy and wear techno-fashion for fashionable, aesthetic and expressive rather than just functional reasons, it would be a disappointment for the design to remain completely contextually transparent. In that case, the design is expected to
attract rather than avoid attention. Before purchasing techno-fashion, wearers should evaluate whether the garment strikes the desired balance between transformation and transparency: is their main motivation for wearing techno-fashion to make a fashion statement by radically transforming their outer appearance, or are they mostly looking for a tool through which their perceptions are transformed in a maximally transparent way? This leads us back to the issue of embodiment relations, and the question of how wearing technology differs from merely using it.

**Wearing Technology: The Borderline Case of Embodiment Relations**

In the previous section of this chapter I explained that although Ihde’s version of the emperor’s new clothes belongs to “the extrapolated imagination of fiction,” it does help to highlight that transparency – both literally and metaphorically – is key to our ambiguous relation to technology (ibid.: 75). As Rosenberger and Verbeek explain, “[w]e want technology to at once both optimally transform our relationship to the world, and at the same time, we want the experience of the means of that transformation to itself remain as experientially transparent as possible” (Rosenberger and Verbeek 2015: 14-15). This ‘double desire’ or “essential ambiguity” (Ihde 1990: 76, original emphasis) towards technology is particularly relevant in relation to clothing or techno-fashion, precisely because it is worn.

Ihde’s examples of embodiment relations are limited to instruments and tools, i.e., artifacts designed and used ‘in order to’ perceive, do, or experience something. Yet, as Ihde himself also realizes, clothing is a borderline case of embodiment relations because of its connection to the fashion system:

Clothing is not designed, in most cases, to be “transparent” in the way the previous instrument examples were but rather to have a certain opacity without restricting movement. Yet clothing is part of a fringe awareness in most of our daily activities (I am obviously not addressing fashion aspects of clothing here) (Ihde 1990: 110).

Assuming that what Ihde here terms ‘fashion aspects’ refers to those aspects concerning appearance, aesthetics, and expression rather than functionality, this remark clarifies why techno-fashion is an ambiguous and complex phenomenon when it comes to transparency within embodiment relations. On the one hand, techno-fashion is often about functionality: it helps to track and show data about the environment or wearer’s body, assists or protects the wearer in specific activities or circumstances, enhances
2. From User to Wearer

perceptual capacities, functions as a communication device, et cetera. On the other hand, techno-fashion cannot be isolated from the “fashion aspects” of clothing (ibid.). Techno-fashion such as Wipprecht’s notably distinguishes itself from ordinary clothing by attracting attention to itself and providing the wearer with a whole new look or form of personal expression [figure 31, 32].

Ihde’s discussion of embodiment relations does not further address the “fashion aspects” of technology, nor take into account that some of the technologies he describes are worn rather than just used and that there is a fundamental difference between the two. When mentioning eyeglasses as an example of a technological artifact that typically involves embodiment relations, he does not make explicit that eyeglasses are not only instruments to see through, but visible fashion statements as well. A notion of embodiment relations that overlooks the social role of dress thus fails to acknowledge that wearable technological artifacts involve technological mediation for the sake of bodily adornment and self-fashioning, more than functionality. Their model, material, shape, style, and color are inextricably connected to the dynamics of fashion and, hence, to how we express ourselves and communicate with each other through what we wear. The fact that model Heleker describes her embodied experiences of the ‘Spider Dress 2.0’ in terms of increased confidence, a stronger posture, “a boost for the ego,” and “a fashion statement of power” (Interview WH 2017), signals that techno-fashion mediates much more than just bodily perception. Except for technological mediation, the embodiment relations at stake in wearing technology involve processes of adornment, self-expression and social interaction as well.

When a user embodies technology, this implies the intentional and one-directional incorporation of a tool, instrument, or device (e.g., a hammer, glasses, or a telescope). The intentional use of technology, in other words, suggests that the artifact is primarily perceived as an instrument that serves to aid, transform, enable or extend bodily perception. The embodiment relations that arise when technology is worn, however, are multidirectional and not necessarily intentional. This wearable type of embodiment relations can be schematized as follows:

(Wearer – techno-fashion) \rightarrow \leftarrow world

As this alternative model visualizes, wearing technology involves embodiment relations that do not just affect the wearers’ bodily perception of the world but also mediate how they perceive themselves herself and are perceived by the world around them. Ihde’s
schematized view of embodiment relations helps to explain how techno-fashion mediates the embodied experience of the wearer, but it overlooks the fact that wearing technology transforms how the outside world perceives the wearer, as well. He thereby contradicts his own argument that “embodiment is both actional-perceptual and culturally endowed” and fails to capture “the double sense of sensory and social dimensions of embodiment” (Ihde 2003: 13-14).

My alternative schema for embodiment relations attempts to solve this issue by illuminating how the technological mediations evoked by techno-fashion work in multiple directions: techno-fashion mediates how the wearer perceives her body and/in the world and, vice versa, how the world perceives the wearer. The motile, actional embodiment of techno-fashion thus always has to be understood in relation to “the social cultural experience of being seen by another and also experienced by oneself” (ibid.: 14). In the specific case of techno-fashion, technological artifacts become incorporated into the socio-cultural and material practices of dressing (Entwistle 2015). It is in the encounter between embodied and social-cultural experience that the difference between using and wearing technology is revealed.

**Conclusion**

The main purpose of this chapter was to explore how techno-fashion transforms and mediates embodied experiences, taking into consideration that it is worn on and by the body. Using Anouk Wipprecht’s ‘Spider Dress 1.0’ and ‘2.0’ as a case study, I focused on the bodily-sensory experiences evoked by techno-fashion and further developed the phenomenological approach to fashion by extending it to the realm of techno-fashion. In addition, I examined the different ways in which techno-fashion relates to the wearer’s body by bringing a model’s wearing experiences of the ‘Spider Dress 2.0’ into dialogue with phenomenological and post-phenomenological theory.

Techno-fashion, firstly, has the capacity to transform the wearer’s embodied being-in-the-world actively. As materials that “we hang at the margins of our body,” garments “enjoy a close proximity to the flesh, outlining, emphasizing, obscuring or extending the body” (Entwistle 2003: 138). The phenomenological insights of Merleau-Ponty help to understand and emphasize that the already deeply embodied nature of clothing becomes even more present with the advent of techno-fashion. Widening the span and perceptual range of the wearer’s body, the ‘Spider Dress 2.0’ turned out to transform the wearer’s motility and spatial awareness, as well as to empower the wearer to
assume a strong and confident demeanor (Interview WH 2017). Moreover, phenomenology provided insight into the how the integration of technology and fashion may “transform the human experience more than technology alone could ever do” (Quinn 2013b: 436). Techno-fashion allows the wearer to become more aware of the things happening inside, or in the direct vicinity of, the body. Extending the spatiality of the body, ‘Spider Dress 2.0’ outlines, emphasizes, and extends physical and personal space; and stimulates renewed, enriched and intensified connections between fashion and the body.

Secondly, I outlined the ways in which a postphenomenological approach to techno-fashion can help to bring studies of technology into the field of fashion studies. I addressed how techno-fashion relates to the wearer’s body and mediates bodily-sensory experience. The postphenomenological approach to clothing as a technology, as well as its notion of embodiment relations contributes to a better understanding of how techno-fashion can become incorporated into the sensing system of the wearer. When technology is worn rather than used, however, such embodiment relations become inevitably connected to the socio-cultural role that fashion and clothing performs. The benefits and constraints of techno-fashion as an extension or mediation of perception, thus relate to its embodied and socially embedded dimensions (DePreester 2010: 343-344). Addressing how techno-fashion affects the wearer bodily-sensory experience of the world and vice versa is vital to understanding its impact, current shortcomings, and potential. To both developers and potential consumers of techno-fashion, attention to this balance is vital in determining the added value or define the shortcomings of wearing, instead of just using, technology. When technologies are integrated into garments, this will have radical consequences for the way space and body are perceived, experienced and used.

Finally, postphenomenological reflections on embodiment relations and the issue of transparency showed to be of value to the extent that they help to emphasize the variability and context-dependency of human-technology relations (Rosenberger and Verbeek 2015: 15-16; also see Ihde 1990: 80, 98). Postphenomenology provides the theoretical tools to study the embodied dimensions of techno-fashion and to assess if and how a specific design strikes a balance between transformation and transparency. For techno-fashion to be embodied in ways that are both useful and interesting for the wearer it has to be designed on, and in harmony with, the body. In addition, I reflected on the postphenomenological notion of embodiment relations to assess its value for the study of techno-fashion.
Embodiment relations occur between the ‘Spider Dress 2.0’ and the wearer to the extent that this particular design can be experienced as really being a part the wearer’s body (Heleker 2015b). However, I argued, Ihde’s discussion of embodiment does not take into account the multidirectional and socially embedded types of technological embodiment that techno-fashion enables. Proposing an alternative model, I demonstrated that wearing technology involves distinct embodiment relations because it not only mediates how the wearer experiences the world, but also transforms how the world perceives the wearer. Since wearing technology involves both the embodied and socio-cultural practice of dressing, it can be concluded, its embodiment relations are significantly different from those involved in using technology.
3. Flashy and Fleshy: The New Materials of Techno-Fashion

Case Study: Sensoree, ‘AWE Goosebumps’

Clothes (…) are also, and always have been, the most effective way of inverting the proper relations between animate and inanimate things. (…) What clothes are able to do is by way of the material of which they are made (Küchler 2008: 115).

The notion of materiality allows us to focus on the actual matter of technology and how our – material – bodies relate, often intimately, to the technical objects that enhance our clothes and our selves (Smelik 2017: 268).

When we say that something gives us goosebumps, we generally refer to the physical sensation of being excited, frightened, or cold. But goosebumps are also thought to be a manifestation of emotional experiences, intuition, feelings, or memories revealed on the surface of our body. Sensoree’s ‘AWE Goosebumps’ [Figure 33] is a garment that imitates and intensifies this “goose-bumpy mix of fear and wonder” (Sensoree n.d.). It uses biosensors to monitor the galvanic skin response (GSR)

1 A galvanic skin response (GSR) sensor, also known as Electrodermal activity (EDA) sensor, measures the electrical conductance of the skin. GSR sensors are based on the idea that skin conductance is an indication of psychological or physiological arousal, because it varies with the state of sweat glands in the skin. As sweat glands are controlled by the autonomic nervous system, it is believed that arousal can be measured as an increase in sweat gland activity, which in turn increases skin conductance.
Sensoree’s ‘AWE Goosebumps’ foregrounds the specificities and significance of techno-fashion’s materiality, as well as the inherently material dimensions of wearing and interacting with techno-fashion. It signals that the integration of technologies affects the materiality of fashion in three interrelated ways. First, the design highlights how the incorporation of technology into garments opens up a whole new array of materials for fashion. Techno-fashion introduces fashion to materials ranging from silicone, biosensors and LED lights – as in the case of ‘AWE Goosebumps’ – to optic fibers, 3D printed plastics, printed electronics, conductive textiles, solar cells, muscle wire, and microchips. Second, ‘AWE Goosebumps’ demonstrates that techno-fashion equips garments with new material abilities, allowing them to inflate, illuminate, move, twitch, make a sound, or change the color of their own accord (see also Toussaint and Smelik 2017: 94). A third and final way in which ‘AWE Goosebumps’ calls attention to the pivotal aspect of materiality in techno-fashion is by challenging the dichotomous distinction between inanimate and animate matter, and forming “assemblages of human and non-human, animate and inanimate, material and abstract” (Fox and Alldred 2015: 406; see also Barad 2003).

As outlined in chapter one on theory and methodology, the new material properties and abilities of techno-fashion are key to how it materially mediates and transforms relations between the wearer, her body, and her social surroundings. The previous chapter demonstrated the effects of technological mediation in terms of embodied experience and technological embodiment, exploring how techno-fashion influences the way in which the wearer physically navigates and experiences the world. The current chapter starts from where I left the previous chapter, that is with an understanding of embodiment relations that recognizes the ways in which techno-fashion mediates wearers’ perceptions of their own bodies as well as influences how others perceive them. The example of ‘AWE Goosebumps’ points out that techno-fashion not only materially mediates in the sense that it transforms human experience on a material (i.e., embodied, sensorial, incarnated, fleshy) level, but also because of its own material peculiarity. As Valérie Lamontagne argues, it is important to study “how materiality – a garment’s fabrication, aesthetic choices, colors, materials, and more – also perform on the body, as well as with the technology” (2017: 79).
Apart from animating the sensation of goosebumps, techno-fashion possesses the power to purify the polluted air surrounding the wearer [Figure 35], to read out a poem when wearers hug themselves [Figure 36], to curl and unfurl in reaction to light [Figure 37], and even to move as if it is breathing [Figure 38]. Incorporating technology, in other words, activates and “animates” the matter of fashion (Interview KN 2017). Garments are turned into apparently autonomous, active, and living things that exhibit a certain force, liveliness, and ‘animatedness’ (Bennett 2004; 2010) as well as material power (Bennett and Joyce 2010). Placing emphasis on materiality helps to gain a better understanding of the characteristics, mediating role, and capacities of the materials of techno-fashion. It allows for a study of techno-fashion at the intersection of material experience and socio-cultural practices (Woodward and Fisher 2014: 14; cf. Giaccardi and Karana 2015).

Inspired by the theoretical and methodological shift known as ‘the material turn’ in the humanities and social sciences (Hicks and Beaudry 2010; Bennett and Joyce 2010; Mukerji 2015; Muntéan, Plate and Smelik 2017) as well as postphenomenological orientations toward materiality within the philosophy of technology (Ihde 2009; Ihde and Selinger 2003; Rosenberger and Verbeek 2015; Verbeek 2005a, 2011, 2015), this chapter focuses on the materials, material capacities, and materiality of techno-fashion. More specifically, I will explore how techno-fashion transforms and activates the matter of fashion, using the ‘therapeutic biomedia’ designed by Sensoree as a case study. The chapter starts with a discussion of how, and to what extent, a material culture approach helps to systematically attend to the way in which the social and material aspects of techno-fashion are entangled. Combining an object-based analysis of ‘AWE Goosebumps’ with data from my interview with Sensoree founder Kristin Neidlinger (Interview KN 2017), I then inquire into relational approaches to materiality within material culture studies (Woodward, S. 2007; Miller 2005, 2010). In addition, I will discuss such relational accounts of materiality in light of phenomenological, postphenomenological and new materialist ways of thinking materiality (Barrett and Bolt 2013; Coole and Frost 2010; Dolphijn and Van der Tuin 2012; St. Pierre, Mazzei, and Jackson 2016). Finally, ‘AWE Goosebumps’ will be the starting point for an exploration of how techno-fashion
relates to ongoing debates on the material agency of objects. The chapter ends with my argument for further developing a theoretical framework that helps to understand the complex and powerful matter of techno-fashion through a combination of postphenomenological and new materialist theory.

Material Culture

Techno-fashion obviously has material properties. ‘AWE Goosebumps’ is crafted from materials including laser-cut fabrics, inflatable pockets, biosensors (including heart rate, galvanic skin response, and respiration sensors), speaker actuators, and conductive fabric (Neidlinger et al. 2017). Like all cultural artifacts, it has been created out of certain materials, which give the design specific materiality and allow it to be experienced and used in certain ways. But there is more to the materiality of techno-fashion than its ‘brute’ and objectively identifiable material properties (Tilley 2007: 17). Understanding how techno-fashion mediates human-object relations requires a concept of materiality that goes beyond its crude materiality, putting it into a broader socio-cultural and historical context (ibid.).

In the Handbook of Fashion Studies, Amy de la Haye describes materiality as "an object-specific word that simultaneously evokes the fabric (frequently described as material) from which garments are made and the infinite possibilities it holds as an embodiment of value and meaning" (De la Haye 2013: 231). This definition of materiality is in line with historical, archaeological and anthropological studies of dress and fashion in which garments are understood and examined from a ‘material culture’ perspective (Hicks 2010). The field of material culture research has its origins in the object-based research of anthropologists such as Igor Kopytoff and Daniel Miller (Kopytoff 1986; Miller 2005, 2010). Fashion studies, similarly, is founded upon object-based studies of dress and clothing, notably those of dress historian Lou Taylor (1998, 2002, 2004). Among new fashion scholars, however, descriptive and object-based approaches to dress artifacts are comparatively rare (Mida and Kim 2015: 18; Palmer 2013: 269). Some believe this is due to their descriptive and seemingly old-fashioned methodology (Palmer 2013: 269), but it may also be explained by the time-consuming and minute process of examination it requires or a lack of specialized technical knowledge among academics (Skov and Riegels Melchior, 2008: 11). Nonetheless, I believe that object-based analysis can be a useful and significant step in the research process, even if it concerns contemporary dress or fashion artifacts outside of the museum context.
According to the influential definition of art historian Jules Prown, material culture is a mode of cultural investigation that uses objects as its primary data to study “the beliefs—values, ideas, attitudes, and assumptions—of a particular community or society at a given time” (Prown 1982: 1). Clothing and dress are man-made objects that embody the cultural milieu in which they were created, designed and worn (Mida and Kim 2015: 12). Although fashion can also be understood as an immaterial system of signification and commodification, Heike Jenss explains, understanding fashion as material culture invites a notion of fashion that “is (...) particularly grounded in the etymology and active meaning of fashion as a verb: ‘to fashion’—derived from the Latin facere—which means: ‘to form, mould, shape (either a material or immaterial object)” (Jenss 2016: 22). Following this perspective, the mere fact that techno-fashion concerns objects fashioned by man implies that it can be studied as material culture: it embodies the beliefs of those who make or consume it “and by extension [reflects] the beliefs of the larger society to which they belonged” (Prown 1982: 2).

Prown was not the first to propose object-based research on dress and clothing, but his method is still the most cited and used among fashion scholars (see, for example, Steele 1998; Palmer 2001, 2013; Mida and Kim 2015). For Prown, material culture “is the object-based aspect of the study of culture” (1982: 5). In the case of dress and fashion, this means that garments are considered a gateway to information about the culture and society in which they were created, purchased, used or worn. Such an object-based approach starts with a close observation and basic description of the material properties of the object itself: the material that was used (its strength, ductility or hardness); the techniques and technologies that have been applied to fabricate the object (e.g. weaving, printing, knitting, pleating); and any physical dimensions (e.g. weight, measurements) or formal characteristics (e.g. color, shape, style, form, silhouette) of the garment. From there, the material culture analysis proceeds to the interaction between the object and the perceiver, including sensory engagement with the garment (e.g. aspects such as flexibility, touch, texture, smell, sound, feeling) as well as the emotional response it triggers (e.g. joy, fright, awe, indifference, curiosity, disgust). After progressing from the artifact, to the interaction between object and perceiver, Prown’s analysis finally moves to the mind of the perceiver who formulates theories and hypothesis and develops a program of research based on a dialogue between the artifact and external evidence (Prown 1982: 9-10).

Applying Prown’s three stages of object analysis to Sensoree’s ‘AWE Goosebumps,’ I will evaluate the value of this material culture approach for studying how techno-fashion transforms the matter of fashion.
An Object-Based Analysis of Techno-Fashion: Description, Deduction, Speculation

Following Prown’s three-step method for object analysis, techno-fashion can be investigated through a process of description, deduction, and speculation (ibid.: 7; see also Granata 2012: 71 and Steele 1998: 329-332). The phase of description concerns a substantial analysis that describes the physical dimensions, materials, and technical specifications; a content analysis (if applicable); and a formal analysis (ibid.: 7-8). The deduction stage involves an interpretation of the sensory, intellectual and emotional engagement with the object (ibid.: 8-9). During this stage of reflection, the researcher may also contemplate on what it would be like to wear the garment, and whether it would fit or be comfortable on the body (Mida and Kim 2015: 29). The speculation stage, finally, is where the analysis moves towards a self-reflexive and creative review of the information from the previous two stages in order to develop theories, hypotheses, and plans for further research (Prown 1982: 10).

Both the description and deduction phase require access to the physical and original artifact. For techno-fashion, this generally means paying a visit to an exhibition, festival, fair, museum archive, or design studio in order to study the real-life object in detail. As many techno-fashion designs are still one-off and fragile prototypes, however, this might be challenging, problematic, or even impossible. In the case of Sensoree’s ‘AWE Goosebumps’, fortunately, I was able to observe the material, technical and formal characteristics of the design at two occasions: first at the ‘WEARABLE fashiontech festival’ at Gaîte Lyrique in Paris (9-14 February 2016), and again at the ‘Mind the Step’ and ‘Manifestations: Will the Future Design Us’ exhibitions during the Dutch Design Week in Eindhoven (22-30 October 2016; 21-29 October 2017). In terms of material qualities, this design can be described as a two-piece outfit consisting of a smooth, close-fitting and shimmering silver-black skirt and bodice. The back and side panels of the top contain a series of laser-cut Kirigami (a variation of origami that includes cutting rather than solely folding as is the case with origami) that covers the inflatable silicone air pockets underneath the cut-outs [Figure 39]. A white 3D printed plastic container is placed in a
large pocket on the lower back of the bodice, holding the battery and Arduino\(^2\) in place as well as forming the base from which the circuitry and transparent tubes for the air flow spring [Figure 40, 41].

During the second phase, the deduction phase, I got a firsthand idea of what the design can do and how (Steele 1998: 330). Although it was not possible to try on the garment, I could deduct information and knowledge from ‘AWE Goosebumps’ through sensory engagement by carefully touching its different components, having a close look at its materials, listening to the sounds it made and walking around the mannequin to observe its different sides. Imagining what it would be like to wear this design, I focused on my subjective experience of how the garment felt, looked, how it smells, works, and sounds. In addition, I paused to reflect on how the design also invites emotional engagement. It was clear to me that the color and shape of the ‘AWE Goosebumps’ was changing in response to the environment, which urged me to try and trigger some changes in behavior. I tried to play and interact with the object by moving towards and around it, making a sound, and touching its surface. As the garment was only shown on a still mannequin, however, it was at this point impossible to figure out exactly how, when, and why the design would inflate or change color, although I could guess that it involved sensors based on my knowledge of the field of techno-fashion.

Studying the exhibition catalog marks the start of the third and final step in my object analysis: the speculation stage. According to Prown, this phase calls for a program of research in which information obtained from other sources external to the object is key (Prown 1982: 6). It was not until I consulted the contextual information in the catalog, that I learned that ‘AWE Goosebumps’ incorporates different types of biosensors to measure the galvanic skin response, breathing, and heart rate of the wearer. It now also became clear that the garment mimics the wearer’s breathing rate by changing the color of the illuminated kirigami from blue (exhale) to teal (inhale), as well as animates and amplifies the wearer’s excitement through inflation and pink illumination of the air pockets on the back.

This third stage in the object analysis, Valerie Steele explains, also entails “the framing of questions and hypotheses that then need to be tested against external evidence” (1998: 331). In the case of my object analysis of ‘AWE Goosebumps,’ this stage indeed informed my research question and hypothesis for this chapter because it made me wonder how techno-fashion transforms the materiality of fashion. The speculative character of this

\(^2\) Arduino is a project, computer hardware and software company, and user platform that designs and makes open source microcontroller kits for building responsive objects and devices.
stage in Prown’s methodology can be problematic, however, in that there is no clear way forward with the descriptive and sensory information that has been gathered from the dress artifact. Ingrid Mida and Alexandra Kim, therefore, propose an alternative step, which they name ‘Interpretation’ (2015: 31). The information acquired through observation and sensory engagement, they argue, has to be synthesized with insights from fashion theory and personal experience (ibid.). This resonates with my own research methodology for this dissertation, which combines object analyses of techno-fashion with theoretical reflections and interview data on the experiences of designers and wearers.

Prown’s three-step material culture approach offers a valuable and relevant methodology for studying techno-fashion because it directs the attention towards the materials and material aspects of designs and invites sensorial as well as emotional engagement with the designed object. Moreover, Prown’s observations on different categories of material culture are interesting because they include both the categories ‘adornment’ and ‘devices’ (1982: 12). Clothing, he argues, is a particularly rich and interesting topic for material culture studies because it serves both functional and aesthetic purposes, and has “a high correlation [to] personal identity and values” (ibid.: 13). By embodying the combination of function and style, clothing holds particular potential for cultural interpretation. He claims that device materials may also serve as cultural evidence because “most devices incorporate some decorative or aesthetic elements, and every device can be contemplated as an art object (...) completely apart from utilitarian considerations” (ibid.: 15). This helps to see how even the most utilitarian artifacts have an aesthetic and artistic dimension that, quite literally, provides rich material for material culture studies. There are, however, several problems with Prown’s theory and method for object analysis as well.

Several crucial material dimensions of techno-fashion escape the material culture approach as set out above. Reducing the concept of materiality to the static physical properties of the object, it does not include an analysis of how different wearers or spectators interpret and respond to the color changes and inflations of ‘AWE Goosebumps,’ and vice versa (Interview KN 2017). In other words, Prown’s traditional approach to material culture does not help much in understanding how people relate to and interact with the materials and material capacities of the object in different contexts.

“While a focus on fashion’s materiality offers a seeming concreteness as there is “stuff” to analyze”, Sophie Woodward notes, it “also poses its own methodological challenges” (2016: 42). Exploring the material dimensions of fashion, she highlights, calls for “the acknowledgment of the relationship between materiality and humanity” (ibid.). On a similar
note, Heike Jenss argues that studying material culture should have methodological implications beyond object-based research or the examination of fashion as a static material ‘thing’ (2016: 21). In addition to an analysis of the object’s material qualities, Jenss asserts, studying material culture requires attention to material practices and relations: to “what people do with material things, what things do with people, and how they relate to each other” (ibid.: 21-22, my emphasis). In the following sections, I further develop the argument that techno-fashion demands a renewed or “reactionary” (Beaudry and Hicks 2010: 2) view of material culture that accounts for its material dynamics and relationality as well.

A Matter of Relations

‘AWE Goosebumps’ is based on what designer Kristin Neidlinger terms “a biofeedback loop for the wearer” (Interview KN 2017). This loop consists of a combination of three components: a detection system, controlling system, and feedback system (Heijne, Ivan and Shkribliak 2015). It starts with the integrated biosensors that detect the skin conductance, breathing, and heart rate of the wearer. With the help of an Arduino3, the control unit then collects and interprets these data, responding when goosebumps (‘piloerection’ in technical terms) are detected. This marks the beginning of the feedback process when the air is pumped into the inflatables, and the color of the LED strips is transformed in accordance with the measurements (ibid.). ‘AWE Goosebumps’ externalizes and mimics the behavior of the erected hairs on the wearer’s skin, giving direct feedback to the wearer and her surroundings. Finally, a new loop begins when the wearer physically responds to the behavior of the garment or to the reactions on this behavior within the environment.

To elucidate this continuous feedback loop between the wearer, the design, and the observers, a conventional material culture approach does not suffice. The materiality of responsive techno-fashion such as ‘AWE Goosebumps’ is not reducible to a description and documentation of its static material properties. It is fleeting and continuously transforming depending on the dynamic interaction between different material, human and non-human ‘actors’: the body of the wearer, the technology-infused garment, and the surrounding world (Latour 1996). Understanding the situated and embodied practice of wearing technology thus requires a more relational approach to materiality. Whereas the object-centered approaches of traditional dress history and material culture studies tend to regard materiality as singular and given, phenomenological and postphenomenological thinking address precisely “how material culture, artifacts, technologies, are taken into human experience through human-technology relations”

3 For an explanation see previous footnote on page 103.
Within material culture studies, phenomenology has been used to locate the lived bodily experience of the world at the center of the interpretation of the material world, and to relocate the focus of material culture studies upon concrete human experience (Hicks 2010: 71). Christopher Tilley (1994, 2006) and Julian Thomas (2006/2013), most notably, draw on the work of phenomenologists Martin Heidegger and Maurice Merleau-Ponty “to account for the bodily, meaningful, thoughtful, and reflective encounters between humans and the non-human world” (Hicks 2010: 71). Christopher Tilley explicitly develops “a phenomenological perspective linked to a concept of materiality” by analyzing human experience through the sensuous, tactile and embodied qualities of landscapes and prehistoric stones (2007: 19, also see Tilley 1994, 2004).

Equally inspired by phenomenology, Julian Thomas points out that it is surprising that few studies of material culture explicitly identify themselves with phenomenological thought, given its occupation with the human experience of ‘things’ (2013: 43). Demonstrating how the work of phenomenologists such as Brentano, Husserl, Heidegger, and Merleau-Ponty has influenced the study of material things, Thomas summarizes phenomenology as studying “the precise relationship between consciousness and the material world”, the sensorial aspect of human experience, and the idea that our subjective experiences “are the means through which the material world reveals itself to us” (ibid.: 56-57). Thomas applies these phenomenological insights mostly to geography and architecture and notes that their full potential for studying material culture has yet to be realized (ibid.: 43).

In many ways, Tilley’s and Thomas’ argument for realizing the potential of phenomenological approaches to material culture echoes the recent shift within material culture studies from approaches that just focus on the static materiality of objects, to those that emphasize the trajectories, mutability and transformations of materials (Woodward and Fisher 2014: 6, also see Hicks and Beaudry 2010). Although they have different roots and interests, their approach fits into a broader theoretical trend that aims to re-enter materiality and the object into research and theory. “In current studies of material culture,” Ian Woodward explains, “the object-person relation is the direct focus of inquiry and taken to be a matter of interest in its own right” (Woodward 2007: 29). Another helpful take on the inherent relationality of material culture is Daniel Miller’s (2005, 2010). “The best way to understand, convey and appreciate our humanity is through attention to our fundamental materiality,” he writes (2010: 4). Contrary to Tilley and Thomas, Miller does not explicitly refer
to phenomenological sources of inspiration, but it is clear that his account of materiality has much in common with the phenomenological premise that perception of the material world (i.e., of the “things themselves”) precedes reflection and knowledge (Merleau-Ponty 1945/2002: ix-x). Discussing clothing and fashion, Miller demolishes what he considers the “most common academic and popular view of stuff – the idea that objects signify or represent us and that they are principally signs or symbols that stand for persons” (2010: 10). In many respects, he argues, “stuff actually creates us in the first place” (ibid.).

Although the material culture approach of Tilley, Thomas, Woodward, and Miller are rooted in archeology and anthropology, their emphasis on the relational character of materiality also resonates with the ways in which scholars from Science and Technology Studies (STS) have theorized matter as inherently relational (Muntéan, Plate and Smelik eds. 2017: 3). Actor-network theorist John Law, for example, describes his approach to technology as “a way of thinking about the material in which this is treated as a continuously enacted relational effect” (Law 2004: 161). “For STS,” Law summarizes, “materiality cannot be prised apart from the enactment of relations or, more generally, the practices that do these relations” (Law 2010: 173, original emphasis). Such an approach can help to complement the object-analysis method of material culture studies because it proposes a methodology that not only places materiality itself center stage but also focuses on material practices and the enactment of material relations (ibid.: 174). Without studying the experience of ‘AWE Goosebumps’ as part of the practice or act of wearing technology, for example, it would remain unclear how the material reacts upon and interacts with the wearer.

What material culture studies and Science and Technology Studies thus have in common is their acknowledgment of the relational character of materiality. Regardless of whether the research object concerns high-tech designs, anthropological artifacts, or archeological findings, they signal the vital importance of recognizing that materiality is all about “the relations between people and things,” as László Munteán, Liedeke Plate and Anneke Smelik phrase it (2017: 3, original emphasis). Adopting such relational accounts of material culture helps to illuminate and comprehend the role of the new, ‘smart’ and responsive materials involved in techno-fashion. The material properties of techno-fashion change depending on the way in which the object reveals itself to and

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4 As Michelle Addington and Daniel Schodek explain, it is difficult to put forward a precise definition of the term ‘smart materials’ (2005: 8). Although the terms ‘smart’ and ‘intelligent’ materials are widely used, there seems to be no general agreement as to what they mean precisely. Aiming to come up with a working definition relevant for designers, Addington and Schodek define ‘smart materials and technologies’ as materials that possess the internal capacity to respond to their environment and activate themselves directly, in real-time, and in discrete and predictable ways (ibid.: 9).
interacts with human bodies (wearers or observers) and the environment. The materiality of techno-fashion hence has to be theorized and conceptualized as a relational effect or event; it is a transformative and unstable matter of relations, rather than a fixed and solid ‘thing’ (Hicks 2010: 81-94, my emphasis). The material capacities and effects of designs such as ‘AWE Goosebumps’ cannot fully be grasped through the direct observation and interpretation of its physical properties only. The conceptual and theoretical shift in thinking about materiality as a relational effect, therefore, also poses a methodological challenge. After all, if one would analyze the materials and material capacities of ‘AWE Goosebumps’ merely by observing its physical characteristics, their changing and ‘smart’ behavior would be overlooked.

As elaborately discussed in the method section of the first chapter, I attempt to overcome the methodological challenge of studying the material relationality of techno-fashion by combining my object analyses with other qualitative research methods, including analyses of written and visual representations, and in-depth interviews with designers and wearers of specific techno-fashion designs. In the case of ‘AWE Goosebumps’, an interview with lead designer Kristin Neidlinger provided further details on technicalities and materials used, as well as insights into how the use for certain materials reflects the designer’s intent to make a therapeutic garment that improves the emotional health and physical awareness of the wearer. Moreover, incorporating the wearer experiences of wearers into the research helps to gain a better understanding of the ways in which people relate to techno-fashion in real life. In addition to a conceptual and theoretical rethinking of materiality, techno-fashion thus requires a research methodology that accounts for both the stable and the relational qualities of its materiality. The experiences of both the designer and wearers of ‘AWE Goosebumps,’ illustrate the value of incorporating qualitative research data when studying the material qualities of a techno-fashion design.

On the one hand, the visions and ideas of designers can illuminate how the materiality of techno-fashion can change from one context to the other. Designer Kristin Neidlinger noted that when ‘AWE Goosebumps’ was presented in Europe, for example, wearers generally attempted to calm themselves down so as to prevent the design from attracting too much attention. While presenting the outfit in Brazil, on the contrary, she found that wearers constantly tried to make the inflation and color changes of ‘AWE Goosebumps’ as dramatic as possible, manipulating the measurements by artificially increasing their respiratory rate and heartbeat (Interview KN 2017). This shows that the materiality of techno-fashion may reveal itself differently depending on the setting and, importantly, that the perception of materiality is culturally formed.
On the other hand, wearer experiences of ‘AWE Goosebumps’ provide insights into the relations between the materiality of the body and the materiality of techno-fashion. When presenter Elfie Tromp describes her experience of wearing ‘AWE Goosebumps’ for a Dutch television program on design, she notes how the material transformations of the garment seem to comment on her feelings and emotions. “When they [the silicone ‘goosebumps’] start swelling up it feels like I got caught while doing something wrong,” she says, “almost as if I shouldn’t be able to feel it” (Tromp 2016). This psychological experience of ‘being caught in the act of feeling’ is caused by the direct relation between the wearer’s bodily signals, the garment’s material form, and the material surroundings in which both of them are situated. Without incorporating such experiences, an analysis of ‘AWE Goosebumps’ would completely overlook some of its most powerful and striking material effects, that is the ways in which it can (physically, emotionally, psychologially) affect the wearer.

A relational account of materiality shows that the materiality and material properties of techno-fashion are closely connected to, and co-constituted by, the cultural and social context in which it is worn. It is through the material capacities of technological components such as biosensors, silicone, and LED strips that ‘AWE Goosebumps’ co-constitutes a social and material relationship between the wearer, her outfit, and the environment (Woodward 2016: 361). Moreover, this perspective helps to understand that ‘AWE Goosebumps,’ along with many techno-fashion designs, is built upon the relational qualities of the materials. The design functions by the grace of material relations: the dynamic material signals given off by the wearer’s body (i.e., skin conductance, heart rhythm, and breathing rate) are mirrored in the material transformations of the garment (i.e., inflation, air flow, LED light and color). Wearing technology, in other words, is a matter of situated and embodied relations between the wearer, the garment, and the surrounding world.

To a certain extent, relational materiality is always present in fashion and items of clothing, regardless of whether it incorporates technology or not. Conventional materials such as textiles and accessories wear out, discolor, tear, smell, stain, or deform under the influence of time’s passing, washing, sweat, light exposure, or intensive use. Similarly, the technological materials of techno-fashion may corrode, break, tear, or become damaged. Yet what seems to be new about the materiality of techno-fashion is that its material transformations are speedier, more radical, and appear to come from within the object rather than from the outside. The technological materials embedded in ‘AWE Goosebumps’ are capable of going through constant and fast transformations.
in response to the wearer’s biometric data. While the material may at one moment seem purple and relaxed, they can become red and inflated during the next. The ‘smart’, active, ‘intelligent’ and responsive materials of techno-fashion thus “move the goalposts of material culture” (O’Connor 2005: 46), somehow affecting the material ontology – the very matter – of fashion.

‘Unmuting’ Matter: Postphenomenology and New Materialisms
The first part of this chapter indicated that a traditional material culture approach helps to focus on materiality both as a ‘stuff’ of techno-fashion and as “a route into understanding wider social contexts” (Woodward 2016: 42). Prown’s material culture approach, I revealed, helps to identify the static material characteristics of techno-fashion designs such as ‘AWE Goosebumps.’ I then explained that the ‘smart’ and sensing materials often incorporated into techno-fashion are not just static and fixed, and therefore require an understanding of materiality that moves beyond traditional material culture studies and acknowledges the material relations and practices involved in wearing technology. Both Prown’s material culture analysis and the relational approach to materiality, however, still treat garments as “mute” objects from which information about culture and society can be extracted (Barrett and Bolt 2012: 3, 5). Even when both approaches are combined, I want to argue, the specific material powers and transformative effects of techno-fashion are still overlooked.

The materials of techno-fashion, cannot be reduced to their functionality or symbolic meaning for people, because they also have the capacity to act, transform and respond by themselves (Verbeek 2005a: 208-9). Techno-fashion is transformative and ‘agentive’ in the sense that it can take an active role or actively produce an effect in the wearer and/or the surroundings. In fact, as Kaori O’Connor notes, the raison d’être of these garments is to do: “Man-made fibers are not inert, they have been created to do” (O’Connor 2005: 53, original emphasis). I, therefore, believe that a study of the new materiality of techno-fashion requires another, more radical step in thinking materiality. A step with which to move from a focus on stable materiality and the relationships between objects and humans to one that focuses “upon the permeabilities between them” (Hicks and Beaudry 2010: 11). Starting from the case study ‘AWE Goosebumps’, the following part of this chapter will begin to develop an interdisciplinary theoretical framework for understanding the inherently relational as well as transformative and ‘agentive’ matter of techno-fashion as such. Proposing a theoretical encounter between postphenomenological theory (Ihde 1990, 2002, 2009, 2010; Friis and Crease eds. 2016; Rosenberger
and Verbeek eds. 2015) and new or renewed materialisms (Barrett and Bolt 2013; Coole and Frost 2010; Smelik 2018), I will explore how the new materials of techno-fashion ‘unmute’ the matter of fashion.

Like Wearing Electronic Frogs on Your Back

“The suit is totally out of control; it is freaking out!”, presenter Elfie Tromp cries out while she wears ‘AWE Goosebumps’ in her television program on contemporary design (Tromp 2016). One of the researchers from the team that developed ‘AWE Goosebumps,’ Edwin Dertien, has just elaborately explained the concept behind the design to her. He showed her the inflatable silicone pockets that have been integrated into the design, has described the design process, and demonstrated several of its technological components. Throughout this entire explanatory process, Tromp was allowed to touch, examine, test, and hold each of the materials involved. When she finally gets to wear ‘AWE Goosebumps,’ she nonetheless appears to be overwhelmed and amazed by the material transformations and actions of the garment: “It feels as if I am wearing electronic frogs on my back that then suddenly start to croak” (ibid.).

This anecdote illustrates why the conventional tools of object-based dress studies fall short when it comes to theorizing and understanding the materials and materiality of techno-fashion (Smelik 2018). Observing and examining these materials is one thing; wearing them is another. To a certain extent, this difference can be explained by the ‘using versus wearing’ argument I made in the previous chapter: wearing technology involves embodiment relations that do not just affect wearers’ bodily perception of the world but also mediate how they perceives themselves and are perceived by the world around them. To fully grasp the intensive, interactive, and transformative role that materiality plays in the embodied experience of ‘AWE Goosebumps,’ however, it is necessary also to examine its intrinsic material characteristics and capacities. That Tromp describes the technological components within the garment as croaking electronic frogs, signals that the materials of techno-fashion are experienced as having peculiarly animate and even animalistic qualities. I, therefore, want to look for ways to update material culture from within, proposing an encounter between post-phenomenological and new materialist thinking that conceptualizes techno-fashion as ‘agentive’ beyond its strictly instrumental role in relation to humans (Olsen 2010: 5

As the discussion of material culture at the beginning of this chapter makes clear, materiality has always played an important role within dress and fashion studies. Instead of claiming that ‘new materialism’ is a novel way to deal with fashion, Rocamora and Smelik therefore argue, “it may be better to speak of ‘renewed materialism’” (2016: 13-14; cf. Smelik 2018).
But before I further explore how a combination of postphenomenological and new materialist theories can contribute to a better understanding of techno-fashion, I will first discuss how these two philosophical approaches respectively emphasize, rethink, and theorize matter.

Although Don Ihde does not explicitly relate to new materialist thinking in his work, I agree with Helena de Preester that it is highly interesting to “concentrate on those places where Ihde opens doors to the thoughts or ways of thinking of others and where he—perhaps unwittingly—enters into dialogue with thinkers he does not mention” (De Preester 2010: 339). Several commonalities between postphenomenology and new materialisms triggered my interest in a combined approach: they (1) share a clear “predilection for a more phenomenological approach to embodiment” that focuses on the materiality of the body and artifacts (Coole and Frost 2010: 20); (2) theorize matter in terms of ‘material agency’; and (3) endeavor to surpass the classic dichotomies between subject and object, nature and culture, human and non-human. Using ‘AWE Goosebumps’ as my case study again, I will show that the synthesis of all three theoretical arguments is key to gaining a better understanding of the ‘agentive’ materials, material qualities and material mediations of techno-fashion.

1. Carnal Matter
As elaborately discussed in chapter two, postphenomenology shows how material culture (i.e., artifacts, instruments, and technologies) is taken into human experience through embodied human-technology relations (Ihde 2003b: 14). Postphenomenology distills the notion of materiality from phenomenology in order to theorize the role of materiality in human-technology interrelationships. Building upon the phenomenology of Husserl and Merleau-Ponty, postphenomenological thinkers such as Don Ihde and Peter-Paul Verbeek conceptualize “materiality [as] a central feature within human and social activity” (Ihde 2003a: 5) and demonstrate how “[t]hings mediate the relation between human beings and their world not in a linguistic but in a material way” (Verbeek 2005a: 209). As a result, Don Ihde points out; it seems “that the kind of phenomenology that emerged at the end of the twentieth century is more materialist and embodiment-oriented than the phenomenology done during at the beginning of the century” (quoted in Crease et al. 2003: 16). Within the context of the current chapter, the postphenomenological attention to embodiment and the material dimension of human-technology relations is significant in helping to think and rethink the ways in which bodily matter (e.g., organs, skin, and bones) relates to technological matter (e.g., sensors, batteries, and microcontrollers). ‘AWE Goosebumps’, as its name suggests,
is based on the bodily phenomenon of goosebumps. The materiality of the design (its color, movement, behavior, shape, and texture) amplifies the material characteristics of the human skin, mimicking its unique capacity to externalize the internal sensation of ‘awe’ on the surface of the body. The matter of techno-fashion thus absorbs some of the material capabilities of the human flesh, turning the garment into an object that can sense and respond to its wearer as if it were a living body. I will return to the analogy between bodily matter and techno flesh in the final section of this chapter when I use postphenomenological and new materialist theory to further analyze the materials and material capacities of ‘AWE Goosebumps.’

“One of the central ideas in the development of the postphenomenological approach,” Verbeek notes, “is that we need a ‘material turn’ in the philosophy of technology: we also need to study things, rather than merely focusing on humans” (Verbeek 2015: 192). This “phenomenological materialist” (Ihde 2010: iii) approach of postphenomenology is relevant insofar as it concerns “a multidimensional sense of the body” and accounts for the material mediations technologies perform (ibid: iv). According to Don Ihde, the philosophy of technology has indeed developed “a growing sensitivity to the ways in which materiality plays subtle and deep roles in our ways of moving about in the world” (2003a: 1, original emphasis), and differentiates itself from other styles of philosophy “in its necessary sensitivity to the concrete, to materiality” (ibid.: 2, original emphasis). Connected to techno-fashion, this implies that the body of the wearer and the body of the ‘thing’ (i.e., the garment) deserve equal attention, for it is the relation between these two concrete materialities that determines the effect and meaning of techno-fashion. In fact, most techno-fashion is based upon the relationship between a material stimulus in or around the human body (e.g., galvanic skin response, temperature, heartbeat, or breathing) and the material transformations of the garment (e.g., color change, movement, light emission, or inflation).

Like postphenomenology, new materialisms draw on Merleau-Ponty’s ontology of flesh and the “phenomenological task [of showing] how consciousness emerges from, yet remains enmeshed in, this material world” (Coole 2010: 101). “If for Merleau-Ponty it is corporeality that introduces meaning or structure into matter,” Diana Coole notes, “this is because the body literally incarnates material capacities for agency” (ibid.: 101). Coole reconstructs and further develops some elements of Merleau-Ponty’s phenomenology which, according to her, suggest that “the French phenomenologist was envisaging a radically new materialism” (ibid.: 93). His consequent emphasis on corporeality and primacy of perception, in particular, inspires a new materialist account of “material existence as
folded flesh” (ibid.). As Coole sees it, Merleau-Ponty’s aim “is to explain a generative, self-transformative, and creative materiality without relying on any metaphysical invocation of mysterious, immaterial forces or agencies” (ibid.). This is where new materialisms rethink and conceptualize materiality in ways more radical than postphenomenology does. To new materialists, materiality is transformative and vibrant in and of itself. This argument becomes particularly apparent in the discussion of material agency.

2. Material Agency

In addition to theorizing embodied perception, postphenomenologists focus on the non-neutrality of technological mediation (Ihde 2003a, 2003b; Verbeek 2015). Typically using objects such as medical instruments and scientific devices as their research objects, they analyze how technological artifacts make previously imperceptible and invisible worlds observable (Verbeek 2005a: 141-143). Techno-fashion allows wearers and their environment to perceive and see things that would otherwise remain (mostly) unnoticed: ‘AWE Goosebumps’ makes biosignals such as heartbeat, respiration and skin conductance visible to the wearer as well as her environment. In the words of Ihde, technological artifacts are the means by which mute things are given a ‘voice’ and get to ‘speak’ from and for themselves (Ihde 1998: 151). The examples he gives to illustrate this voice metaphor mostly concern auditory perception, e.g., the way in which things that are seemingly silent can be “given voices” through musical percussion or when something inaudible is mediated by the proper instrument (ibid.: 151-152). Understanding Ihde’s notion of an object’s voice metaphorically, ‘AWE Goosebumps’ can be said to ‘unmute’ the sensation of goosebumps in the sense that it reveals how “that which had not been visible can now become visible, and that which was unheard can now begin to be heard” and that “[t]hings, too, have or may be given voices.” (Ihde 2009: 80).

The idea that material artifacts are able to exert power over human experience and behavior and that technologies allow things to ‘speak’ for themselves, signals the influence of the work of sociologists Bruno Latour and Andrew Pickering among postphenomenologists (Ihde and Selinger eds. 2003). Latour is highly influential for developing a more sensitive and symmetric approach to things, arguing that objects have agency too (Latour 2005: 63). Non-human actants, Latour emphasizes, possess a “type of force, causality, efficacy, and obstinacy” that science should inquire into (ibid.: 76). Things, in general, are able to exert power over humans, affecting how we behave, think and live in many different ways. Latour uses the classic example of a speed bump or the bulky object attached to the hotel key ring: their concrete materiality (height, weight, solidity) physically compels people to slow down respectively
or return the hotel room key upon departure (Latour 1992, 1994; cf. Verbeek 2005a). Similarly, Pickering’s notion of a ‘dance of agency’ describes how much of our everyday life has the character of an interplay between human and non-human actions (Pickering 2010: 195). According to Pickering, the world is filled with agency – with materials that are “continually doing things, things that bear upon us (...) as forces upon material beings” (Pickering 1995: 6).

In their own distinct ways, both Pickering and Latour seek out to establish a vocabulary and scientific practice that accounts for the ways in which artifacts do things (Latour 2005: 55, original emphasis). Verbeek, most notably, has used these insights as a source of inspiration for developing the postphenomenological conceptual framework in the direction of material agency and technological mediation (Verbeek 2005a, 2011, 2016). Focusing on “what things do,” he outlines the elements of a philosophy of technological artifacts that turns the attention to things themselves and the roles technologies play in our culture and daily lives (2005a, 2011). According to Verbeek, several scholars from the field of Science and Technology Studies have already reflected upon material agency, but generally without discussing the phenomenon of technological mediation in detail (Verbeek 2016: 191). The question to which extent technologies have (moral) agency is key to the theory of technologically mediated morality that he develops (2011).

According to new materialist ontologies, the problem with predominant modes of thinking about matter is that they are shaped by the Cartesian understanding of matter as inert, passive and mute substance (Coole and Frost 2010: 9; St.Pierre et al. 2016: 101). Barrett and Bolt explain that new materialist thinking is a reaction against the cultural turn, because “where social constructivist theories thrive, matter becomes mute” (2013: 3). This “idea that the world is a passive resource for use by active humans is no longer sustainable,” they argue (ibid.). Similarly, Dolphijn and Van der Tuin state that it is inadequate to understand matter as inert substance because “[b]ehind or, better said perhaps, beneath every object, every representation, every physical of metaphysical ideality lies a phenomenon, which is the flesh and blood of the world, the life that continues to live in and through being as it is represented in itself” (2012: 108). For both postphenomenology and new materialisms, material agency and the question if human beings are the only entities to ‘act’ is one of the main discussion points. Although the vocabulary of new materialisms and postphenomenology clearly differ, they share an interest in the agency and power of both human and non-human matter. This brings me to the third and final commonality: their critique on human-centricity and dichotomous modes of thinking.
Beyond Dichotomies, Beyond Anthropocentrism

The auditory metaphor of the "croaking frogs" (Tromp 2016) that I cited earlier signals that self-acting or self-transforming artifacts such as ‘AWE Goosebumps’ can be experienced as having lifelike or, in this case, animal-like features. This wearing experience aligns with recent approaches in both postphenomenological and new materialist thinking characterized by an explicit decentering of the human and deconstruction of classic dichotomies such as human-nonhuman, object-subject, and nature-culture oppositions. Although such approaches are not exclusive to postphenomenology and new materialisms\(^6\), I consider these two schools of thought particularly suitable and relevant for understanding and conceptualizing the materiality of techno-fashion.

Despite their different roots and research objects, the fundamental argument of new materialist and postphenomenological accounts of materiality is that nonhumans and humans should be considered symmetrically. Within postphenomenological theory, Ihde’s concept of alterity relations and Verbeek’s theory of technological mediation most explicitly voice this argument for getting beyond human-centricity and subjectivism (Ihde 1990; Verbeek 2015). Alterity relations – the third type of human-technology relations that Ihde identifies in addition to hermeneutic and embodiment relations – concern relations to or with technology wherein the technology is experienced as alterity, as a “quasi-other" (1990: 98, original emphasis). As Verbeek explains, the term quasi-other her points out that, although we often tend to project human properties onto technologies that seem behave as if they are another living subject (e.g., robots), they can never be a genuine other (Verbeek 2005a: 127). I believe this idea of alterity relations is applicable to techno-fashion in the sense that it explains why we may have the eerie yet fascinating experience of encountering a ‘quasi-other’ when wearing or observing self-transforming and self-acting artifacts such as ‘AWE Goosebumps.’

The second postphenomenological notion of value to studying techno-fashion is the notion of material (i.e., technological) mediation. As mentioned several times within this dissertation, a postphenomenological understanding of materiality (and technology in particular) involves recognizing the non-neutral and mediating role of objects...
in human perception and life (Ihde 1990; Verbeek 2005a). Postphenomenology, therefore, could be considered a ‘material phenomenology’ (Ihde 2003b: 21; cf. 2010: iii). “Materiality,” Verbeek explains, “is no blank projection screen for human interpretations, but plays an active role in our technological culture” (2005b). Taken together, the notion of alterity relations and material mediation underscore the fact that in situations of mediation, human beings are not simply ‘extended’ with technological artifacts (Kiran 2015). Rather, technologies help to constitute what it means to be a human being (Verbeek 2012: 393). This highlights the ways in which human beings – be it wearers or observers – and their experiences are co-shaped by technological mediations. As ‘AWE Goosebumps’ mimics and amplifies goosebumps, a phenomenon normally reserved for the human skin, it reflects on what it means to have a body and creates an exchange of material qualities between a human and a nonhuman being.

The postphenomenological conceptions of alterity and material mediation recognize that human and nonhuman matter and object and subjects cannot simply be understood as two opposing poles but interfere and mix. It does not, however, yet give up the modernist subject-object distinction entirely (Verbeek 2005b). It does not distance itself from humanist values but does seem to make an attempt at formulating a post–humanist theory in the sense that it gets rid of the primacy of the ‘pure’ human subject and replaces it with a human subject that embodies all kinds of technological objects (ibid.). In this endeavor to rethink the human subject in tandem with the non-human matter, postphenomenology crosses paths with new materialist explorations of “how matter is thought and where agency resides” (St. Pierre, Jackson, and Mazzei 2016: 100).

The difference between the postphenomenological and new materialist position in my view resides in the fact that new materialisms rethink matter in ways more radical, critical, and ethico-political than postphenomenology (Healy and Schlunke 2015). New materialisms’ all-encompassing reconceptualization of materiality, I believe, can add a more radically post-anthropocentric and post-humanist approach to postphenomenological theory. Not unlike the postphenomenological perspective, the new materialist orientation “is post-humanist in the sense that it conceives of matter itself as lively or as exhibiting agency” (St. Pierre, Jackson, and Mazzei 2016: 101). New materialisms, however, go much further in decentering the human subject, critically unraveling contemporary subjectivity through doing radically interdisciplinary research (Van der Tuin et al. 2013: 3). In turn, I want to argue, postphenomenology can complement the abstract and deeply philosophical approach of new materialisms, with an empirical research methodology based on concrete technological artifacts.
Connecting the Dots: Towards a New Materialist Postphenomenology

With their shared interest in carnal matter, material agency, and post-anthropocentrism, postphenomenology and new materialisms seem to be on a similar quest for rethinking materiality and the status of the contemporary human subject. Both strands of academic thought pay special attention to material agency and reconceptualize what this means for subjectivity. Postphenomenology confines this reconceptualization to a rethinking of human-technology relations, whereas new materialisms develop non-human-centric understandings of materiality and the human in response to “today’s technological, ecological, natural-cultural terrains” (Healy and Schlunke 2015). In this third and final section of this chapter, I will further elaborate on how postphenomenological and new materialism can complement each other by highlighting the overlapping as well as conflicting elements in their accounts of (human and nonhuman) matter and subjectivity. In addition, I will apply the ‘new materialist postphenomenology’ that I propagate to my case study ‘AWE Goosebumps,’ demonstrating the significance of such a radically interdisciplinary theoretical framework for the study of techno-fashion.

Does Techno-Fashion Have or Just Enact Agency?

As I explained in the introduction, several scholars have introduced the thought-provoking idea that techno-fashion equips garments with the material capacity to “act” (Cranny-Francis 2013: 162). “What makes smart fabrics revolutionary,” Rebeccah Pailes-Friedman notes, “is that they have the ability to do many things that traditional fabrics cannot, including communicate, transform, conduct energy, and grow” (2016: 14). As such self-acting, self-transforming, and responsive capacities of techno-fashion confront us with a non-human form material agency that has yet to be explored, a theoretical framework developed for unraveling the material agency of techno-fashion is more than welcome.

For postphenomenologists, material agency is not located exclusively in the technology, but in ‘the assembly’ of the wearer, fashion, and technology (Verbeek 2011: 64). The work of Ihde, in particular, suggests that we cannot possibly say anything about the agency of technological artifacts as distinct from us, because we are only able to think material agency as it manifests itself in relation to us. We incorporate, inhabit, and belong to technology just as technology incorporates, inhabits and belongs to us. Moreover, Ihde’s work maintains that isolated agency cannot be located in non-humans independent of humans, since humans decide to wear jackets and jackets simply do their job by keeping us warm (Jørgenssen 2003: 222). According to him, technologies need human intentionality in order to work: “[a] technological object, whatever else it is, becomes what it ‘is’ through its uses” (Ihde 1990: 70). Hence, Ihde does not recognize
material agency to be a legitimate way of speaking about non-humans (Jørgenssen 2003: 222). Being a diehard phenomenologist, Ihde denies the existence of ‘a thing-in-itself’ outside of embodied human perception. Non-humans are non-neutral and multi-stable, but only insofar as they are constituted in relation to humans (ibid.).

Postphenomenology, or at least the postphenomenology as formulated by Ihde, does not look at materiality itself but only in relation to a human lifeworld (ibid.: 224, original emphasis). This view aligns with new materialist ways of thinking matter in the sense that both acknowledge that there is a mutual constitution of, an ‘intra-action’ between human and nonhuman beings (Barad 2003; Jones and Boivin 2010: 351). Unlike new materialisms, however, postphenomenology retains a human-centered perspective to the extent that it always starts from the position of the embodied human subject. New materialisms are more interested in exploring the open-endedness of human subjectivity, highlighting the entanglement of humans and non-humans hence opting for a perspective that allows for more radical symmetry between them (Barad 2007).

When applying the partially overlapping yet also diverging notions of material agency in postphenomenology and new materialisms to my case study, it becomes clear that both positions are equally significant for understanding the material capacities and qualities of techno-fashion. Usually, garments move with the wearer’s body. ‘AWE Goosebumps’, however, is a garment able to move autonomously in response to the signals of the wearer’s body. A postphenomenological perspective helps to recognize that material agency here partially resides in and depends upon the human: ‘AWE Goosebumps’ is able only to amplify and ‘animate’ the goosebumps of the wearer insofar as it relates to a human body and subjectivity (Interview KN 2017). Yet, I want to argue; this postphenomenological view highlights only one form of material agency exhibited by ‘AWE Goosebumps.’ The integration of technology into fashion also pushes clothing into a new dimension “where it is not anymore just a passive surface, but behaving as a living, sensing and transforming interface” (Uğur 2013: 15). As a consequence, it seems as if the garment possesses some kind of autonomy and independence from the human subject. As model Inka Siefker tellingly describes:

I can’t say that I have ever been surprised by the [behavior] of the dress, but I have felt like I could control it. In the same sense that I think I have a handle on my emotions. As I stated before, I am a performing artist so I like to think I can emote awe and wonder on a whim. However, true goosebumps are too primal to imitate so controlling the inflation is not feasible” (Interview IS 2017).
This wearing experience signals that ‘AWE Goosebumps’ involves two types of material agency at once. Some of its reactions and material transformation can be influenced by the wearer, to the extent that she can make her body perform certain emotions. But the garment also exhibits a (frog-like) type of material agency that cannot be controlled by the wearer as it is activated by the material sensation of getting goosebumps, which is too primal to be controlled. The material agency of techno-fashion, then, “is a matter of intra-acting, an enactment, it is not possessed by something or someone” (Jones and Boivin 2010: 351). Or, as Karen Barad puts it:

Agency cannot be designated as an attribute of either subjects or objects, as neither subjects, not objects pre-exist as fixed identities. (…) Agency is not then simply a subject-centered ability to act, but instead defines the way in which courses of action are mediated and articulated over time, whether that action is physically carried out by people or by things (2003: 827).

By adhering to an idea of material agency that combines postphenomenological with new materialist theory, we can see how ‘AWE Goosebumps’ creates alliances and encounters between the fabric and LED lights; sensors and bodies; between garment and technology; and between the animate and the inanimate. Tromp describes how ‘AWE Goosebumps’ makes her uncomfortable because she feels “caught” when the garment starts to inflate (Tromp 2016). The design shows how agency can be performed by technology in such a way that it intra-acts with human agency yet can no longer be understood as strictly human property. In ‘AWE Goosebumps,’ the mental (invisible) state of the spectator has a material effect on the garment, animating what would normally be a ‘mute’ material. Moreover, the muscle wires in the garment actively do something beyond and without the intervention of the wearer: once they have been programmed, they ‘self-organize’ and self-transform without and beyond the control of the wearer. ‘AWE Goosebumps’ is able to ‘animate’ and amplify the goose-bumpy sensation of the human skin on the surface of an inanimate object like clothing, and hence represent an ‘agentic’ yet nonhuman type of agency (Neidlinger et al. 2017; Knappet and Malafouris 2008). The integration of technology turns fashion into animated and agential matter (St. Pierre, Jackson, and Mazzei 2016: 100), into matter that has a “transformative force in itself” (Dolphins and Van der Tuin 2012: 107). The human subject is still there and cannot be denied, but it is transformed and decentered in the encounter with techno-fashion. The remaining question is how far this symmetry between human and nonhuman matter goes in the case of techno-fashion, and how ‘fleshy’ the materials of techno-fashion truly are.
The ‘Flesh’ of Techno-fashion
Not only does a combination of postphenomenological and new materialist theory help to account for the material agency of techno-fashion (Smelik 2018), it also allows for an analysis “which incorporates both non-human matter (e.g., fashion objects) and human matter (e.g., physical, experiential, living bodies)” (Bruggeman 2014: 43). The ‘material aesthetic’ of ‘AWE Goosebumps’ is inspired by the manner in which skin reacts to its environment. Neidlinger used both human and animal skin as a source of inspiration for modeling the laser-cut material of the design (Sensoree n.d.). This project thus takes the notion of the second skin quite literally by mimicking and animating its material texture, look, and behavior. From a new materialist perspective, the duality between human and non-human is blurred, questioning where the garment begins, and the body ends. Techno-fashion here “marks an unclear boundary ambiguously, and unclear boundaries disturb us,” it shows that “[i]t is at the margins between one thing and another that pollution may leak out. Dress is the frontier between the self and the non-self” (Wilson 1989: 2-3).

This chapter started with an object-analysis of ‘AWE Goosebumps’ that focused on the materiality of technologies: on the concrete physical substance and characteristics of the garment and the technologies it incorporates. I then moved on to discuss the design in terms of relational materiality, addressing how it materially mediates and relates to other material actors including the wearer and her physical surroundings. “Having shifted its focus from human understandings of technology toward the materiality of technologies,” Verbeek argues, “we now have to move toward to technologically mediated human beings” (2015: 192). Following Verbeek’s argument for a theory of technological mediation, I agree that it is now time again shift the focus and explore the question of what it means to be a technologically mediated human being and to wonder about the material ontology of this second, technological layer that techno-fashion augments the body with. In order to do so, I will return to the philosophy of Merleau-Ponty that inspired both postphenomenological and new materialist accounts of materiality.

Merleau-Ponty does not give much credit to things’ capacities or competence (Olsen 2010: 80). In his last and unfinished book, however, his phenomenology does seem to cross paths with more recent work in feminist and Science and Technology Studies. One of the central concepts in Merleau-Ponty’s posthumously published The Visible and the Invisible is the notion of the ‘flesh.’ He writes that the material world (including ‘things’ such as color, sound, and tactile textures) has a “thickness” and a “flesh” that is fundamentally homogeneous” with human flesh (Merleau-Ponty 1968.: 113-114). As explained in chapter one, where I introduced phenomenology as one of the theoretical pillars for
this dissertation, Merleau-Ponty uses the term flesh to describe the basic homogeneity of the materiality of the body and the material world it inhabits. The body and the world are relational, intertwined, and reversible aspects of a single flesh or “fabric,” as he also terms it (Merleau-Ponty, 1945/2002: 273). In philosophy, this is also known as the chiasm or reversibility of two divergent entities, such as the subject and the object or the self and the other (Reynolds n.d.). With the notion of the flesh, Merleau-Ponty suggests that the materiality of different entities does not mark their difference, but in fact enables the possibility of overlapping and encroachment between them (1968: 248). The porous flesh of the body is woven into the permeable flesh of the world, and vice versa.

“After skin,” Seçil Uğur argues in her design-based dissertation on wearable technology, “clothes are the most intimate surfaces between our surroundings and our bodies” (Uğur 2013: 12). Wearing clothes comes so natural to us that they are generally experienced as an integral part of our embodied existence, hence the prevalent metaphor of clothing as a ‘second skin’ (see for example Horn 1975; Sontag and Schlater 1982; Berzowska 2005; Dunne 2010b). Although the notion of the second skin is controversial – it “comes freighted with all kinds of cultural assumptions, not least through its genesis in the colonialist (and essentially racist) anthropology of the 1930s” (Cranny-Fancis 2013: 170) – it does seem to gain relevance again in the case of techno-fashion like ‘AWE Goosebumps’. In a way, the animated goosebumps equip the wearer with a second and ‘technological skin’, through which she can sense and locate things beyond and in addition to the perceptual capacities of her ‘first and fleshy’ skin (Horn 1973: 122). As Dan Hicks writes, “[l]ife, both human and non-human (...) involves not relations between fixed entities, but life as the ongoing flow of permeabilities” (Hicks 2010: 90-91).

When the wearer of ‘AWE Goosebumps’ experiences stress or anger, her heart rate, skin moisture, and temperature will increase, causing the dress to turn bright red. Through interpreting the color red as a sign of stress or anxiety, the wearer is consequently alerted to her own emotional state. This might cause her to calm down and her temperature and heart rate to drop to a normal level or, on the contrary, it might make her feel ashamed of herself in front of others and hence even more stressed and anxious. Exposing the inner state of the wearer to the outside world, as well as visualizing how the wearer’s body reacts to her environment, the garments “experiments relentlessly with ways of defining and redefining the boundaries between self and other, subject and object, inside and outside” (Warwick and Cavallaro 1998: xviii). The incorporation of technology affects the material ontology, animating the very matter of fashion. In allowing some of the material qualities of the human skin to flow into those of the
garment, and vice versa, ‘AWE Goosebumps’ presents an interesting analogy and permeability between the human and nonhuman flesh.

Conclusion
This chapter addressed how the incorporation of technology into garments opens up a whole new array of materials for fashion. I started by noting that there are three ways in which ‘AWE Goosebumps’ foregrounds the specificities and significance of techno-fashion’s materiality, as well as the inherently material dimensions of wearing and interacting with techno-fashion. Techno-fashion introduces fashion to materials ranging from silicone, biosensors and LED lights – as in the case of ‘AWE Goosebumps’ – to optic fibers, 3D printed plastics, solar cells, muscle wire, and microchips. Through an object analysis of ‘AWE Goosebumps,’ I showed that a conventional material culture approach to techno-fashion is helpful to the extent that it stimulates direct and careful observation of the materials and material aspects of the artifact and invites sensorial as well as emotional engagement with the designed object. A material culture approach to techno-fashion allows for a focus on the materiality of the object and enables the researcher to deduce information about cultural values and beliefs starting from that object. On a more critical note, I noted that material culture studies tend to reduce materiality to static physical properties and therefore fail to address how the dynamic materials and material transformations of techno-fashion affect people’s behavior and experiences.
Secondly, I argue that studying the materiality of techno-fashion requires attention to material practices and relations: to what people do with techno-fashion, and vice versa. In addition to an analysis of the object’s material qualities, a relational perspective on materiality is indispensable when it comes to studying the materiality and of techno-fashion. Relational notions of materiality rooted in material culture studies and science and technology studies, help to see that the matter of techno-fashion cannot be confined to the object itself but always manifests itself in relation to the material, social, and cultural context in which it is embedded. Some of ‘AWE Goosebumps’ material aspects are relatively static (e.g., its metallic color, fit, and weight) and hence easily detectable through conventional object analyses. Other material features are transformable (e.g., the shape, silhouette, and color of the LEDs) and can only be fully investigated when their relational character is accounted for. Moreover, the notion of materiality as a relational effect or event stimulates the use of a research methodology that accounts for its transformative and unstable character. Without studying the experience of techno-fashion as part of the event or act of wearing technology, it would remain unclear how the material reacts upon and interacts with the wearer. The material capacities of the biosensors, microcontrollers, valves, inflatable silicone, and LED strips integrated into designs such as ‘AWE Goosebumps’, I demonstrated, cannot fully be grasped by their stable physical form but have to be understood and studied as an effect of the relations between the wearer’s body, the garment, and the environment.

Thirdly, I discussed that the new materialist argument for abandoning subject-object dichotomies, thinking material agency and reappraising matter, bears striking similarities to the postphenomenological call for a focus on “inter-relational ontologies”, as well as its the fact that postphenomenology draws “from an embodiment analysis of human action and perception” and is “materially sensitive” (Ihde 2015: xv). Although postphenomenology does not hold to a strict symmetry between humans and non-humans, it is materially sensitive because it recognizes instrumental “intentionality” (Ihde 1990: 32) and develops a material hermeneutics that is modeled upon the capacity of contemporary science instruments to “let things speak” (Ihde 2015: xv). In that sense, postphenomenology also assigns a certain agency to matter but only as it comes to the fore in the relations between human beings and objects.

‘AWE Goosebumps’ represents the new matter-reality of fashion, showing technological materiality that reaches beyond the concept of the object altogether, however fluid this conception may be (Küchler 2008:103). Its fleshy and flashy materiality urges us to gain a perspective from which we can no longer distinguish subjects from objects and
examine the consequences of our various beliefs about the properties of materiality itself (Miller 2010: 10). These new materials have a new material quality that makes them seem ‘animate,’ ‘skin-like’ and agentic rather than passive and mute. Behaving in ways that were long held to be exclusive to the human subject (e.g., adapting and responding to the environment) the materials of techno-fashion are making themselves ‘heard.’ ‘AWE Goosebumps’ demonstrates that it is not just us designing non-human objects, but also the other way around. The non-human matter of techno-fashion constitutes what it means to be a human wearer in the first place.

This chapter discussed that techno-fashion equips garments with new material abilities, with the ability to act and transform ways more radical than ever before. To test this hypothesis, I connected postphenomenology and new materialisms. Incorporating technology into fashion, activates and ‘animates’ the matter of fashion in something more flashy and fleshy. I developed the argument that techno-fashion, in particular, demands a renewed or “reactionary” (Beaudry and Hicks 2010: 2) view of material culture that accounts for its transformative and agentive materiality, in order for it to include the active, lively, ‘smart’ materials such as those inhabiting techno-fashion. What appears to be new about the materiality of techno-fashion is that its material transformations are speedier and appear to come from within the object rather than from the outside. Discussing the ways in which ‘AWE Goosebumps’ mimics the behavior of human skin, finally, I argued that techno-fashion challenges a dichotomous distinction between inanimate and animate matter.

Techno-fashion invites a rethinking and reconceptualization of the materiality of fashion not only because it lends new material qualities to clothing, but also because it impacts how garments are able to externalize and materialize certain characteristics of the wearer. Combining postphenomenology with new materialisms provides a conceptual and theoretical framework to think the entanglement of animate and inanimate, address the material agency of techno-fashion, and emphasize the often-neglected role of materiality and technologies in the humanities and social sciences (Ihde 2009: 74). This chapter revealed how the integration of technology turns fashion into animated and agential matter (St. Pierre, Jackson, and Mazzei 2016: 100); into matter that has a “transformative force in itself” (Dolphijn and Van der Tuin 2012: 107). A new materialist postphenomenology is needed for understanding the ways in which the matter of techno-fashion intra-acts with human agency. Techno-fashion calls for perspectives that think materiality beyond a strictly human-centered perspective yet without erasing or denying the human subject altogether.
Imagine a nocturnal walk through the city. A pack of jumpy bright lights catches the attention. As the lights approach, a group of runners emerges from the dark. The pace of their blinking outfits decelerates, collectively slowing them down just before they pass you by. ‘Phototrope’ is a series of LED-illuminated sports shirts, designed by Pauline van Dongen to improve safety for runners in ill-lit and nocturnal settings [Figure 42]. Made from technical jersey embedded with washable low-energy LED ribbons and sections of reflective foil, the shirts refract the light in a playful and slightly multi-colored way. The latest version of the project includes the possibility of interactive illumination, controlled by an app. Allowing a group of runners and their trainer to set and adjust the pace, pattern, and intensity of the lights on each individual shirt, the project not only enhances the visibility and hence safety of the runners but also demonstrates how combinations of fashion and technology allow for new forms of social interaction and communication (Ryan 2014: 144). No longer do the runners have to gesture, speak, or shout to exchange information about their running practice, as the lights in their outfits already tell them what the plan is.

Van Dongen’s ‘Phototrope’ is just one example of how the integration of technology into fashion materially mediates processes of communication. In addition to aiding and transforming the (nonverbal) communication between the members of a running team,
techno-fashion can publicly display the wearer’s vital signs or mood, send hugs over distance, signal air pollution or the infringement of personal space, and communicate many other sorts of information to or about the wearer and outside world. Techno-fashion, in other words, can be used as a whole new vehicle for communication, self-presentation, and social interaction. Yet how does the material mediation of techno-fashion impact the communicative and self-expressive role of fashion? What meanings and interpretations does techno-fashion convey? How can techno-fashion express or ‘say’ something about the wearer that regular fashion cannot tell? And how does wearing it affect the ways in which we socially interact with others and relate to ourselves?

The previous chapter showed that techno-fashion activates and unmutes the matter of fashion, in the sense that it turns garments into ‘agentive’ (i.e., self-transforming, self-acting, responsive, smart) material artifacts. I adopted and extended an object-based research approach that “reads” techno-fashion through observing, describing, classifying, and analyzing its basic material properties (Steele, 1998: 329). Arguing that its ‘animate,’ agentive and transformative materiality is key to understanding how techno-fashion affects the wearer and her (interaction with) the environment, I showed that techno-fashion blurs the boundaries between human and non-human matter. In order to develop a full understanding of processes of mediation through techno-fashion, however, we should not only study ‘what things do’ but also how humans give meaning to these mediations – both empirically and conceptually (Verbeek 2015: 190).

This chapter explores how people interpret and give meaning to the embodied experiences and material properties of techno-fashion. If fashion and clothing “are always already performing a communicative function” (Barnard 2007: 137), then what happens when technology enters the scene? Using Pauline van Dongen’s ‘Phototrope’ as a case study, I will look at the ways in which techno-fashion materially mediates the meanings that fashion convey. Building upon the combination of postphenomenological and new materialist theory unfolded in the previous chapters, I will shift the focus to processes of communication and social interaction through techno-fashion while maintaining an emphasis
on the embodied and material dimensions of such processes. In addition, I will use the notion of performativity to address how the material and embodied character of techno-fashion co-constitutes and expressed the wearer’s subjectivity in relation to others.

Van Dongen’s ‘Phototrope’ serves as an interesting case study for gaining insight into techno-fashion as a vehicle for interpersonal communication and personal expression because it deliberately invites social interaction between wearers. Within the context of the Crafting Wearables research project, moreover, team members Marina Toeters and Pauline van Dongen conducted several user tests with ‘Phototrope’ in different social contexts. These tests included short questionnaires conducted with wearers after a public running competition, as well as interviews after a series of training sessions with a running team in a public park. A complete and detailed overview of these ‘Phototrope Test Sessions’ can be found in the list of interviews in the Appendix (‘Phototrope’ Test Sessions 2015). This particular design has thus been tested on several occasions and in different real-life settings, providing rich data on how the project is interpreted and experienced by actual wearers. Firmly situated in-between the realm of expressive and applied techno-fashion, ‘Phototrope’ is a case study that signals both the elements of techno-fashion that allow it to enhance communication and self-expression, as well as helps to address how wearers give meaning to these social interactions in an everyday context.

Does Techno-Fashion Speak?

“Do Things Speak?”, Don Ihde asks in Postphenomenology and Technoscience (2009: 63). By rephrasing his discussion within the context of this research, the question is if techno-fashion ‘speaks’ and whether technology adds new meanings to garments in the sense that it gives them a ‘voice.’ According to Fred Davis, the statement “that the clothes we wear make a statement is itself a statement that in this age of heightened self-consciousness has virtually become a cliché” (1994: 3). Clothes “speak” only in the sense that they tell something about the subject wearing them; they are the means through which we – deliberately or unconsciously – communicate something about our background, taste, personality, interests, occupation, et cetera. The idea of fashion as a language can, therefore, at best be applied metaphorically because the meanings clothing evokes are, by definition, ambiguous and imprecise (Davis 1994: 92; Entwistle 2015: 67).

Malcolm Barnard also takes stand in the debate on fashion as communication, arguing that the idea that our clothes make a statement “is not, of course, literally true”: “The
clothes we wear do not sit upon us or wait in the wardrobe shouting ‘I’m cheerful!’ or ‘Open the door for me!’ Nor do they whisper seductive nothings from the depths of the lingerie drawer” (Barnard 2002: 29). None of these authors anticipated the advent of techno-fashion, which introduces the possibility for garments to literally speak as well as radically expands the possibilities for clothing to communicate written messages. While the literal statements of clothes used to be limited to texts written or printed onto the fabric, techno-fashion has extended the repertoire to garments that play spoken language (e.g., the Google/YESYESNO ‘Talking Shoe’ [Figure 43]), display multiple real-time Twitter messages (e.g. the ‘Twitter Dress’ by CuteCircuit [Figure 44]), or project programmed text-based visuals (e.g. CuteCircuit’s ‘tshirtOS’ [Figure 45] and ‘Mirror Handbag’ or ‘VIEW N˚1’ and ‘VIEW N˚2’ by Moondial [Figure 46]). As techno-fashion can make the invisible visible and the unheard heard, these examples already provide a partial answer to the postphenomenological question if techno-fashion can speak. If ‘speaking’ is understood as the ability to utter a word or message then, yes, “[t]hings, too, have or may be given voices” (Ihde 2009: 80).

Notwithstanding the ways in which techno-fashion can literally make itself heard, this chapter will argue that it would be a mistake to understand the phenomenon from a purely linguistic or semiotic point of view. Even if techno-fashion expresses spoken or written messages, it always also involves communicative processes that precede or transcend language (Barnard 2002: 29). This still influential idea that fashion functions as a nonverbal system of communication and self-expression have to be traced back to scholarly literature written long before the advent of techno-fashion. Before I elaborate on how techno-fashion such as Pauline van Dongen’s ‘Phototrope’ communicates and conveys meaning beyond or prior to speech and language, therefore, I will first sketch the scholarly background against which this question has to be framed. The work of English psychologist John Carl Flügel and American novelist and academic Alison Lurie, most notably, informs almost all later studies of how and why people communicate through clothing and fashion.
Wearing Your Heart on Your Sleeve: Communicating through Fashion

Although Flügel’s Freudian-inspired *The Psychology of Clothes* (1930) has been criti
cized for prioritizing the psychological over the socially constituted and symbolic char-
acter of clothing (see, for example, Davis 1994: 84 and Entwistle 2015: 64-65), his work
has become canonical as one of the first to recognize the social and communicative
role of fashion. Clothing, Flügel argues, prompts our impressions and judgement of
people, as well as influences our behavior towards them:

Man, it has often been said, is a social animal. He needs the company of
his fellows and is delicately reactive to their presence and behavior. And
yet, so far as the sense of vision is concerned, civilized\(^1\) man has but little
opportunity of directly observing the bodies of his companions. Apart from
face and hands (...) what we actually see and react to are, not the bodies,
but the clothes of those about us. It is from their clothes that we form a
first impression of our fellow-creatures as we meet them (1930: 15).

Clothes are among the primary visual cues that inform our initial reaction too, and in-
teraction with, others. According to Flügel, clothing, therefore, constitutes a nonverbal
communication system that in fact often even precedes other forms of communication,
such as speech. He states that individuals express themselves through garments and
that an outfit can tell us something about the wearer’s sex, occupation, nationality, and
social standing (1930: 15). The things that wearers are trying to express through their
outfit and the initial reaction that the outfit evokes do not necessarily have to match.
Nonetheless, it is commonly believed that fashion enables us to “make a preliminary
adjustment of our behavior towards [others], long before the more delicate analysis
of feature and of speech can be attempted” (ibid.). Connected to techno-fashion, this
insight already partially explains why celebrities have been so eager to wear tech-
no-fashion: the illuminated, flashy, self-transforming and responsive outfits allow them
to make a strong visual statement about their unique personality, and creative stature
before any other forms of communication become involved.

In addition to the three anthropological explanations he gives of why we wear cloth-
ing (i.e., bodily protection, modesty, and decoration), Flügel thus also hints at a fourth

\(^1\) Note that Flügel’s use of the word ‘civilized’ (as opposed to ‘primitive’) to distinguish his own culture from
that of less technologically advanced people as well as his stereotypical assumptions about the innate
dress variations between “man” and “woman” (the man “is more ornamental than the female” and the most
“adventurous and decorative” in his appearance), would be unacceptable in today’s scholarly discourse.
explanation (1930: 16-17). Highlighting how garments generally ‘tell’ us something about an individual, he implicitly puts forth that clothing stems from the fundamental human propensity to communicate through symbols (Entwistle 2015: 66). Flügel, however, does not further elaborate on the characteristics of interpersonal communication through clothes. He bases his analysis on the argument that humans have a fundamentally ambivalent relationship to clothes because garments function to simultaneously hide and exhibit the body (Flügel 1930: 18). He argues that clothing represents an unresolved tension between two conflicting human impulses, between modesty and shame, display and exhibition. For Flügel, clothes, therefore “resemble a perpetual blush on the surface of humanity” they simultaneously hide and advertise, conceal and reveal, our ambivalent feelings towards the human body (ibid.: 21). On the one hand, fashion is like the blush on our cheeks that unwillingly reveals our collective shame about the naked body. On the other hand, garments are our principal means of showing off and marking the body.

Flügel’s understanding of clothing as a sign of the paradoxical tendency to conceal and reveal the body has become a dominant yet debated theoretical framework, adopted by many scholars to explain the purpose of fashion in modern societies (Entwistle 2015: 58, 66). For studying techno-fashion, specifically, it is insightful to the extent that it helps to elucidate how the combination of fashion and technology adds another dimension to this tension between modesty and display and further complicates the already so complex purposes of fashion. Pauline van Dongen’s ‘Phototrope’ protects and exhibits the body by (both literally and metaphorically) making wearers more visible to themselves and to the environment. But it also conceals the wearers in the sense that it allows them to blend in with the running team and directs the attention away from their individuality towards the flashy technology. The same paradoxical purpose is manifested in the potential of techno-fashion to alternate between revealing and concealing the wearer. The integration of technology and new materials makes it possible for garments to, for example, switch from exhibition to camouflage (e.g., the ‘Flashback’ anti-paparazzi collection by Betabrand & Chris Holmes) or from opaque to transparent (e.g., the ‘Intimacy’ designs by Studio Roosegaarde [Figure 47]).
Another dominant way to study the social and communicative roles of fashion has been to focus on the direct analogies between fashion and language. Heavily influenced by Flügel’s work, Alison Lurie’s *The Language of Clothes* (1981) explores how fashion operates ‘as a language’; “an older and more universal tongue” that is indicative of the wearer’s sex, age, and class as well as gives important information or misinformation about the wearer’s occupation, origin, personality, opinions, tastes, sexual desires and mood (Lurie 1981: 3; cf. Barthes 1967/1983). Being ‘dressed to impress’ or ‘dressed to kill’ thus refers to the ways in which individuals can claim and manipulate their dress to send particular, in this case striking or attractive, kinds of messages about who they are (Parkins 2016: 83-93).

Lurie even goes as far as to literally analyze dress and fashion in terms of a ‘vocabulary’ and ‘grammar,’ as well suggests the existence of taboo words, slangs and accents, conventional and eccentric utterances, speech disorders, and foreign languages within the world of fashion. Even though practical considerations such as comfort, durability, availability, and price also play a part in these choices, she notes, the moment of choosing a specific garment over another is, to some extent, indicative of the wearer’s characteristics and personality (Lurie 1981: 5). However, as Lurie herself also realizes, the language of fashion is much more ambiguous than her direct comparison between the two seems to suggest:

As with spoken language, communication through dress is easiest and least problematical when only one purpose is being served; when we wear a garment solely to keep warm, to attend a graduation ceremony, to announce our political views, to look sexy or to protect ourselves from bad luck. Unfortunately, just as with speech, our motives in making any statement are apt to be double or multiple (Lurie 1981: 34).

Lurie’s work has greatly contributed to the now common belief that fashion is a meaningful tool of communication and social interaction, yet the problem with her semiotics of dress is its rather restrictive and univocal interpretation of clothes. “To choose clothes either in a store or at home,” she writes, “is to define and describe ourselves” (ibid.: 5). Using the language metaphor, she reduces clothing and fashion to a merely symbolic and immaterial system of signification. As discussed elaborately in the previous chapter, this overemphasis on the immaterial and signifying effects of fashion often results in a general neglect of its material properties and powers.
The insights of Flügel and Lurie indicate that in modern Western societies, habitually apply the idea that people’s outer appearance gives a sense of who they truly are: “We take cues from how [people] present themselves”, Ilya Parkins writes, “including most importantly, how they dress” (2016: 83-93). Following such assumptions, techno-fashion is not (just) worn for practical or functional reasons, but because of its visual appearance and the meanings that people directly or associatively attach to that (Calefato 2004: 5, 10). Indeed, I argued, the relatively uncommon and often eye-catching look of techno-fashion may be interpreted as a clue about the wearer’s identity. A carried device such as a smartphone or tablet may already reflect some external evidence of the user’s identity through a personalized desktop, its brand, or the design of the cover sleeve. But a worn artifact, Lucy Dunne elucidates, “has a much more intimate impact on the wearer’s identity: it becomes in some ways ‘part’ of the wearer just as clothing does, exerting influence on body image, perceived social status, and societal roles” (Dunne 2010a: 60).

The LED lights integrated into ‘Phototrope’ make the wearer stand out from her environment. Even if this striking visual appearance only serves the purpose of safety, it will also convey meanings beyond its mere functionality. The high-tech look of the illuminated shirts may, for example, be associated with hip urban yuppies or sporty attention seekers. Like any type of dress and clothing, techno-fashion thus functions communicatively. Whether individuals are aware of it or not, within a social context their clothes will be interpreted as telling something about their identity. As techno-fashion is worn on the body, it will also inevitably be read for clues about the wearer, no matter how speculative, coincidental, or arbitrary they may be. Techno-fashion thus ‘speaks’ visually, in the sense that its appearance will consciously or unconsciously be interpreted as ‘saying’ something about the wearer. To further explore the extent to which such linguistic metaphors adequately define the communicative and expressive value of techno-fashion, I will now turn to the meanings that techno-fashion conveys and how such meanings are communicated in the case of ‘Phototrope’.

**In Search of Meaning**

A first step towards answering the question what meanings techno-fashion communicates and how is to analyze ‘Phototrope’ in light of two dominant and common models of communication. In his *Introduction to Communication Studies*, John Fiske points out that there are two main schools in the study of communication: the ‘process school’ and the ‘semiotic school.’ Both approaches simply understand communication as social interaction through messages, but in a slightly different way (Fiske 1982/2011: 2;
As they provide the basis for any study of communication, and heavily influenced the few texts that have so far explored the topic of techno-fashion and wearable communication (e.g., Calefato 2003; Dunne 2004; Kozel 2007; Ryan 2014), I will dedicate the following two paragraphs to these two communication models in order to critically assess their applicability, as well as their benefits and limits for the study of techno-fashion.

**Medium and Message**

According to the first school, the ‘process school,’ communication is the process of sending and receiving messages by means of a certain medium or channel (Shannon and Weaver 1949/1964; Fiske 1982/2011: 5-22). Applying this classic communication model to techno-fashion seems simple: the garment is the medium or channel by which a message is intentionally communicated from one person (sender) to another (receiver) (Barnard 2002: 30). As Malcolm Barnard notes, however, several problems arise when this model is used to analyze fashion or clothing. First of all, it is problematic to determine who or what is the sender, the receiver, and the message of communication through fashion (ibid.: 31). It is difficult to say whether it is the wearer or the designer that ‘sends’ the message if the message concerns the designer or the wearer, and who the recipient of the message is (the wearer, the spectator, or both?).

Second, it is equally complicated to determine if and when a message is intentionally communicated in the case of techno-fashion. After all, it can generate meanings independent of, and far beyond, the intentions of the wearer, programmer, or designer. The one-on-one application of the process model to techno-fashion thus proves to be problematic because it limits the inherently dynamic, ambiguous socially embedded nature of communication and fails to acknowledge how the relation and interaction between wearer, context, and medium eventually co-shapes the messages techno-fashion conveys. An analysis of Pauline van Dongen’s ‘Phototrope’ helps to investigate the potential and shortcomings of the process model further when applied to techno-fashion.

A series of test sessions with ‘Phototrope’ illustrated that the addition of technology (interactive LED lights and smartphone app) could make it more difficult, yet still interesting, to identify who or what would be the sender, medium or receiver within the process of communication through techno-fashion specifically. The main purpose of these tests (see appendix for an overview of the ‘Phototrope’ Test Sessions) was to find out more about how wearers would actually experience the illuminated running shirt in a real-life and social context. After testing the first interactive version of the shirt with...
a running team and their trainer, however, several wearers expressed that the process of communication and interaction through the shirts was unclear to them. When the pace or intensity of the blinking LEDs changed, some of the runners were confused as to who was trying to communicate what. When speaking in terms of the process model of communication, there were moments when they had trouble to determine whether the trainer, the technology, or a fellow runner was the communicator of the message.

If a ‘message’ is understood as “the transmittal of information by signs, signals, cues or words from one living thing to another” (Papadopoulous 2015: 7), then the message of ‘Phototrope’ consists of a certain pace, order, or movement whereas the lights constitute the medium (they are the vehicle through which the message is transmitted). Although the wearers knew about this communication system, they had trouble interpreting the message because of a delay in the LEDs’ response time or because the lights were blinking out of sync (‘Phototrope’ Test Sessions 2015). The app that controls the behavior of the illuminated shirts, moreover, further obscures who (sender) is communicating a message here.

On the one hand, ‘Phototrope’ thus illustrates that the classic communication model by Shannon and Weaver is not sufficient to comprehend the complex and multidirectional communicative processes at work in techno-fashion (Barnard 2002: 30). Unlike postphenomenological mediation theory, the process model fails to address how material entities such as the LED technology, the app, the smartphone, or even the garment as such function as active ‘mediators’ in the process of communication (Verbeek 2015: 190). On the other hand, just the attempt to identify the different actors and their roles within the communication process can help to analyze what may hinder, distort, or even block the process of communication and to improve its effectiveness (Fiske 1982/2011: 6).

Shannon and Weaver identify three interrelated types of problems: technical problems, semantic problems, and effectiveness problems (1949/1964: 4-6). In the case of ‘Phototrope’, it is valuable and easy to spot technical problems. They concern issues such as low or dead batteries, response delays, and blinding or distracting light intensity. One of the main technical problems, however, was that wearers were unable to accurately perceive the message (i.e., the changing light signaling the running pace or order) that their own shirt was communicating, and therefore had to look at the other runners in order to receive the message in the first place. As some wearers suggested, this issue could simply be solved by adding some lights to visible parts of the outfit such as the sleeves, waistband or trousers. The semantic problems, secondly, are equally simple to
identify, yet much harder to solve. They concern any unanticipated meanings conveyed by the shirts, such as blinking lights that evoke the image of an illuminated landing strip (‘Phototrope’ Test Sessions 2015). The effectiveness problems, finally, relate to any responses the communication effects in the receiver. Some wearers of ‘Phototrope’ felt that the illuminated shirt was diminishing rather than enhancing safety and communication because the lights distracted them, defected their visual perception of the environment, and shifted their attention away from the running track.

The results of the user tests with ‘Phototrope,’ in sum, reveal that the process model wrongly presumes that communication is an unambiguous, univocal, and unidirectional transmission of information from a sender to receiver. Shannon and Weaver presume a power relationship in which the sender has full control over a purely passive recipient, which fails to account for how other entities will always co-shape, mediate, and even subvert the message. My analysis of ‘Phototrope’ indicates that wearers play an active role in shaping the meaning of the messages conveyed. Moreover, it highlights that social relationships, the context, and all the ‘mediators’ (app, smartphone, LED technology) also involved actively influence the communication process. The process model is valuable to the extent that it can be a first step towards mapping the different actors and possible problems at work in communication through techno-fashion, but it does not sufficiently explain how and what techno-fashion communicates. The ambiguous, interrelation, and embodied communication processes enabled by techno-fashion thus call for another, more dynamic, model.

**Negotiating Meanings**

The classic understanding of communication as the transmission of messages informs a second model of communication, commonly referred to as the ‘semiotic’ or ‘structuralist’ school (Barnard 2002: 31; Kawamura 2011: 81-90; O’Sullivan et al. 1994: 50). As Fiske points out, the semiotic model ‘is concerned with how messages, or texts, interact with people in order to produce meanings’ (Fiske 1982/2011: 2). Roland Barthes’ *The Fashion System* (1967/1983) was seminal in developing this influential view on how fashion communicates. Ever since the publication of his semiotic account, fashion is often regarded and theorized as a system of signification, signs, and meanings (Barnard 2002; Brand and Teunissen eds. 2006). In *The Fashion System*, Barthes explicitly moves beyond Flügel’s interpretation of clothing as mainly serving the purposes of decoration, modesty, and protection (Flügel 1930: 16-17). “Man”, he writes, “has dressed himself in order to carry out a signifying activity. The wearing of an item of clothing is fundamentally an act of meaning that goes beyond modesty,
ornamentation and protection” (Barthes 2006: 97, my emphasis). Barthes argues for understanding clothing as “a semiotic system” that reflects “the tendency of every bodily covering to insert itself into an organized, formal and normative system that is recognized by society” (Barthes 2006: 6-7, 33).

With his view of fashion as a socio-cultural system of meanings, Barthes draws upon the structuralist linguistics of Ferdinand de Saussure (Bruggeman 2014: 34). Whereas De Saussure originally developed his idea of the sign as comprising a signifier (i.e., the physical appearance, sound or shape of the sign) and a signified (i.e., the linguistic concept or meaning associated with it), semiotics extended his theory to all kinds of non-verbal communicative practices, including dress (ibid.: 67-68). Indeed, this structuralist perspective “has become a dominant framework for considering fashion, particularly within cultural studies” (Entwistle 2015: 67). Notably influenced by Barthes’ semiotic approach, Alison Lurie’s *The Language of Clothes* – which I discussed at the beginning of this chapter – uses semiotics of dress to explain the meaning of fashion details such as specific neckties, trimmings, and accessories (1981). Barnard, similarly, uses the semiotic model to unravel what the language used to describe fashion signifies (e.g., the written or spoken forms of the word ‘shirt’) and extends the notion of the linguistic sign to fabrics and textiles, garments and parts of garments, such as an open collar without tie as signifying casualness or informality (Barnard 2002: 81-82). Even if the messages and meanings ascribed to garments are seldom fixed, unambiguous or accurate, he argues, fashion and clothing “are always going to perform a communicative function” (Barnard 2007: 138). Semiotic interpretations of fashion, such as those by Lurie and Barnard, thus explain fashion as a linguistic code whereby people send messages about themselves to others (Twigg 2009: 3).

Compared to the process model of Shannon and Weaver I discussed above, the question of who or what sends or receives a message and through which medium, is less relevant in a semiotic approach. The semiotic model “defines social interaction as that which constitutes the individual as a member of a particular culture or society” (Fiske 1990: 2-3), which means that any notion of the sender, receiver, message, or medium is gained only from social interactions (Barnard 2002: 31). Concentrating on how meanings are negotiated, rather than on the sending or receiving of messages, the semiotic model thus recognizes that there is no such thing as a communication failure. Communication is, by definition, all about constant negotiations between different actors within different social and cultural settings and, hence, it is only logical for messages to be “read” in many different ways (Barnard 2002: 32).
The LEDs in ‘Phototrope’ have been integrated with the specific purpose to improve the wearer’s safety and physical performance, and to aid interpersonal communication within a running team (Van Dongen n.d.), but their meaning is constantly negotiated once the shirt is worn in a social context. Whereas one person may perceive the rapidly blinking LED ribbon as enhancing visibility and group dynamics, another may interpret it as hindering, distracting and confusing (‘Phototrope’ Test Sessions 2015). From a semiotic point of view, both experiences are equally ‘accurate’ and valuable. As Dunne, Profita and Zeagler note, however, there is a difference between how the formal characteristics of a garment (such as its shape, color, texture, or volume) and its referential characteristics (such as a brand logo, a symbol, or a badge) are interpreted (2014: 27). The design’s direct visual and material properties, they argue, “are in some ways less open to interpretation as they tend to play on innate responses and associations (...), whereas referential characteristics depend more on the experiences and prior knowledge of the viewer” (ibid.: 27).

In the case of ‘Phototrope,’ most spectators will immediately understand that the LED lights are intended to make the runners more visible and, hence, safe in a dark environment. A semiotic approach helps to understand why such material characteristics are less open to interpretation than referential characteristics, such as the rhythm and intensity of the LED lights. That the blinking LED lights to function like a referential ‘code’ that signifies a certain running pace, position within the group, or training exercise is clear only to those with prior knowledge of the project.

A semiotic approach allows to reveal the processes of interpretation and signification at work in wearing or observing techno-fashion, and highlights that such processes are arbitrary and shifting. Yet semiotics reduces the social interaction between the wearer of techno-fashion and her environment to the nature of language interpretation and representation, without taking the material and embodied dimensions of such hermeneutical processes into account. My analysis of ‘Phototrope’ indicates that the meanings and interpretations associated with the illuminated running shirts may vary, but that they are inextricably connected to their material, technological and embodied character. The nature of the material actors involved in the communication process (in this case the interactive LED lights), as well as the fact that these materials are worn and embodied by the wearer, is vital to the kind and range of possible meanings that techno-fashion conveys. As a merely semiotic approach reduces the meanings of techno-fashion to signs and representations, it overlooks the embodied, material and non-verbal forms of communication that a garment such as ‘Phototrope’ is actually designed for.
Meaningful Matter: From Communication to Material Mediation

Applying the process model and semiotic model to ‘Phototrope,’ I have unraveled how wearers – as members of a particular social and cultural group (in this case a running team) – negotiate the meanings of techno-fashion through their relationship with other group members. The various communication models (i.e., the sender-receiver and semiotic model) outlined in this chapter are often discussed as though they contend with one another. However, Crilly et al. insist, “[s]uch competition between the different perspectives is misleading” because “they are actually complementary rather than contradictory” (2008: p. 428). As each method simply gives insight into a different aspect of communication, a plurality of approaches is, in fact, both inevitable and highly valuable (Buchanan 1985: 73-74). Amongst communication theorists who distinguish between a semiotic and process view, for example, it is acknowledged that each of these traditions is well suited to examine communication from a given perspective but that to fully explore the problem both traditions must be combined (Fiske 1982/2011: 4, 190; Barnard 2002: 29, 39, 196; Crilly et al. 2008: 4).

This is the problem with all these complementary models of communication. Jeremy Packer and Stephen Crofts Wiley note that “[c]ommunication is often seen as immaterial, as a layering of human perception, thought, language, and symbol over the real.” (Packer and Crofts Wiley 2012b: 110). Although semiotic approaches are still popular in fashion studies and science and technology studies, they have also increasingly endured criticism in both these fields. The semiotic preoccupation with representations and signs “puts a distance between the theorist and the subjects under investigation,” Entwistle argues, while overlooking the lived, experienced, and embodied forms of communication that fashion enables (Entwistle 2015: 69). The (post)structuralist tendency to textualize fashion and dress, she moreover writes, “displaces the idea of embodiment and the individual and can give us no account of the experience of agency” (Entwistle 2015: 69).

Central to this thesis is the argument that semiotic interpretations of techno-fashion fall short in the sense that they are limited to what it represents, reducing it to an abstract system of signification while neglecting the embodied experiences and material agency at its core. A linguistic or semiotic approach is relevant to the extent that it shows how techno-fashion can signify social, cultural and political structures, but it fails to also take the physicality of the body and materiality of the garment into account (Bruggeman 2014: 10). Whereas a semiotic approach can illuminate how meaning is continuously constructed and negotiated in the dynamic interaction between humans and techno-fashion, it thus has to be complemented with approaches that also considers the material ways
in which the meanings of techno-fashion are conveyed and negotiated. The immateriality of communication is a predominant ontological assumption for mainstream theory in the fields of communication, rhetoric, and media studies as well as critical theory. This has led many scholars to long for an escape out of a poststructuralist (i.e., immaterial) impasse, led them to turn away “from ‘mere communication,’ toward materiality as a corrective” ((Packer and Crofts Wiley 2012b: 4).). I consider both postphenomenology and new materialisms the philosophical offspring of such longing for the revaluation of materiality.

In the following section, I aim to complement the existing models of communication, with a ‘new materialist phenomenology’ that I develop in this dissertation, in order to do more justice to the material and ambiguous nature of the meanings of techno-fashion. I will then turn to the concept of performativity, that brings postphenomenological and new materialist understandings of meaning and matter together. As I will argue in the following section of this chapter, we should, therefore, develop an understanding of techno-fashion that acknowledges how it mediates meanings in ambiguous and performative (i.e., embodied, material, and socially situated) ways.

A Material Hermeneutics of Techno-Fashion

Integrating the postphenomenological notions of embodied and hermeneutic relationships into my theoretical framework for this dissertation (see chapter two), I have already indicated that postphenomenology provides a fruitful basis for an analysis of processes of signification and interpretation constructed in the making, wearing and perception of wearable technology. In his later work, Ihde starts to problematize the absence of materiality in traditional hermeneutics and develops a growing sensitivity to “the ways in which materiality plays subtle and deep roles in our ways of moving about the world” (Ihde 2003a: 1; cf. Ihde 2009). Hermeneutics is traditionally associated with linguistic phenomena, he writes, and usually “thought of as some set of interpretative principles” (Ihde 2009: 63). This privilege of the linguistic continued to dominate the humanities and social sciences in the twentieth century, a philosophical development commonly identified as ‘the linguistic turn’ (Rorty 1967).

As Ihde passionately argues, to hold true to a merely linguistic framework in a contemporary context is a mistake (Ihde 2009: 64). In order to “give voice to the things,” linguistic hermeneutics neglects, he introduces a material hermeneutics that “retains the critical, interpretive work that all hermeneutics requires” but “is more perceptual than a linguistic interpretation” (ibid., original emphasis). Although Ihde is currently still developing this material take on hermeneutics (Ihde 2015), his idea of giving ‘things’
a voice even though they are situated in a non-linguistic context is very useful for the
study of techno-fashion (also see chapter three on material agency and ‘the voice’ of
nonhuman artifacts). What sets the philosophy of technology apart from other styles
of philosophy, Ihde writes, is “its necessary sensitivity to the concrete, to materiali-
ty” (Ihde 2003: 2). Techno-fashion, specifically, is clearly not an exclusively linguistic
phenomenon that requires a linguistic form of interpretation, nor is the technology or
clothing it is rooted in (Verbeek 2001: 141).

Semiotic approaches undervalue non-verbal forms of communication and user be-
behavior by reducing technology from embodied, material reality to discourse (Hansen
2000). Yet the influence of techno-fashion on human interactions, I want to argue, is
also of a non-linguistic kind. Techno-fashion designs are able to exert influence over
wearers and their environment not only as carriers of meaning but also as material
things (Verbeek 2006b: 58, original emphasis). ‘Phototrope’ helps to illustrate how
 techno-fashion indeed functions as a material thing that ‘sticks’ communication and
meanings to the wearer’s body (Calefato 2003: 163-164).

During the test trials with ‘Phototrope’ organized during a nocturnal public running
competition and five training sessions (see appendix), some wearers noted that the
illuminated garments invited creative, innovative and playful kinds of communication
and social interaction. Rather than communicating through speech, which is tiresome
and difficult during a high intensity running session, the communication almost exclu-
sively took place through the materiality of the wearers’ bodies (movements, running
pace, path, and position) in interaction with the blinking LEDs. This shows why Patrizia
Calefato calls the human body “[t]he real protagonist (…) of the late 20th-century tech-
nological revolution in the field of communication” (2003: 163). According to Calefato,
the human body “has become a fluctuating and hybrid entity and has lost whatever
it had of the unknowable and incommunicable. It is no longer a monad in search of
a place, word, or gesture, but a terminal that is never switched off” (2003: 163). The
ways in which the ‘Phototrope’ wearer creates, conveys and represents messages is not
confined to any deliberate gestures or language but extended to the entire surface of
her body. With the advent of techno-fashion, in other words, the human body becomes
“endowed with” and “completely absorbed into” communication (ibid.).

The user tests with ‘Phototrope’ demonstrate that techno-fashion extends fash-
ion’s potential for communication. It not only shows the possibilities of techno-fash-
ion for sports performance and safety, but it also reveals its potential for embodied
communication, social interaction and bonding, and even psychological well-being. The wearers interactively used, played with, and reinvented the visual communication system behind the garments. Moreover, several wearers described the effects of the garment as enhancing the sports performance, increasing social interaction, encouraging the team spirit, raising the awareness of and attention to other team members, or even as stimulating “a kind of mindfulness” (‘Phototrope’ Test Sessions 2015). As Joanna Berzowska highlights, “[o]ne of the important futures for electronic textiles and wearable technologies is to perpetuate the “function” of fashion: to have fun, to connect with friends, and to bring social networking information back onto the body, exploring the emotional resonance of personal space” (Berzowska 2013: pp. 468-469).

Another interesting result of the tests we did with ‘Phototrope’ was that the design showed the potential to counteract the increased disembodiment of communication and social interaction. Bringing communication back onto the body, it reintroduces the body as the locus and source of all communication and social interaction. Realizing that the blinking LED lights made them more visible to their environment, the wearers suddenly became more attentive to what their clothes were ‘telling’ and how these messages might be interpreted by the environment (‘Phototrope’ Test Sessions 2015). This indicates that techno-fashion is not just communicative in itself, but also increases “our awareness of the fact that clothes convey meaning and that the clothed body is open to communication” (Calefato 2003: 164). “Communication exposes the body to contact with others and extends its boundaries”, Catefato postulates, whereas written or printed text on any regular garment constitutes the meeting point between body, clothes, and language, “the new information communication technologies (ICTs) open up communicative possibilities for the body of a different type” (ibid.). Techno-fashion’s new, embodied, situated, and soft forms of communication have the potential to revalue and reclaim the body in the act of communication.

Along with many other wearable technologies in which the body in its entirety is involved, ‘Phototrope’ illuminates how techno-fashion can stimulate physical, playful, intimate and intuitive interactions between people, technology and fashion, and people and their environment. It turns the clothed body into a material thing that is “totally communicable, like a computer interface” (2003: 164). In other words, techno-fashion seems to embody “a new frontier for corporeality”, it represents a rapidly unfolding scenario in wherein “[t]he body wears communication: bits, not just atoms; signs, not just fabrics that cover it and keep it warm” (Calefato 2003: 165, my emphasis).
Celebrating Ambiguity

The insight that techno-fashion evokes meanings as a material thing and not only as a passive carrier of meaning (Verbeek 2006b: 58) becomes even more relevant for the analysis of techno-fashion when complemented with the recognition that “[n]o technology is ‘one thing,’ nor is it incapable of belonging to multiple contexts” (Ihde 1999: 47). This signals an important difference between the semiotic and the postphenomenological approaches to artifacts”. Semiotics is interested in what it refers to, in the reference and not in the mediating role, whereas postphenomenology is preoccupied with how the artifact shapes and orders human behavior and interaction. For semiotics, the sociocultural function of the artifact consists of this reference, not in its mediating role (Verbeek 2005a: 207). From a postphenomenological perspective, the process of communication through techno-fashion produces a multiplicity of meanings and experiences because “technologies are non-neutral and essentially, but structurally, ambiguous” and “may be variantly embedded” from one (cultural) context to the other (Ihde 1990: 144).

When the semiotic notion of communication is supplanted by the postphenomenological notion of technological mediation, it becomes clear that the unforeseen and unintentional meanings ‘Phototrope’ produces. These meanings reflect how “the mediating roles of artifacts are not properties of the artifacts themselves”, “but come to light in complex interactions between designers, users, and the technologies” (Verbeek 2005a: 217; 2011: 98). They result from the playful and creative interaction through which different actors (including technologies) make the illuminated shirts meaningful, rather than a sign of communication failure. The illuminated shirts do not serve a single meaning, purpose or context, but acquire “stability” in interaction with the people interpreting and using them, and the socio-cultural setting in which they do so (Verbeek 2005a: 136).

In addition, the semiotic and postphenomenological perspective have in common that they, unlike the process model, do not presume that the designer or the wearer or the trainer or the spectator of the garment “is the source of the intentions that provide the meanings” (Barnard 2002: 33). Meaning and purpose are the results of the negotiation between these actors and, consequently, “positions of relative power [are] established in and through the process of communication” (ibid.). A random spectator might associate the shirts with an urban, tech-savvy, fashionable, and healthy young woman. But any other runners from outside of the ‘LUMI team’ might consider its wearers attention-seeking show-offs. “[W]hile the aesthetic effect of the system may hold one meaning for the designer of the technology,” Lucy E. Dunne et al. therefore point out, “to an observer this meaning may be completely lost or interpreted as something else
entirely” (Dunne et al. 2014: 27). If techno-fashion can be considered code, it is thus an inexact and aesthetic code rather than a conventional sign code. As Julia Twigg puts it: “[l]ike other cultural goods, its [fashions’] meanings are by their nature immanent and hidden, subject to masking, interpretation and uncertainty” (Twigg 2009: 3).

My analysis of ‘Phototrope’ has shown that the meanings of techno-fashion are not fixed or shared and heavily context-dependent and that the link between the intention of the wearer and the interpretation of the observer is far from straightforward (Davis 1994: 7-11). Fred Davis suggests to consider fashion and clothing as forms of communication close to music rather than language or speech: they express emotions, moods, and meanings, but in a manner distinct from linguistic forms (1994: 3; cf. De la Haye and Wilson eds. 1999: 5). This analogy between music and fashion as forms of communication has mostly been discussed in terms of their interrelated role in shaping identities, taste and consumption culture (Calefato 2004: 117-122). Implicitly, however, the comparison between these two domains of expression also hints at the distinctly material manner in which fashion communicates. Not unlike music, fashion provides “a means by which people can share emotions, intentions, and meanings” that can “exert powerful physical and behavioral effects” (Miell et al. 2005: 1). Fashion and clothing are among the many forms of non-verbal communication — including body movement, posture, eye contact, facial expression and other bodily signals such as blushing, smell, sweat — that influence how we perform ourselves towards and with others (O’Sullivan et al. 1994: 204-206).

Performative Techno-Fashion
The key to understanding the ways in which techno-fashion conveys meanings, is to attend to the materiality of performance and performativity. The dramaturgical perspective foregrounds that techno-fashion can be studied as a performance regardless of whether it is worn in a staged or in an everyday environment. Techno-fashion can become part of the wearer’s act (performance) of self-presentation, of communicating and interacting with those around her in order to consciously or unconsciously enact certain roles. Although this perspective may be relatively new to the field of human-computer interaction, it in many ways aligns with what has been termed the ‘performative turn’ in the humanities and social sciences (McKenzie 2001; Burke 2005; Schechner 2013; Bachmann-Medick 2016).

The performative turn refers to a methodological approach that entered the humanities and social sciences in the 1990s yet has its roots in the work of anthropologists (Turner
1957), sociologists (Goffman 1959) and philosophers of language (Austin 1955/1975; Burke 1945) from the 1940s and 1950s (Burke 2005; Hensel 2010). As various cultural turns overlap, it would be too simplistic to state that there is a strict division between the performative turn and other turns (Bachmann-Medick 2016: 74).

What surely sets the performative turn apart, however, was the urge to conceptualize how human practices relate to their contexts in a way that went beyond the traditional sociological methods that did not problematize representation.

Instead of focusing solely on given symbolic structures and texts, scholars started to stress the active, social construction of reality as well as the way that individual behavior is determined by the context in which it occurs. Whereas the term performance previously denoted a theatrical act, it was now employed as a metaphor and an analytical tool for studying any social action (McKenzie 2001). As a result, the underlying hypothesis of the performative turn is that “all human practices are ‘performed’ as an act of public staging of the self” (Hensel 2010: 39). Generally speaking, the performative turn is thus concerned with the informal performances of everyday life rather than formal theatrical performances, but the two senses of performance should be seen as part of a continuum, rather than as two distinct categories (Burke 2005: 43; Schechner 2013: 170).

Within studies of dress and fashion, notions of performance and performativity have increasingly been used to emphasize and theorize the link between clothing and identity. Bruggeman clarifies how historical views of the body as “the visible form of the self-have given rise to the prevailing view of identity in terms of one's outer appearance” (2014: 40). Following fashion scholars Joanne Entwistle (2015) and Llewellyn Negrin (2016) in their critique on the tendency to reduce identity to mere outer appearance and self-presentation, Bruggeman welcomes the notion of performance as the first step towards a “reconceptualization of the relationship between fashion, identity and the clothed body” (Bruggeman 2014: 226). Julia Twigg argues that the notion of performance helps to understand identities as “embodied processes, experienced and performed at the level of the body” (Twigg 2009: 8-9). Referencing a “flurry” of literature on the articulation of identity through fashion, Joanne Entwistle finally concludes that “the formation of modern subjectivity seems bound up with various forms of dress and self-presentation” and that identities, moreover, are “themselves performed through the forms of dress adopted” (2013: 97, original emphasis). As techno-fashion can be considered one such form of

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dress and self-presentation, it follows that techno-fashion is inevitably concerned with self-presentation and the performance of identity as well (Lamontagne 2017).

In his article on ‘The “Performative Turn” in Science and Technology Studies,’ Christian Licoppe argues that the notion of performativity is particularly helpful “for understanding the situated use of technical devices” when combined with the notion of agency (2010: 1). Licoppe stresses that a sender-receiver or semiotic model of communication presumes that communication technology can be treated as a transparent transmitter of information. The notion of performative utterances as developed by Judith Butler (1990), he states, provides the tools to question “such an alleged ‘transparency’ of communication technologies and grasp their agency in communicative events” (ibid.: 6).

Andrew Pickering employs the concept of performativity to argue for the need to move from the “representational to the performative idiom” for thinking about science (Pickering 1995: 5). As Jari Friis Jørgenssen explains, Pickering’s claim is “that in order to get a better understanding of the world we have to abandon the representational idiom and look at performance, focusing our attention on how humans and machines interact” (Jørgenssen 2003: 213-214). Pickering describes his favor towards a performative idiom as follows:

The point is this: Within the representational idiom, people and things tend to appear as shadows of themselves. Scientists figure as disembodied intellects making knowledge in a field of facts and observations (...). But there is quite another way of thinking about science. One can start from the idea that the world is filled not, in the first instance with facts and observations, but with agency. The world, I want to say, is continually doing things, things that bear upon us not as observation statements upon disembodied intellects but as forces upon material beings. (...) These remarks, then, sketch out a basis for a performative image of science, in which science is regarded a field of powers, capacities, and performances, situated in machinic captures of material agency. And my aim in the rest of this book is to understand scientific practice within such a performative idiom (Pickering, 1995: 6-7, original emphasis).

Like Licoppe, Pickering here couples the concept of performativity to an emphasis on material agency and embodiment, which happen to be two conceptual pillars that unite
postphenomenological and new materialist thinking. Even though Pickering’s use of the term has been severely criticized for lack of clear definitions and historical contextualization (Selinger 2003: 152-154), and despite of the relatively little success the concept has so far had within science and technology studies (Hensel 2010: 40), I, therefore, believe that the notion of performativity provides the key to opening the door between postphenomenology and renewed materialisms.

Whereas Licoppe and Pickering have employed a performance approach to connecting the classic sender-receiver and semiotic understanding of communication to the debate on material agency (see chapter three), feminist scholar Karen Barad redeems the concept of performativity from a techno-scientific perspective. She argues that science is inherently “performative” because it actively constructs knowledge in experiments, in laboratories, with specialized apparatuses, with human agents, etc. (Barad 2003, 2007; cf. Jefferies 2012: 161). Barad notes that “the move towards performative alternatives to representationalism shifts the focus from questions of correspondence between descriptions and reality (e.g., do they mirror nature or culture?) to matters of practices/doings/actions”, and states that “these approaches also bring to the forefront important questions of ontology, materiality, and agency” (2003: 802). Expressing a similar interest in the notion of performance as an escape out of the predominantly representationalist framework within fashion studies and sociology, Joanne Entwistle thinks that performance “might bridge the gap between the traditions of structuralism, post-structuralism, and phenomenology” (2015: 12). She connects Merleau-Ponty’s focus on the embodied experience of space, to Goffman’s reflection on the social stratification of spatiality (ibid. 33-34). In extension, I want to add, an elaboration of performativity can link the traditions of structuralism and post-structuralism to the postphenomenological and new materialist perspectives introduced in the first chapter of this dissertation.

When Wearer, Spectator, and Performer Become One

Similar to how it spurs the humanities and social science scholars to attend to the socially situated (i.e., in a given spatial and social context) and interrelational (i.e. in relation to and interaction with other actors and the environment) character of human behavior, science and culture, the dramaturgical metaphor of performance inspires scholars from the fields of Interaction Design and Philosophy of Technology to rethink human-technology relations in terms of performativity. In my view, the concept of performativity, therefore, represents an approach that acknowledges the socially situated and material nature of communication through fashion and technology respectively. It
therefore only seems logical to also consider this notion of vital importance in defining the communicative value of techno-fashion.

In their article ‘Performing Perception—Staging Aesthetics of Interaction,’ Peter Dalsgaard and Lone Koefoed Hansen argue “that the realm of performance studies and theory can be helpful when understanding user interactivity” (2008: 16). Drawing upon a combination of insights from the field of Human-Computer Interaction (HCI), performance theory, phenomenology, and sociology, they explore how an understanding of the term ‘performance’ as a “very physical thing” involving “actual acts” (ibid.: 9) helps to analyze the relations between systems, users, and spectators. Within the framework of their article, they reserve the term ‘user’ for “a personal interaction with a system”, whereas they use the term ‘system’ to refer to the discrete or multiple artefacts with which the user interacts, and the term ‘spectators’ to “denote persons somehow observing the interaction between user and system” (ibid.: 4).

Aware of the contested meaning of the term ‘user,’ one of Dalsgaard and Hansen’s main arguments is that the ‘user’ should be understood as a person that enacts multiple roles (including the role of ‘performer’) throughout the process of interaction (Ibid). After attending to embodiment, contextual perspectives and spectator experience of user-system interaction, Interaction design has arrived at a point where it should also be concerned with how the user’s “awareness of being in a user-system-spectator trichotomy” affects the whole situation of interaction (2008: 5, 8). Interestingly, they illustrate their understanding of this interactive experience by discussing two examples of techno-fashion: the ‘Bubelle’ dress [Figure 48] and ‘Frisson’ [Figure 49] bodysuit developed within the framework of the Philips SKIN Probe project (ibid.: 16-19). Since both of these designs visualize bodily signals on the surface of the garment, Dalsgaard and Hansen argue that they are both “unquestionably examples of highly performative clothing” (ibid.: 19). As I will discuss in the following section of this chapter, this approach leads to some interesting insights for the study and design of techno-fashion as a form of communication and personal expression.
Influenced by how Reeves et al. (2005) use the term ‘performer’ as a synonym for the user and ‘performance’ as synonym for the user-system interaction, Dalsgaard and Hansen propose a model of human-technology interaction that also accounts for the distinction between the user that interacts in solitude, and the one that interacts “under the potential scrutiny of spectators” (6). It is precisely the user’s awareness and experience of (potentially) being observed by a spectator, they state, “that transforms a user into a performer” (ibid.: 6-7). The user and spectator position, in other words, are reciprocally influenced and inextricably entangled. Following this dramaturgical and performative approach to user-system-spectator relations, I want to argue that the roles of the wearer of techno-fashion are similar to the user’s roles as described by Dalsgaard and Hansen, in the sense that the wearer is also a performer whenever she wears techno fashion in a social situation. To explain this, I will again use ‘Phototrope’ as a case study.

After wearing ‘Phototrope’ during the first public test setting, the Nike 10K night run in Amsterdam, a team of female wearers (n=5) notably reflected on their experience of being observed by and interacting with the crowd. One respondent mentioned a lot of people in the audience were surprised by their illuminated outfits and encouraged them because of that (“which is nice”), and that ‘Phototrope’ made her supporters recognize her from quite a distance. Another respondent remarked that the visibility of the illuminated design has a motivating effect: realizing how much more visible she was in comparison to runners from outside of ‘team Phototrope’ (aka the ‘LUMI League’ [Figure 50]), she felt extra motivated to run fast. Other respondents, similarly, described the garment as an “eye catcher” that made them “stand out from the crowd” and visible to the audience from afar (‘Phototrope’ Test Sessions 2015). Here, communication is all about self-expression: it concerns the social relationships and performance of the wearer, rather than the transmission or negotiation of meanings, messages, and information.

These wearers’ responses point to how their awareness of being a performer in front of (a large group of) spectators affected their experience and overall appreciation of
‘Phototrope’ and, in some cases, even the quality of their physical performance. As Dalsgaard and Hansen demonstrate, such interplay between the user and the audience lends itself for the dramaturgical approach introduced by their seminal source of inspiration, the philosopher and sociologist Erving Goffman (Dalsgaard and Hansen 2008: 11-14). Erving Goffman used the term ‘performance’ to cast light on social life as a kind of theatre wherein people present themselves in a certain way in order to control the kind of impressions others have of them (Goffman 1959: 13, 32). Central to his argument is that people are, in any given situation, inevitably relating to other people present—even when an awareness of other people is not directly visible (Dalsgaard and Hansen 2008: 12).

The findings of the first test with ‘Phototrope’ seem hardly surprising. It was to be expected that the respondents were highly aware of other people present in this situation, considering the fact that it concerned a ‘staged’ event specifically organized for a group of performers (i.e., the runners) to be observed by a large group of spectators (i.e., the audience) while engaging in a particular performance (i.e., a running contest). In the terminology of Goffman, the running contest can be identified as a typical ‘front stage’ or ‘front region’ performance: not unlike a catwalk show, concert, or red-carpet moment, it is an “accentuated” (Goffman 1959: 114) and “spectacularized” (Smelik 2011: 79) activity occurring in the presence and sight of others. Here clothing functions as part of the “expressive equipment,” or ‘personal front,’ that the runner possesses to manage the impressions others have of her (Goffman 1959: 34). As opposed to the ‘backstage’, which Goffman defines as the place “where the performer can reliably expect that no members of the audience will intrude” (ibid.: 116) and “where action occurs that is related to the performance but inconsistent with the appearance fostered by the performance” (ibid.: 135), the frontstage is expected and supposed to be the place where the performer knowingly presents herself in front of an audience.

The distinction between a frontstage and a backstage highlights how techno-fashion co-shapes the wearer’s act of self-presentation in social and public life. Once techno-fashion makes it to the streets, it will become part of the two “channels of communication” people have to present information about themselves: it will be one of the elements constituting both the expressions they intentionally give and the ones they unintentionally give off (ibid.: 2, original emphasis). Goffman however also teaches us that “[p]erformers can stop giving expressions but cannot stop giving them off” (ibid.: 111). This insight is vital because it helps to consider the kind of things techno-fashion can intentionally and unintentionally communicate about a wearer and can hence aid both wearers and designers to make decisions about what to wear or design for a
specific occasion, space or audience. While participating in a public event such as a running contest, a remarkable garment such as ‘Phototrope’ can give the audience the impression that the wearer is, for example, a team player, a professional, or a fashionista, but it might just as well give off the impression of an attention-seeker, or show-off.

Although the findings of the first public test with ‘Phototrope’ may not be surprising, they are valuable to the extent that they signal the role of the audience in shaping the wearer’s experience and provide a first indication of how techno-fashion influences the communication and relation between a performer and the audience. The group training sessions in which the interactive version of ‘Phototrope’ was later on tested, however, reveal that the effects of the wearers’ awareness of being observed by others are not only notable in a such an overtly ‘performed’ and ‘staged’ act as a running contest, but in public space and daily life in general.

After an initial Nike ten-kilometer nocturnal running contest and a private training session with five prototypes, the design of ‘Phototrope’ was improved in terms of fit, proportions and choice of material. Moreover, designer Van Dongen decided to extend the shirt’s functionality with interactive light that could enable a group of runners to play ‘games’ initiated by a professional trainer via a smartphone app. She developed a custom circuit board with an accelerometer, a Bluetooth Low Energy module and LED controller, and integrated light sensors into the garment that measure surrounding light levels. With the help of the app, the light in each shirt could be controlled individually. A trainer could for example assign a pacer by changing the blinking frequency, challenge the runners to align their pace, or program the brightness of the light to increase in case of a higher running pace.

This second iteration of the illuminated shirt was tested during a sequence of five nocturnal group training sessions of one and a half hour each, that took place in a public park in the Netherlands. The respondents of these five user tests were twelve amateur runners that were asked to individually reflect on their experiences after each session by indicating both positive and negative aspects of the garment. This research method resulted in a total of 466 comments on how wearing ‘Phototrope’ was experienced (‘Phototrope’ Test Sessions 2015). Almost without exception, the runners expressed how the illuminated shirt made them visible to their environment. Regardless of whether they thought the shirt already fulfilled this expectation, they mentioned the importance of being visible not just to any observers present in the public space at the time of the training sessions, but also to themselves, their fellow runners and their trainer. Such
responses included comments on the visibility of the designs from their own perspective as a spectator, including descriptions of the lights as “not catching that much attention,” being “beautiful” or “distracting,” or “looking professional and serious” (‘Phototrope’ Test Sessions 2015). The runners participating in these five tests thus proved to not only be equally as aware of any spectators observing them as those participating in the running contest but also to discern different spectator categories — including themselves — in their reflection on the visibility and ‘noticeability’ of the illuminated shirts. This reaffirms Goffman’s conviction that even non-staged and less “framed” everyday life behavior is determined by social norms and interpersonal interaction paradigms.

Dalsgaard and Hansen’s analysis of user-system interaction helps to further explain the results of the user tests with the interactive version of ‘Phototrope.’ First of all, their notion of ‘performing perception’ makes clear that the respondents expressing their visual experience of the shirts were relating to the illuminated shirt not just from the perspective of a wearer operating the interactive light system to safely run in the dark while communicating with team members, but also as from the perspective of a
performer who knows she is being watched by others while interacting with the system. In the words of Dalsgaard and Hansen, the tests thus demonstrate that much of the “interaction potentiality” of ‘Phototrope’ lies in how the wearer can simultaneously engage in three different actions:

the act of interacting with the system; the act of perceiving the relation between her and the system and her and the surroundings; and finally, the act of performing where she is a performer for others to observe (2008: 9-10).

That ‘Phototrope’ wearers also perceived their relation to the system and the surroundings is evidenced by remarks such as “when running in the group you don’t notice that it [the light] is so visible”, and “it is harder to see where I am running because of the bright light” (‘Phototrope’ Test Sessions 2015). Finally, the tests also indicate that most wearers realized they were involved in the act of performing in front of (different kinds of) spectators while running in the park, as demonstrated by responses like “you really notice how the other runners behave, which is fun!”, “you are paying much more attention to each other with interactive light,” “you first have to see others to know what is happening” and “it [the light] makes me more visible to myself and to others” (ibid.).

The tests with different versions of the illuminated running shirt in different public settings call attention to the fact that ‘Phototrope’, as an illustrative case study, “manifests how the user is never able to be only operator, spectator, or performer of an interaction but is always all three at once” (Dalsgaard and Hansen 2008: 26). Wearers simultaneously enact three different roles when ‘using’ interactive techno-fashion like ‘Phototrope’. This threefold role as operator, performer, spectator has a big impact on what, how, and when wearers will be communicating through the garment, as well as on their relationship to the environment at large. An example like ‘Phototrope’ points to the performative character of techno-fashion, and to how the presence of an (imagined or actual, known or unknown) spectator shapes the wearer’s experience and appreciation of a garment (ibid.: 26).

Through analyses of the user tests with ‘Phototrope’, I have shown how the wearers’ experience of their communication through and with techno-fashion is in this case shaped by the three roles they simultaneously enact: they are the operator of the system, the performer for other people present, and the spectator of their own actions as well as of the
action in their immediate surroundings (ibid.: 31). As the tests with the interactive version of ‘Phototrope’ demonstrate, each of these roles is intertwined with the other two roles the wearer/user enacts. Wearers of ‘Phototrope’ cannot separate their role as performer in front of the running team, trainer, or public park visitors, from their role as individuals interacting with the illuminated shirts, the other wearers, or the various spectators around them.. The challenge for the designer of interactive techno-fashion thus lies in finding an “aesthetics of interaction” that allows the wearer “to dynamically alternate between different roles” (ibid.: 20) and that carefully considers “the tensions between looking and being looked at, between contemplating and interacting, and between being a performer and being a spectator” (ibid.: 32). In the following section of this chapter, I will look further into the dynamics of these different roles by connecting the idea of the wearer as performer and techno-fashion as performance, to the notion of posthuman subjectivity.

The Posthuman Wardrobe
Chapter three already briefly mentioned the ‘post-humanist’ character of postphenomenological and new materialist perspectives on materiality, which refers to their understanding of matter as lively or as exhibiting agency. The previous section added a performative perspective to this insight, indicating that techno-fashion not only produces signs and representations in terms of interpretation or hermeneutics but also enacts and expresses meanings on material and embodied level. I argued that the new and agentive materials of techno-fashion transform what it means to be a human wearer. No matter how hackneyed, cliché and long established the theme might be within fashion studies (Davis 1994: 3; Twigg 2009: 2; Entwistle 2013: 97), the topic of fashion and identity is of renewed interest within the context of this research. Discussing the idea of techno-fashion as a performance in tandem with the issue of posthuman subjectivity, I can complement my earlier analysis of how techno-fashion ‘speaks’ and “tells people something“, with an exploration of how it may also serve “as the means by which an individual declares and performs his or her selfhood” (Gradisek 2009: 12). As Ada Brunstein rightfully wonders, “[i]f a garment alone can play a role in constructing a self both for internal and external examination what happens when that garment does stuff?” (Brunstein 2011: 92-93, original emphasis).

In Garments of Paradise, Susan Elizabeth Ryan observes that “[m]aking a statement’ is what we say when we select something out of the ordinary to wear” (Ryan 2014: 143). According to her, “dress is a matter of the assemblage of performative utterances” (ibid.). Referring to J.L. Austin and John R. Searle’s speech act theory, as well as
Judith Butler’s reconceptualization of the speech act as “a bodily act” (Butler 1997: 10, original emphasis), Ryan introduces the concept ‘dress act’ or ‘performative utterance’ to study what and how the combination of dress and technology communicates (Ryan 2014: 8-13; 140-144; cf. Tseëlon 2001). Performative utterances, according to Ryan’s definition, are constantly reformulated and heterogeneous dress acts that “draw upon endless and diverse connections between garments and meaning” (ibid.: 10). Other than Speech Acts, Ryan writes, “[d]ress acts are hybrid forms of communication in which the behavior of wearing is bound up with the ‘technological’ (…) materiality of garments, accessories, and devices (…), as well as their evolving historical and linguistic associations” (ibid.: 10).

Following Butler, Ryan critiques speech act theory for its attempt to categorize and pin down utterances. She argues that technological dress, like any type of speech, is performative in the sense that the body from which the speech is uttered may perform meanings unintentionally and unknowingly (Ryan 2014: 142-143, cf. Butler 1997: 10). As techno-fashion uses technology as part of its system of meaning, the possibilities for performative utterances and communication become even more heterogeneous. Van Dongen’s ‘Phototrope’ introduces a whole new system of communication and meaning; it reformulates the meaning of a running shirt, transforming it into an assemblage of safety wear and interactive training technology.

To a certain degree, Ada Brunstein states, wearable technology is “just one more example of a tool for functioning within a network” (Brunstein 2011: 99). “We are already communicative creatures,” she observes, but we are now “developing tools to expand that communication in such a way that we don’t have to reach for other devices” (ibid., original emphasis). The basic communication functions of dress – i.e. “the way dress helps to define the individual and group identity of the wearer and the wearer’s context” – are mostly achieved through visual means such as color, aesthetics, texture, and shape (Dunne 2014: 26). Wearable technology, and techno-fashion, by extension, combine these basic features with functionalities previously reserved for other devices such as laptops, smartphones, headsets, microphones, or radios. Whereas the communication between a running team and their trainer used to be confined to, for example, a portable microphone and headphones. ‘Phototrope’ offers the possibility of transmitting information to the runners through their shirts. Acknowledging that such added functionalities and communication tools inevitably become part of the wearer’s performed or “reconstructed” self (Brunstein 2011: 99, original emphasis); how does techno-fashion affect the way we “think of and experience ‘self’?” (ibid.:}
98). Or as I would like to rephrase it: in what ways – if at all – does techno-fashion transform our notion and understanding of subjectivity?

Ryan only very briefly touches upon the question of subject- or selfhood in relation to techno-fashion. She begins with a discussion of the general relation between dress as communication and identity by mentioning the work of Bill Verplank. Verplank describes “fashion” as one of the five principal design paradigms for computer interaction, the others being “tool,” “media,” “life,” and “vehicle” (Verplank 2007, quoted in Ryan 2014: 138). Inspired by his understanding of fashion, she points to how wearable technology also acts as a language of display and hence “denotes the goals of belonging, recognition, style, and pleasure” (Ryan 2014: 138). The tests with Phototrope affirm that techno fashion can indeed grant the wearer a sense of belonging and recognition. Several respondents expressed how the illuminated shirts led to social bonding: “it simulated contact with other team members because we all look the same,” one of the wearers noted. Others described this “homogeneity of the group” as giving them a “nice” and “special” group feeling (‘Phototrope’ Test Sessions 2015).

The remarks that respondents made about the group feeling evoked by ‘Phototrope’ also resonate with the ‘modes of expression’ that Elise Co recognizes in computational fashion (2000). According to Ryan, Co pairs communication and identification in order to “address the relationship between clothes’ perennial performativity as utterance and technology’s ability to enhance communication in new ways” (Ryan 2014: 144). Techno-fashion inherited both these performative and communicative qualities, bringing the realms of fashion and technology together (Lamontagne 2017). This means communicating through techno-fashion involves much more than mere signification; it impacts the subjectivity, the very being of the wearer. As Ada Brunstein convincingly remarks:

> The transition to this kind of fashion – this kind of technology – will be thrilling to watch. And the integration of beauty, style and desirable wearability with the functionality of what have become our most necessary tools, will be a welcome change. But it should be a change that prompts much thought and consideration about who we will become (2011: 101).

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3 I prefer using the terms ‘subject’ and subjectivity, rather than ‘self’ or selfhood, because this avoids suggestion of a universal, singular, and essential identity or ‘Self’. As Cavallaro explains, “the word ‘self’ traditionally evokes the idea of identity as a private possession and a notion of the individual as unique and autonomous”, whereas the term ‘subject’ allows for a more ambiguous, unstable and decentered notion of identity (2001: 86).
The ‘new materialist postphenomenology’ that I develop throughout this dissertation illuminates that the materiality and material properties of techno-fashion are crucial to the way in which they are experienced and become meaningful to people. In chapter three, I explained that techno-fashion exhibits non-human agency. The smart and self-transformative materials of techno-fashion prompt a post-anthropocentric understanding of what it means to be human in a posthuman reality. The presence of this non-human agency, however, does not imply that the subject disappears entirely. As Rosi Braidotti notes, “the human or posthuman subject is still very important, if only because we experience everything from a position that is human” but “within a posthuman reality, multiple standpoints can be taken” (Braidotti 2014). The connections and permeabilities that techno-fashion establishes between human and non-human ‘flesh’ (see chapter three) invites an attempt at rethinking materiality beyond – or even prior to – human experience.

The tests with ‘Phototrope’ make clear that wearers — simultaneously enacting their role as spectator, performer, and operator — not only connect the illuminated shirts to functionality (i.e., safety in the dark), they also relate the appearance of the design to who they are. They note how the similar look of the design supports their experience of group identity, yet simultaneously realize how it highlights their individuality because of its dissimilar look in comparison to wearers dressed in non-illuminated garments (‘Phototrope’ Test Sessions 2015). Experiences of ‘Phototrope’ indicate that wearers feel like they become a different person under the influence of wearing technology. ‘Phototrope’ illustrates the potential for techno-fashion to constitute a posthuman subject that defines her embodied, material, and performative subjectivity in relation to and interaction with the technological skin that she inhabits. As postphenomenology and new materialist help to realize that stuff – in this case, the illuminated and interactive stuff of techno-fashion – creates us in the first place. Or, as Ada Brunstein describes it: “These garments will not only change our relationship with the world of fashion but will change how we construct the ‘self’” (Brunstein 2011: 90).

‘Phototrope’ not only affected the physical performance and embodied interaction of the respondents, but it also caused them to perform and experience their identity (as teammate, runner, child, contester, etc.) differently. If and when techno-fashion becomes a “physical appendage” (ibid.: 98) of the wearer, it will also unavoidably transform and redefine who the wearer is and how she – as an embodied subject – relates to and interacts with the human and nonhuman world around her.
Conclusion
Building upon the combination of postphenomenological and new materialist theory unfolded in the previous chapters; this chapter focused on the processes of communication and social interaction that techno-fashion allows for while maintaining an emphasis on the embodied and material dimensions of such processes. Understanding the impact of techno-fashion requires not only the in-depth analyses of what it ‘does’ on an embodied or a material level (see chapter two and three) but should also involve a thorough investigation of how people give meaning to these mediations (Verbeek 2015).

The first part of this chapter made clear that techno-fashion actively expands the scope and nature of the messages and meanings that ‘regular’ fashion conveys. According to the traditional yet influential approach of John Flügel (1930), clothes are among the primary visual signs that shape our initial reaction to, and interaction with, others. This elucidates why techno-fashion has been particularly popular among celebrities, who can use the eye-catching technological outfits to make strong visual statements about their personality and status before any other forms of communication become involved. Flügel also argues that fashion and clothing are the symptoms of a collective human shame about the naked body, while they simultaneously signal the common desire to exhibit and mark that same body. Integrating technology into fashion further complicates this paradoxical purpose of modesty versus display, because techno-fashion can alternate between concealing and revealing (parts of) the wearer’s body and bodily signals. With techno-fashion, the wearer’s toolkit for self-expression through garments significantly expands. Another influential perspective on communication through clothes is Alison Lurie’s exploration of the analogies between fashion and language (1981). She makes clear that, within a social context, clothes are always interpreted as telling something about the wearer’s identity. This insight is of value to the study of techno-fashion because it points out that techno-fashion, like any type of dress and clothing, functions communicatively.

Techno-fashion thus ‘speaks’ visually, in the sense that its appearance will consciously or unconsciously be interpreted as ‘saying’ something about the wearer. I further explored the extent to which linguistic metaphors adequately define the communicative and expressive value of techno-fashion by integrating a postphenomenological perspective. If ‘speaking’ is understood post-phenomenologically – that is as the ability to utter a word or message – then it may even be said that techno-fashion has or may be given “voices” (Ihde 2009: 80). Techno-fashion can make invisible visible (e.g., heart rate) and the unheard heard (e.g., air pollution or bad posture). In the specific case of ‘Phototrope,’ techno-fashion acts like a ‘voice’ that, through the
flashing LED lights, tells the running team how fast and in what order to run. What is problematic about the idea of techno-fashion as a language or type of speech, however, is that it reduces garments to merely symbolic signs without acknowledging their more intimate impact on the wearer’s sense of self. As techno-fashion is worn on the body, it will inevitably be read for clues about the wearer, but these meanings may be highly speculative, coincidental or arbitrary. Although there are examples of how technology enables fashion to literally speak (e.g., through voice recordings or real-time textual projections), techno-fashion does not communicate in univocal, universal and unambiguous ways.

The second part of this chapter dealt with the question what meanings techno-fashion communicates and how analyzing ‘Phototrope’ in light of two classic communication models: the process and semiotic model. The findings of the user tests with ‘Phototrope’ indicated that the process model overlooks the complex and multidirectional communicative processes at work in techno-fashion by presuming that communication is an unambiguous, univocal, and unidirectional transmission of information from a sender to receiver. In the case of ‘Phototrope,’ several material entities and circumstances co-shape and mediate the communication, including the social context and the technological ‘mediators’ such as the software, smartphone and LED technology. The process model is valuable to the extent that it can be a first step towards identifying the roles of different actors and the possible problems at work in communication through techno-fashion, yet it does not fully or adequately capture how and what techno-fashion communicates. In the case of techno-fashion, communication no longer merely refers to the transmitting of information from a sender to receiver, it now ‘sticks’ to the body, where it acts as a mediator between the wearer and her surroundings (Calefato 2003: 163-164).

The semiotic model is much more suitable for mapping the ambiguous, interrelation, and embodied communication processes enabled by techno-fashion because it offers a more dynamic understanding of communication as the constant negotiation of meanings. The technological materials and functionalities integrated into techno-fashion may serve a specific purpose, but within a social context, its meaning will constantly be negotiated. Functioning as an illustrative case study, Pauline van Dongen’s ‘Phototrope’ made clear that wearers negotiate the meanings of the blinking LED lights in interaction with and relation to the other members of the running team. A semiotic approach helps to understand that the referential characteristics (i.e., the light intensity and blinking) of the LEDs are much more open to interpretation than
their direct visual and material properties (i.e., illumination of the wearer). Moreover, semiotics highlights that wearing or observing techno-fashion involves shifting and often arbitrary processes of communication and interpretation. Techno-fashion further complicates this already complex hermeneutical interaction between the wearer and her environment, resurfacing the pivotal role of embodiment and materiality. The meanings and interpretations that techno-fashion evokes, vary from situation to situation, but their kind and range are always connected to the embodied, material and technological specificities of the garment. As a purely semiotic approach reduces the meaning of techno-fashion to mere signs and representations, it overlooks such material dimensions.

In the final part of his chapter, I took a first step towards integrating ‘a new materialist phenomenology’ into the existing communication perspectives, by arguing for understanding communication through techno-fashion as a performative act involving both matter and meaning. What is problematic about the idea of techno-fashion as a language or form of speech, is that it understands fashion as an abstract system of signification and representations without acknowledging their more intimate and material impact on the wearer’s subjectivity. Inherently connected to the performative practice of dressing, communication through techno-fashion is much more than the mere exchange of messages or negotiation of meanings: it is concerned with subjectivity and self-expression.

The concept of performativity points to how techno-fashion, because of its material and embodied character, co-constitutes and expresses the wearer’s subjectivity in relation to others. Techno-fashion can never be considered separately from the body and, hence, mediates meanings in ambiguous and performative (i.e., embodied, material, and socially situated) ways. The user tests with ‘Phototrope’ show that techno-fashion extends fashion’s potential for communication. It aids and mediates the communication between the members of a running team, exemplifying the ways in which techno-fashion may provide information about the wearer’s biological signals or physical performance as well as directly or indirectly influence her behavior and social relations. Wearers’ experiences of ‘Phototrope’ demonstrate that techno-fashion has the potential to not only enhance physical performance or safety but also to stimulate embodied interaction, social bonding, and even psychological well-being. Techno-fashion, in other words, exerts influence over wearers and their social relationships because it acts *both* as an immaterial carrier of meaning (i.e., involving signs and symbols) and as a material thing (i.e., involving bodily, technological and textile matter).
By introducing a new and technological form of non-verbal mediation, techno-fashion can inform and affect the wearer’s subjectivity in even more profound ways than mere fashion and clothing already do. The concept of performativity captures how wearers simultaneously enact three roles when wearing techno-fashion such as ‘Phototrope’: they are spectator, operator, and performer all at once. This means that wearers’ experiences of their own subjectivity are co-shaped by the texts, light patterns, colors, movements, or sounds that their garments express, as well as implies that they are aware of how others are likely to interpret such signals as telling something about their personality and identity. This chapter connected the idea of performativity to the issue of posthuman subjectivity, concluding that techno-fashion could have vital and powerful effects on how human subjectivity is constructed and understood. As techno-fashion materially mediates the ways we ‘talk’ with and to each other through our clothes, it offers a whole new vehicle for embodying, expressing and performing the self.
5. Creepy or Comforting? Wearable Surveillance and the Quantified Wearer

Case Study: Byborre, ‘BB Suit 0.3’

"Have you seen one of these?" The doctor held out a silver bracelet, about three inches wide. Mae had seen health monitors on Jared and Dan, but theirs were made of rubber, and fit loosely. This one was thinner and lighter. (…)

The doctor fit it onto her left wrist and clicked it closed. It was snug. "It’s warm," Mae said.

"It’ll feel warm for a few days, then you and the bracelet will get used to each other. But it has to touch the skin, of course, to measure what we’d like to measure—which is everything. You did want the full program, right?" (…)

"And now," the doctor said, tapping Mae’s wrist monitor, "now it’s active. It’ll collect data on your heart rate, blood pressure, cholesterol, heat flux, caloric intake, sleep duration, sleep quality, digestive efficiency, on and on. A nice thing for the Circlers, especially those like you who might have occasionally stressful jobs, is that it measures galvanic skin response, which allows you to know when you’re amped or anxious. When we see non-normative rates of stress in a Circler or a department, we can make adjustments to the workload, for example. It measures the pH level of your sweat, so you can tell when you need to hydrate with alkaline water. It detects your posture, so you know when you need to reposition yourself. Blood and tissue oxygen, your red blood cell count, and things like step count. As you know, doctors recommend about ten thousand steps a day, and this will show how close you’re getting. Actually, let’s have you walk around the room."

Mae saw the number 10,000 on her wrist, and with each step she took, it dropped—9999, 9998, 9997. (Eggers 2013: 155-156)
As this excerpt from Dave Eggers novel *The Circle* (2013) illustrates, the possibilities and future applications for wearable surveillance are both promising and unsettling. When protagonist Mae is employed at ‘The Circle,’ a social media giant that swallowed Google, Twitter, and Facebook, she is slowly but steadily indoctrinated by the company’s vision of total transparency. The future scenario presented by Eggers’ novel loudly echoes the totalitarian regime in George Orwell’s famous *1984*, yet in fact describes the opposite doctrine: whereas surveillance is imposed from above in *1984*, it becomes the backbone of a “totalitarian democracy” in *The Circle* (Polak 2014). If we will use technologies to voluntarily yet continually monitor, track, and share all kinds information about ourselves and others, Eggers seems to warn, surveillance becomes an all-encompassing, inescapable and internalized system of social control.

Like most novels, films, and other media belonging to the ‘surveillance genre’ within popular culture, *The Circle* is a dystopian and alarming representation of a society pervaded by surveillance (Lyon 2007: 139). Such representations can “help us see and understand (whether emotionally or cognitively) new developments in surveillance” (Marx 1996: 231). While popular culture frequently draws inspiration from actual surveillance technologies, a cultural analysis of fictional surveillance scenarios “can tell us something about the experience of being watched or being a watcher” (ibid.: 193). The wearables featured in *The Circle* – a health-tracking wristband, a real-time video bracelet, and an always-on wearable camera necklace – may thus well reveal something about the experience of wearing surveillance technologies. Mae feels empowered by the “Wonder Woman” (Eggers 2013: 314) appearance and endless social functionalities, preventive health care and information the wearable technology offers her. Yet, as the story unfolds she increasingly struggles with the lack of privacy and how this impacts her behavior and personal relations and starts to realize that the constant monitoring and disciplining of her body through wearables comes at a price.

The tracking of bodily signals, everyday activities, or behavior through techno-fashion and wearables sparks enthusiasm as much as it raises concerns, particularly around the potentially problematic, unethical, or undesirable consequences for the wearer’s health or privacy (see, for example, Bilton 2015 and Cha 2015). Such concerns are currently most notable in relation to self-tracking devices, which are already available on the market and used by an increasingly large group of consumers. While some believe that such wearables can help prevent disease and health problems (Swan 2012), others warn of a culture of extreme navel-gazing (Hill 2011). Similarly, wearable GPS trackers are marketed as benefiting children’s safety (Lamkin 2017) but also criticized for being
the latest excess of paranoid parenting (Sahadat 2016; cf. Furedi 2001). According to Bradley Quinn, such applications of wearable technology are symptomatic of a surveillance society that evolved from protection and defense mechanisms into “a global network of sensors that record human activity in real time” (2002: 57).

The previous chapters addressed how techno-fashion transforms embodied experiences and bodily relations to technology (chapter two); ‘unmutes’ and activates the materiality of fashion (chapter three); and enriches our communicative and performative abilities (chapter four). This fifth and final chapter will zoom out further, focusing on the broader socio-political and biopolitical aspects of the phenomenon. Whereas the previous chapters have a mostly analytical approach, this one thus provides a more critical perspective by connecting techno-fashion’s embodied, material, and performative dimensions to the issues of power and control.

Discussing the impact of techno-fashion in terms of surveillance, privacy, and social control, I will argue that the surveillance potential of techno-fashion calls for an analytic and engaging stance that stimulates “thinking about what technology can add to life” (Smelik 2012: 154), as well as inspires “vocabularies and practices for shaping our lives in interaction with [it]” (Verbeek 2012: 165). What does the ‘wearable surveillance’ that techno-fashion employs entail, and at what or who is it directed? How does techno-fashion form, alter, question, or complement other kinds of surveillance? What are the particularly promising or problematic possibilities of tracking, quantifying, sharing, and commodifying all kinds of information about our health, bodies, environment, or even emotions? To what extent, how, and when is it desirable and beneficial to ‘surveil’ ourselves and others by means of techno-fashion, also in light of current debates about privacy and cybersecurity?

Within this chapter, byBorre’s ‘BB. Suit 0.3: Audience Engaged’ [Figure 51] serves as a case study that helps to assess the power relations at stake in wearing techno-fashion. This self-tracking sweater contains sensors that record the wearer’s heart
rate, movement, and skin conductance in order to show his or her level of engagement with the audience. What makes this case study particularly interesting, is that it has been tested in combination with the large-scale tracking of the audience, which offers the unique possibility to focus on how the tracking and exchange of data through techno-fashion affects the power relations between people, fashion, and technology.

**Wearable Surveillance**

Although the use of techno-fashion is not nearly as widespread and common as the use of wearable activity trackers such as Fitbit or smartwatches, the socio-political and power-related concerns they raise are clearly similar. A cardigan monitoring the rehabilitation processes of geriatric patients [Figure 52], could be an effective and welcome improvement to healthcare services, yet become controversial ‘Dr. Big Brother’ if health insurance companies or commercial parties are granted access to the data (MedicalFuturist n.d.). And a shirt allowing people to “hug” over distance [Figure 53] can improve and personalize long distance communication but could invade physical privacy when wearers start to receive “unwanted hugs” (Brunstein 2011: 101). In many ways, the discourse around wearable forms of surveillance and body monitoring is characterized by the same technophobia versus technophilia dichotomy that familiarly accompanies the introduction of any new technology (Smelik 2012: 153).

On the one hand, there is fascination and excitement around the phenomenon because it holds the promise of an even better, healthier, ‘smarter,’ safer, more productive, and perfect future that fulfills all of our cyborg fantasies. On the other hand, there is anxiety around the high-speed development and potentially dangerous effects of wearable technology (ibid.). Whereas the first attitude is defined by “a naïve or uncritical enthusiasm for technology,” the latter involves a distrust of or hostility towards the technology (Carrico 2006). As Anneke Smelik argues, the right balance can probably be struck somewhere in the middle (2012: 154): we should be open to the real promises that wearable technology clearly holds, while remaining alert to the real dangers and
problems it might introduce. Rather than fearfully resist, assess, and reject, or uncritically trust, embrace, and worship techno-fashion, it would thus be more constructive to critically “accompany” its “development, use, and social embedding” (Verbeek 2011: 164; cf. Verbeek 2010).

In present-day reality, activity and fitness trackers in the form of smartwatches, wearable devices, jewelry or wristbands are hardly remarkable or news anymore. Such wearables usually involve tracking technologies that monitor physical activity (e.g., steps are taken, sleeping patterns, distance travelled, and calories burnt), productivity, spending (e.g. consumption patterns and purchases), mood, or health (e.g. heart rate, blood pressure, ovulation and body temperature), often in combination with an online tool or software that stores the data and may display notifications or personal messages (Van Den Eede 2015: 143). With the advent of techno-fashion, Bradley Quinn notes, “[t]he ability to monitor oneself and others electronically becomes a real and ever-present possibility” (2003: 17).

More often than not, techno-fashion is concerned with the registration, monitoring, and communication of (personal) information about the wearer or her environment. This unavoidably raises ethical questions about privacy, security and social control. As Anna Poli critically wonders:

> Why should we be interested in revealing very private information, including items that social conditioning has always taught us to conceal? Why does industry feel the need to incorporate electronic devices and new data-processing and communications technologies in clothing? Do we really need jackets lined with microchips, shoes with mood monitors, radiation-proof fibers, self-disinfecting shirts, silicone sweaters, and fabrics with therapeutic properties? And is it really true that this new generation of microtechnology will make it possible to amplify and enhance human abilities, to improve the quality of everyday life and work productivity? (Poli 2003: 172).

It is not surprising that the development of techno-fashion and wearable technology is increasingly brought into connection with term surveillance (see, for example, Betzner 2015; Lamontagne 2017: 38-55; O’Connor 2015; Petersen 2015; Weston 2015; Wissinger 2018).
‘Surveillance’ is rooted in the French verb *surveiller*, which literally means to watch (*‘veiller’*) from above (*‘sur’*) (Lyon 2007: 13). This ‘watching over’ can be done for many different reasons and can take on many different forms, ranging from face-to-face watching (literally keeping an eye on the neighbors) to the impersonal gaze of a camera or computer system (government-driven camera surveillance, drone surveillance, or the commercial tracking of Internet traffic). The broad and constant evolution of surveillance practices has led to a steadily expanding body of academic literature, belonging to what has come to be known as the multidisciplinary field of Surveillance Studies (Ball, Haggerty and Lyon eds. 2012; Haggerty and Ericson eds. 2006; Lyon 2001, 2007).

According to David Lyon, one of the most influential thinkers in Surveillance Studies, surveillance can be defined as “any collection and processing of personal data, whether identifiable or not, for the purposes of influencing or managing those whose data have been garnered” (Lyon 2001: 2). Although such a broad definition helps to advance the discussion about the phenomenon at large (Haggerty and Ericson 2006: 3), it also testifies to its complex and heterogeneous nature. It is problematic to come up with a watertight definition of surveillance because it refers to a pluriform and ambiguous set of practices, is connected to many different purposes, and involves multi-directional power relations (Lyon 2007: 15-16). Specific manifestations of surveillance, such as cameras and phone tapping, are part of a much larger phenomenon that raises “some of the most prominent social and political questions of our age” (Haggerty and Ericson 2006: 3).

To understand how techno-fashion acts as a new and ‘wearable’ form of surveillance, first of all, requires an exploration of how it relates to other notions and theories of surveillance. Second, I want to discuss the distinct characteristics of wearable surveillance through techno-fashion, paying special attention to its embodied, new material, and performative nature with the help of the theoretical framework developed in the previous chapters. Finally, I will explore the prominent socio-political and ethical questions raised by the new, wearable surveillance practices of techno-fashion.

**Ambiguous Purposes**
The general purpose of surveillance, David Lyon argues, is to influence or manage those under observation, which includes influencing consumer behavior, managing military

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1 See, for example, Beniger 1986; Lyon 1994; Smith 1994; Bogard 1996; Lyon and Zureik 1996; Ericson and Haggerty 1997; Staples 1997; Brin 1998; Etzioni 1999; Froomkin 2000; Garfinkel 2000; Rosen 2000; and the electronic journal of Surveillance Studies: *Surveillance & Society* (2002-).
5. Creepy or Comforting?

54. Byborre x CWI, 'BB Suit 0.3' (2015) Graphics: Daan Spangenberg and Lilia Pérez. @byborre, byborre.com
conflict, governing health, or safeguarding citizens (Lyon 2001: 2). In *The Circle* (2013), wearables act as surveillance technologies that ‘watch over’ Mae’s bodily functions, location, physical activities, emotional and physical well-being, consumption patterns, and behavior. Much in the way that many civilians seem to accept the ubiquity of street camera surveillance nowadays, Mae seems to be indifferent to, or even content with, being under well-nigh constant surveillance. In her eyes, wearable technology is a welcome surveillance technology for the purpose of healthcare, fitness and sports, information access, safety, and (online) social interaction. Several other characters in the novel, however, most notably her parents and ex-boyfriend, consider the wearables facilitators of an undesirable, dehumanizing and unacceptable form of total control and privacy infringement. Although it may be tempting to regard it as either a good or a bad thing, surveillance thus “always has some ambiguity” (Lyon 2007: 14). According to Lyon, its ambiguous purpose is, in fact, one of the things that make surveillance, in general, “both intriguing and highly sensitive” (Lyon 2007: 14).

That the purpose of surveillance is ambiguous, to say the least, definitely also applies to techno-fashion designs that monitor the wearer or her environment. Techno-fashion can track people for the sake of health, safety, or protection while also – or even simultaneously – being used for the sake of governing, regulating, influencing, and managing their behavior. While a techno-fashion design may have the unambiguous intention to, for example, connect a speaker to his audience [Figure 54] or improve the rehabilitation process of geriatric patients [Figure 52], the personal and bodily data collected with such a design could also cause wearers to feel spied upon or forced into specific behavior. Wearing his own design during a public experiment with the ‘BB. Suit 0.3’, Borre Akkersdijk noted how the ‘double gaze’ of the audience stimulated him to give a better, more lively and engaging presentation (Interview BA 2017). The ‘BB. Suit 0.3’ gave him real-time feedback on his own vitals as well as on the engagement levels of his audience, so that he could immediately respond to any dips in the attention span. For example, Akkersdijk recalls how the ‘BB. Suit 0.3’ showed his heartbeat rising at one point in the presentation because he had noted that the attention of the audience was fading. He then decided to use these data to directly address the audience, asking them: “where is everybody? You are making me nervous! We all seem to have lost our way so I might as well stop presenting”. The audience then laughed, which restored their attention as well as calmed down Akkersdijk’s nerves (ibid.).

In the case of ‘BB. Suit 0.3’, techno-fashion is designed and used to ‘surveil’ the wearer and his audience in ways that are positive, stimulating and creative. Yet at the same
time, as Bradley Quinn rightfully notes, “there is something sinister about their [wearables] panoptic properties, making us wonder if we are actually guarded or policed” (2002: 57). Borre Akkersdijk and the people in his audience voluntarily participated in the wearable monitoring of their ‘engagement’ levels as part of an artistic and playful experiment with the possibilities of smart textiles. Imagining the same design in a context where the wearer is pressured or coerced into this type of body surveillance or where the data would (deliberately or accidentally) become accessible outside of the confined context of a public lecture, makes clear that there is a thin line between beneficial and concerning applications of techno-fashion. This has everything to do with the one characteristic that sets wearable surveillance apart from other surveillance technologies: its proximity to the body.

**Body-Borne, Body-Worn, Body-Based**

Techno-fashion and other forms of wearable surveillance align with a broader shift toward ‘new surveillance’ methods that “probe more deeply, widely and gently than traditional methods, transcending natural (distance, darkness, skin, time and microscopic size) and constructed (walls, sealed envelopes) barriers that historically protected personal information” (Marx 2002: 9). That techno-fashion belongs to this realm of ‘new’ surveillance is due to how it surveils, namely in close proximity and direct, real-time connection to the physical body.

Generally speaking, wearable surveillance is body-borne in the sense that it is directly situated on and in constant touch with the body of the wearer. This implies that the wearer’s body is always the focal point, the locus, and material carrier from which the surveillance technology (e.g., camera, sensors, RFID chips, GPS, audio recorder) detects, registers, transmits or receives data and information. As discussed extensively in chapter two, techno-fashion has to be understood in terms of embodiment because it materially mediates the wearer’s embodied experience and thereby inherently reshapes her “actional and perceptual engagement with the world” (Rosenberger and Verbeek 2015: 14). Wearable surveillance is commonly concerned with the tracking of data directly taken from the wearer’s body, or from stimuli in its direct surroundings. It can thus be directed at others (i.e. ‘other-tracking’) or at the wearer herself (i.e. ‘self-tracking’), but its inherent location on the body inevitably involves personal, embodied, multisensorial, and intimate data.

As Gary T. Marx notes, the ‘personal’ aspect of data resides not just in the fact that they refer to an individual, but also involves considerations of what counts as private,
intimate, or sensitive information (2006). The information collected through wearable technology often involves biological data (heart rate, temperature, steps taken, sleeping pattern, blood pressure et cetera) that can be linked to the personal characteristics of an individual, such as fitness, stress-levels, mental health, productivity, or even fertility. Although the individual behind such body-based information is not always directly traceable (without any added or contextual information it will be hard to identify the person behind, for example, a heart rate chart), the data are definitely personal in the sense that they are directly obtained from the individual body through sensors and measuring technology (Marx 2006: 90).

Its direct contact with the surface and signals of the wearer’s body is, in fact, why techno-fashion is considered so promising as a biomonitoring tool: as opposed to wrist-based trackers and smartwatches it can connect the integrated technology to a larger surface and more accurately measurable areas of the body (Dunne 2010a: 45; McGinty 2015; Sawh 2017). This makes techno-fashion particularly fit for the real-time and continuous tracking of personal data related to the wearer’s physical performance (e.g. ‘Nadi X’ by Wearable Experiments [Figure 55]), physical health (e.g. the ‘Exmobaby’ onesie for babies [Figure 56]), mood (e.g. Sensoree’s ‘GER Mood Sweater’ [Figure 57]), or even brain activity (e.g. Sensoree’s ‘NeurotiQ’ [Figure 58]). To further illustrate these personal and bodily aspects of wearable surveillance through techno-fashion, as well as to highlight its intimate and multisensorial character, will again use ByBorre’s ‘BB. Suit 0.3’ as my case study.

The ‘BB. Suit 0.3’ contains sensors that monitor the wearer’s heart rate, movement and galvanic skin response (Interview BA 2017). As long as such data are recorded for personal use and accessible to the wearer only, they remain relatively impersonal. When knowledge of the data is restricted to the wearer only, this information can, at most, influence his or her embodied perception, behavior, and body consciousness. In this specific case, however, the personal data were collected while the wearer was giving a public lecture and live screened to the audience (Byborre 2016). The ‘BB. Suit 0.3’
wearer is revealing “existentially private” information, sharing something about his embodied and inner experience of the event with his audience (Marx 2006: 90). Private (i.e., “not automatically available”) information about the wearer is here made publicly visible, which indicates that the in itself ‘impersonal’ character of the raw data can easily and suddenly feel highly personal (ibid.).

That Akkersdijk was aware of the private data being shared with his spectators and that his body was monitored with his consent does not prevent the surveillance from being personal, sensitive and intimate. Personal data, such as our thoughts, bodily signals, feelings, and emotions “take their significance from the fact that they are a kind of currency of intimacy,” Marx notes (ibid.: 91). The intimate psychological, emotional, and physical details that are usually contained by our minds and bodies, or concealed by our garments and skin, now become known to the outside world. “This intimacy,” Lucy Dunne argues, “creates a much higher barrier to change for adoption of wearable technology than that of mobile devices” (Dunne 2010a: 60). That techno-fashion is both body-based, and body-worn thus implies that its contents exemplify the intimate and private kind of information we normally reserve only for ourselves and selectively trusted others.

In addition to showing why wearable surveillance is often a highly personal and embodied means of surveillance, the ‘BB. Suit 0.3’ also illustrates its multisensorial nature. Traditionally, the visual is an important element of surveillance: classic forms and notions of surveillance – ranging from Michel Foucault’s conceptualization of the panopticon to the Orwellian scenario of a ‘Big Brother’ – include watching as the main method of observation. That surveillance practices are usually associated with visual observation is not surprising considering the linguistic origins of the word ‘surveillance’ (sur- ‘over’ + veiller ‘watch’). Yet with the introduction of new surveillance technologies, Marx notes, “[t]he eyes as the major means of direct surveillance is increasingly joined or replaced by hearing, touching and smelling” (Marx 2002: 11-12). In addition to, or even instead of, visual perception, much contemporary surveillance practices use multiple senses and non-visual sources of data.

Techno-fashion generally collects data through sensors, which are able to detect and register input ranging from motion, pressure, smell, noise, proximity, touch, temperature et cetera. The ‘BB. Suit 0.3’, specifically, detects non-visual data on the heart rate and alertness levels of the wearer, only to subsequently visualize it to the wearer and outside world. Such wearable surveillance is based on sensing, rather than visually observing, signals of the body. Moreover, as I argued in the first chapter of this
dissertation, techno-fashion can render signals normally imperceptible to the human sensorium perceptible. Without the technological mediation of the ‘BB. Suit 0.3’, the wearer would not be able to monitor his body’s heart rate, alertness, and engagement all at the same time. Wearable surveillance practices thus stretch beyond literal ‘watching over’ and into the realm of multisensorial and technologically aided perception.

So far, I have discussed why its close proximity to the body makes the content of wearable surveillance so personal, embodied, multisensorial, and often even private or intimate. Yet techno-fashion can also monitor contextual and external data such as air quality (e.g. the ‘Aegis Parka’ by Nieuwe Heren [Figure 59]), GPS location (e.g. the ‘BB. Suit 0.1’ [Figure 60]), proximity (e.g. Wipprecht’s ‘Spider Dress 2.0’), or social media use (e.g. the ‘Twitter Dress’ by CuteCircuit). Even in the instances where the monitoring is extracting data from the environment rather than the wearer, however, the wearable surveillance might still involve personal, embodied, and even private matters. When techno-fashion is outward-oriented it often translates the external data into a form of output (e.g., color-change, movement, sound, or vibration) that is visible or otherwise noticeable to the wearer and her surroundings. As explained in chapter four, such output not only transforms how the wearer perceives herself and the world around her but, in turn, also influences how the world perceives her. In that sense, it does not really make a difference whether the data were originally gathered from the wearer or from something or someone else. Whatever the source of the data fueling the blinking LED lights, moving surfaces, or bleeps might be, the signs given off by the garment will be interpreted as telling something about the wearer’s identity. It is, therefore, crucial to bear in mind that techno-fashion “move[s] about, both socially and physically” (Mann, Nolan and Wellman 2003: 336). Regardless of the input being impersonal or even entirely external, people will presume a direct link between the wearer and the output just because of the fact that they occur in tandem.

Multiple and Multidirectional

Like most other forms of surveillance, wearable surveillance is commonly concerned with observing people (Haggerty 2006: 30). It generally monitors (aspects of) the
wearer’s body, behavior, or interior life. Yet as I discussed in the previous paragraph it can also monitor non-human phenomena, such as a certain space (e.g., the space directly surrounding the wearer), network (e.g., social media), or geographical place (e.g., GPS location). This means that the target of wearable surveillance is not confined to human subjects, but broadens the range of surveillance to include “settings and patterns of relationships” between people and non-human entities (Marx 2002: 12). Trying to understand wearable surveillance as an exclusively human-centered phenomenon would thus be a serious oversight of its many targets of observation. The postphenomenological and new materialist ideas that run throughout this dissertation, make clear that wearable surveillance through techno-fashion marks the interrelations between human and non-human entities rather than their distinct characteristics. Techno-fashion also involves non-human ‘actors’ (see chapter three) such as sensors, satellites, biometric devices, camera’s and spyware, many of which “display a form of technological agency, automatically initiating responses when they detect motion, heat profiles, sounds, or pre-established informational thresholds and data configurations” (Haggerty 2006: 32). The role of humans in contemporary surveillance practices, Haggerty therefore argues, is increasingly marginal and nowadays mostly consists of monitoring and operating the technologies that scrutinize other people, places and things (ibid.).

In addition, wearable surveillance renders the dictionary definition of surveillance as a practice that involves the watching of a person obsolete, as it challenges a clear distinction between the watcher and the person or ‘thing’ watched. In the case of the ‘BB. Suit 0.3’, it makes no sense to strictly separate the person watched from the people watching as the wearer belongs to both categories. Monitoring his body while giving a public presentation, the wearer is involved in the act of surveillance that “merges the line between the surveilled and the surveillant” (Marx 2002: 10). In fact, the public experiment by Borre did with this sweater complicates the issue of the watcher and the watched even more. By also equipping the audience with sensors, the wearer of the BB. Suit 0.3 is able to surveil his surveillants, hence becoming a surveillant himself. In this particular case, we could speak of “parallel or co-monitoring,” in which the subject and the external agent are simultaneously involved in the act of ‘watching’ one another (ibid.). “A central question, of course, is just who is being empowered or controlled, and for what ends?” (Marx 2002: 22).

Through wearable surveillance, then, techno-fashion confirms, expands, and problematizes traditional notions of surveillance. It confirms the ambiguity of the purpose of surveillance, often leaving those watched by techno-fashion in the dark about whether
they are protected and defended or policed and guarded. Wearable surveillance expands other forms and practices of surveillance in the sense that it is situated on and hence closely connected to the body. It moreover extends the range of data collected through surveillance beyond the merely visual, incorporating data gained from hearing, touch, smell, et cetera. Finally, wearable surveillance questions the idea of surveillance as an exclusively human-oriented, one-directional practice that involves a clear separation between the person ‘watching’ and the person, ‘thing,’ or phenomenon under surveillance. Techno-fashion surveils not only the human individual but, even more importantly, also allows for the collection of data about the context and dynamics of relationships between people, their environment, and technology. The following sections of this chapter will further elaborate on these three main characteristics of surveillance by connecting them to Foucault’s notions of power and discipline, as well as Deleuze’s discussion of ‘the society of control.’

**The Disciplined and Docile Body**

As the previous section made clear, techno-fashion heralds the advance of a new form of surveillance, characterized by its direct and constant contact with the interior and/or exterior of the wearer’s body. In this context, it is unavoidable to mention the French philosopher Michel Foucault, whose work on the interdependency of power and knowledge and the key role of the body in modern institutions, has been eminent for both surveillance and fashion studies (see for example Ball et al. 2012; Warwick and Cavallaro 1998; Entwistle 2015). In *Discipline and Punish* (1975/1995), Foucault describes how, from the early nineteenth century onwards, new ways of thinking about criminality reformed the managing of criminals within the prison system. Physical punishment is replaced by surveillance installed to permanently observe prisoners, a new strategy of domination intended to make them acutely aware of their bodies and to alter their conduct. In particular, he explores how institutions have created knowledge by acting directly on the body (Foucault 1975/1995: 188). This is reinforced by the organization of space around the principle of Jeremy Bentham’s (1748-1832) architectural design for the perfect prison: the ‘Panopticon.’ Foucault considers the Panopticon, a model whereby self-discipline can be induced by the threat of surveillance. The pervasive normalizing gaze of the observer replaces physical force and punishment, and order is achieved through the “trap” of visibility (ibid.: 200).

While many surveillance scholars have pointed to the limitations of Foucault’s writings for understanding contemporary surveillance technologies (see for example Lyon
2006; Murakami Wood 2007), his work remains popular and relevant for the study of wearable surveillance through techno-fashion. Foucault’s metaphor of the Panopticon served to emphasize the role of ‘the gaze’ and visibility in the emerging surveillance practices of the eighteenth and nineteenth century, but it has clear resonances with today’s surveillance society (Haggerty and Ericson 2000; cf. Lupton 2016b). For Foucault, the Panopticon stands for a modern society built upon the principle of total visibility and perpetual institutional observation, with the ultimate aim to ‘normalize’ bodies and behavior (Entwistle 2015: 17). Surveillance is not just about the actual gaze of the watchers for him but, even more crucially, about how the feeling of permanent and total visibility exerts power over the watched. “The point of the Panopticon is thus not that active surveillance can affect behavior,” Marita Sturken and Lisa Cartwright explain, “but more importantly that the structure of surveillance, whether it is active or not, produces conforming behavior” (2001: 99).

The key role attributed to visibility and watching is the first reason why Foucault’s rethinking of the Panopticon is insightful for an analysis of techno-fashion. Bradley Quinn recognizes the value of understanding fashion, and techno-fashion in particular, in terms of ‘surveillance’ (2002: 57; cf. Quinn 2003). Fashion, according to him, is entirely based on the principle of surveillance in the sense that it places emphasis on visibility:

The presence of television cameras, medical cameras, satellites, military aircraft and digital cameras ensure that we never escape the scrutiny of the lens. Fashion exploits these media to instill the desire to be seen, be visible and even pursued. (...) The ‘I know you’re watching me’ facet of the fashion experience reads as a willed pathology of surveillance. (2002: 58).

Quinn here points to how fashion taps into the actual “gaze of visual technologies” that continuously observe us nowadays (Ibid: 57). In addition, he emphasizes the pivotal role of technology in making surveillance the norm, rather than the exception, in today’s Western world: “surveillance is the gaze of technology itself: forced and distorted, recording our every movement and playing it back to gratify our endless fascination with watching others and ourselves” (Ibid.). Following this line of thought, technology merely augments the already prominent role of visibility and surveillance in the world of fashion. Technologies only make the experience of being visible “more intimate and more exotic,” Quinn argues, as they amplify “the function of clothing as both boundary and margin in the ever-narrowing gap between public and private personae” (Ibid.). Without integrated technology, the ‘BB. Suit 0.3’ would be an ordinary
sweater that marks and mediates the wearer’s visibility to the panoptical gaze of the crowd. Equipped with biosensors, however, the garment amplifies and extends how the wearer is ‘visible’ to his audience, thereby revealing normally hidden information. Here, techno-fashion “makes perceivable things [heart rate, galvanic skin response] that remain invisible to the naked eye” (Verbeek 2005a: 134, ref. Ihde 1991: 73-74). The sensors, screening technology, and app involved in the experiment with the ‘BB. Suit 0.3’ equip the panoptical gaze with the “technological abilities to see more, at a greater distance and in real time” (Haggerty and Ericson 2006: 13).

A second reason why the Foucauldian notion of the panoptical gaze helps to understand wearable surveillance through techno-fashion is that it highlights the self-disciplining and normalizing effects of surveillance. Foucault teaches us that the Panopticon is such an effective surveillance model because the gaze of the watcher is invisible and unverifiable to those being watched. Just the feeling of possibly being under scrutiny is enough to effectively makes us self-regulate our bodies and behavior without any active threat or physical punishment. “To punish is to exercise,” Foucault writes (1975/1995: 180). Fashion, Anneke Smelik notes, thrives on the internalization of such a panoptical gaze, dictating us to “discipline our social behavior, as well as our bodies” (2006: 169). My analysis of ‘Phototrope’ in chapter four indicated, wearing techno-fashion also clearly involves this internalization and awareness of the (real or imagined) gaze of a spectator, which is always connected to the ways in which a wearer performs her identity in front of others (see chapter four). “[I]n the context of highly technological living patterns under late capitalism”, Johannes Birringer and Michèle Danjoux observe, “performative fashion can be linked to disciplinary power in Foucault’s sense of social organization, insofar as fashion coerces the body to shape and rearrange itself in accordance with ever-shifting social expectations” (2009: 392).

Wearable surveillance offers the technological tools to reinforce our self-disciplinary desires, thereby further exploiting our internalization of an omnipresent disciplinary gaze. Discipline, rather than being forced upon on the ‘fleshy’ body through physical coercion, operates through the establishment of the ‘disciplined’ body, which calls upon individuals to monitor and improve their own behavior (Entwistle 2015: 18). “The point is,” Jane Tynan explains, “that we do not require the judgment of authority. We continually search for deviance, excess or fault in ourselves” (Tynan 2016: 189). The growing popularity of self-tracking and biomonitoring devices indicates that wearable surveillance successfully capitalizes on our self-imposed desire for a fit, beautiful, normal, and healthy body. At the same time, all those self-tracking devices to some extent
also relieve us of the constant burden of self-regulation, allowing us to externalize and outsource that responsibility to the technology partially. In that sense, wearables and techno-fashion realize Donald Norman’s techno-fantasy of letting devices carry the burden of reminding us to do or not do specific things:

“Would you like a pocket-size device that reminded you of each appointment and daily event? I would. I am waiting for the day when portable computers become small enough that I can keep one with me at all times. I will definitely put all my reminding burdens upon it” (Norman 1988: 73).

Wearable surveillance serves as the reminder and carrier of the self-disciplinary responsibilities that the internalized panoptical gaze imposes upon us. In the specific case of the ‘BB. Suit 0.3’ this disciplinary consciousness is focused on public performance and self-control: the sweater disciplines the speaker to perform his presentation and engage with the audience optimally. Foucault’s work enables us to see how such examples of surveillance through techno-fashion render the wearer’s body ‘docile.’

“A body is docile,” Foucault writes, in that it “may be subjected, used, transformed and improved” (Foucault 1975/1995: 136). Techno-fashion or wearable technology that measures steps and burnt calories, physical activity, posture, heart rate or temperature is simply the latest emblem of a society that “call[s] upon the individual to take responsibility for their own health and fitness” (Entwistle 2015: 17). Yet, as Eggers’ The Circle anticipates, wearable surveillance can also be used to invite, or even dictate, the wearer to make the ‘right’ decision in pretty much every aspect of daily life. The examples discussed throughout this dissertation show how techno-fashion may urge wearers to exercise better, improve their posture, run faster, and defend their personal space. Wearable surveillance, in other words, has the potential to become a “certain policy of the body” that renders the bodies of wearers “docile and useful,” telling them how to live a healthy, good, and productive life (Foucault 1975/1995: 305). The ethical question this obviously raises is if, or under which circumstances, this new and wearable “modality of power” sounds like a desirable scenario to us (ibid.).

The third and final merit of Foucault’s theory is that it helps to clarify how wearable surveillance structures power relations. According to Foucault, power is located in the network that ‘holds’ the whole system of surveillance together, rather than in the individual: “it is the apparatus as a whole that produces ‘power’ and distributes individuals in this permanent and continuous field” (Foucault 1975/1995: 177). As Entwistle
AUDIENCE ENGAGEMENT

AUDIENCE ENGAGEMENT PERCENTAGE

32% ENGAGED 36% AWAKE 12% BORED 20% AWAY

WEARING SENSE

61. Byborre x CWI, ‘BB Suit 0.3’ (2015) Graphics: Daan Spangenberg and Lilia Pérez. @byborre, byborre.com
explains, power is all about ‘force relations’ for Foucault: “[i]t is not the property of anyone or any group of individuals, but it is invested everywhere in everyone” (Entwistle 2015: 18). This helps to understand how the power exerted by wearable surveillance is never located in a single thing, individual, or group. It is not the designer of the ‘BB. Suit 0.3’ or the sweater itself that possesses power, nor is it the wearer or the audience that surveils his body. Power is relational: it “sustains itself a network of relations from top to bottom, but also to a certain extent from bottom to top and laterally” (Foucault 1975/1995: 176). This helps to gain insight into how wearable surveillance fosters a network of power relations. This network of relations, Foucault writes, “enables the disciplinary power to be both absolutely indiscreet, since it is everywhere and always alert,” functions “permanently and largely in silence” and “sustains itself by its own mechanism” (ibid.: 177).

Panopticism is both a cultural practice and a metaphor for the internalized disciplinary gaze of modern society, and as such adequately explains how wearable surveillance stimulates and embodies a critical view of ourselves and our bodies. Techno-fashion is a phenomenon that combines self-presentation and self-governing, and Foucault’s notions of the disciplined and docile body help to understand how techno-fashion and wearable technology are on the verge of becoming the ultimate every day, socialized and embodied form of surveillance (Tynan 2016: 189)

**Beyond the Panopticon**

So far, I have discussed how Foucault’s insights on the panoptic gaze, the disciplined body, and power relations resonate with the wearable surveillance practices currently enabled by techno-fashion. In many ways, however, techno-fashion also complicates the Foucauldian understanding of surveillance. First of all, wearable surveillance problematizes the idea that the normalizing and disciplinary gaze of surveillance is deployed by visual means only. Although Foucault’s conception of a surveillance culture is not explicitly confined to the realm of the visual, it is important to note how techno-fashion stretches surveillance beyond visually exerted manifestations of power. As Haggerty and Ericson note, “[a] great deal of surveillance is directed toward the human body” (2000: 611). In addition, postphenomenological thinking reminds us that perception is intrinsically embodied (cf. Ihde 1998; 2010). “Even when the visual sense dominates,” Van Den Eede explains, “experience is still given to an embodied subject” (2015: 145). These two perspectives help to see how techno-fashion utilizes and thrives on embodiment for the purpose of surveillance. It turns the normalizing panoptical gaze into something “far more searching and intrusive; its reach onto every surface of our bodies
serves as a painful reminder of just how badly our bodies are ‘failing’ to live up to socially constructed ideals” (Cressida Heyes 2007, quoted in Tynan 2016: 189).

The socially constructed ideals enacted through techno-fashion do not just concern beauty or visual appearance, they may also discipline wearers or their environment in terms of body movement, behavior, communication, health, lifestyle, and productivity. “As social control shifts to data systems”, Bradley Quinn explains, “visual surveillance is becoming outmoded by sensors and key fobs that track access to buildings, and
credit-card transactions that can be relayed at a speed that pinpoints an individual’s location before they have had time to leave the shop” (Quinn 2002: 75). The ‘BB. Suit 0.3’, for example, reinforces ideals of engaged public speaking and effective knowledge transfer by registering “heretofore opaque flows of (...) stimuli”, such as biometric information, that represents the wearer’s performance (Haggerty and Ericson 2000: 611). Moreover, techno-fashion’s inherent proximity to the body enables it to monitor the wearer or her environment by means of haptic and proprioceptive, in addition to visual, forms of surveillance. Byborre’s ‘BB. Suit 0.3’ uses graphic data visualization as its output [Figure 61], whereas designs such as ‘Vigour’ [Figure 62] and ‘Navigate’ [Figure 13 and 14 in the Appendix] use body position and GPS as input and haptic feedback or vibration as output.

As techno-fashion is situated directly on the body, most designs are actually not about surveillance in terms of watching and being watched, but about direct embodied perception in general: about perceiving and being perceived by means of technology. Quinn therefore even wonders if “perhaps fashion’s engagement with visual surveillance will one day be considered purely nostalgic, heralding a desire to return to an exclusively visual world” (2002: 75). What Foucault described as the “trap” (1975/1995: 200) of visibility has become a ‘trap of perceivability’ with the advent of wearable surveillance technologies. In postphenomenological terms, techno-fashion technologically mediates experience which can partially explain its controversial yet effective role as a surveillance technology. It brings stimuli that exist beyond our normal range of perception into the perceptual realm, allowing the wearer and other (possibly unwanted) observers to monitor heretofore hidden streams of information.

In addition to broadening the scope of surveillance beyond the visual and humanly perceivable, techno-fashion complicates the concept of the panoptic gaze because it cannot adequately be captured by the idea of surveillance as a one-directional and “single all-knowing oppressive force” (Surveillance Studies Net n.d.). In the panoptic prison introduced by Bentham and analyzed by Foucault, surveillance is a system of visibility that enables a few isolated watchers to scrutinize the behavior of large groups of people. Although techno-fashion and wearable surveillance may still be used to turn the panoptical gaze to a group of others (e.g. the trainer using ‘Phototrope’ (see chapter four) to monitor the performance of a group of runners), “these technologies also encourage users to surveil themselves or to actually invite others to do so” (Lupton 2012a). As discussed in chapter four, much of the fun and function of techno-fashion resides in its communicative and performative power. These garments allow wearers to
learn, show and express something about themselves, as well as to communicate and socially interact with others in unprecedented ways. From a psychoanalytical point of view, fashion, in general, thrives on the human impulses toward exhibitionism, narcissism, and scopophilia (Smelik 2006: 169; cf. Flügel 1930: 118, Silverman 1986). Deborah Lupton highlights that this social and exhibitionist desire to see and be seen is further extended and intensified by wearable and mobile health technologies. She points out that social media, in particular, stimulate people to share intimate and personal information about their physical health and activities with large numbers of online friends and followers. “Here,” she explains, “the net of surveillance is thus expanded around the user’s body. The panoptic gaze, in this case, becomes inverted so that instead of the few watching the many, the many are watching the few” (Lupton 2012a).

The ‘BB. Suit 0.3’ exemplifies how techno-fashion may do precisely that: it stretches the “net” of surveillance around the body, inverting the panoptic gaze while simultaneously inviting the wearer to engage in the act of self-surveillance. Contrary to the classical surveillance model, the power is not in the hands of a few observers who are both literally and hierarchically positioned above (“sur”) a mass of people or ‘things’ under observation (Haggerty and Ericson 2006: 4, my emphasis). In this specific case, the mass (i.e., the entire audience) can watch the bodily signals of a single wearer while that same individual also willingly turns the panoptic gaze upon himself. Power is evenly distributed among the spectators, causing both the ‘BB. Suit 0.3’ wearer and his audience to simultaneously play the roles of operator, spectator, and performer (see chapter four). Even those examples of techno-fashion that seemingly maintain a clear hierarchical distinction between the observer and those under surveillance (e.g. a trainer using ‘Phototrope’ to monitor each individual runner in the team) do not match the panoptic surveillance model because they generally involve multiple operators as well as a heterogeneity of power relations (e.g. ‘Phototrope’ allows the runners to monitor themselves and the other team members as well). The manifold levers of power exerted by today’s mobile and wearable surveillance have thus replaced Bentham’s idea of an external observer or ‘Big Brother’ with fluid, multifaceted and elusive forms of surveillance (Lyon 2007: 179). “Unlike the Panopticon,” Lyon writes, “surveillance now shifts and undulates, expands and contracts like the swell and tides of the ocean” (ibid.: 180).

Today’s surveillance practices have a more ubiquitous, ever-shifting, and continuous character than those in Foucault’s Panopticon. No longer are they confined to the enclosed and fixed spaces of institutions such as the prison, school, hospital, or factory, nor do they turn their ‘gaze’ upon a clearly demarcated group of subjects (e.g., inmates,
The development of techno-fashion for surveillance purposes should be seen against the background of an upsurge of electronic and mobile surveillance technologies that have ceaselessly expanded the scope and depth of surveillance over the past few decades. As technologies such as CCTV cameras, GPS, smartphones, RFID, and sensors have rapidly become omnipresent in contemporary Western societies, we are now at a point where anyone and anything is potentially monitored at any time and any place. Indeed, technological developments have been of crucial importance in the rise to the new, mobile and ubiquitous forms of surveillance that we are faced with today (Haggerty and Ericson 2006: 4). To shed light on this particular aspect, I will now turn to Gilles Deleuze’s notion of the ‘control society,’ discussing it alongside the postphenomenological idea of technological mediation that has been central to my understanding of techno-fashion throughout this dissertation.

From Discipline to Control

Gilles Deleuze’s short ‘Postscript to the Society of Control’ (1992) deserves special attention in an analysis of surveillance through techno-fashion because he shifts the attention from discipline to control and, unlike Foucault, accentuates the role of technological developments in surveillance practices. Deleuze develops the notion of a society of control to describe how the enclosed spaces of Foucault’s disciplinary society have been replaced by continuous and “free-floating” control mechanisms (1992: 4). Towards the end of the twentieth century, he argues, the old enclosures are no longer the only or the primary sites of surveillance: they have been superseded by a limitless and “open environment” of continuous control (ibid.: 7). “Enclosures are molds, distinct castings,” he writes, “but controls are a modulation, like a self-deforming cast that will change continuously from one moment to the other like a sieve whose mesh will transmute from point to point” (4, original emphasis). This idea of surveillance as a modulation, as a controlling yet perpetually transforming influence, helps to think beyond the disciplinary society and toward the elusive, multifaceted, and mediated character of surveillance through techno-fashion. Again, the case of the ‘BB. Suit 0.3’ can serve as an illustrative example.

This chapter already identified the different ways in which the ‘BB. Suit 0.3’ exerts disciplinary power over its wearer. From a Foucauldian perspective, the design disciplines the wearer into being an ideal communicator who gives an engaging presentation. To a certain extent, therefore, techno-fashion here acts as a mold into which the wearer is ‘pressed.’ In conjunction with the integrated technology, the sweater both literally and metaphorically shapes the outward appearance, behavior, and performance of the wearer. It restricts and affects him physically as well as influences how he presents himself.
to his audience. As Borre Akkersdijk explains, this process of disciplining the wearer through techno-fashion does not have to be a negative or unpleasant experience at all. On the contrary, he emphasizes that he felt completely comfortable sharing live-data about his engagement levels with his audience during the presentation: “I am standing there in this long blouse underneath a ridiculously short sweater, so they already see me as this weird clown anyway. I then better just play along and doing so makes me feel comfortable enough to stand on stage” (Interview BA 2017). In this particular context and in front of this particular crowd, Akkersdijk simply experiences the wearable surveillance as a playful and interesting way to make a direct connection with his audience (ibid.).

The ‘BB. Suit 0.3’ disciplines the wearer into giving a lively and engaging public presentation, allowing for direct visual feedback on his performance and the engagement levels of the audience. Deleuze’s notion of control societies, however, helps to see that wearable surveillance through techno-fashion may also move beyond the confined places of discipline and outward into complex networks of control. As Deleuze signals, the power relations implicit in surveillance technologies are not necessarily coercive or repressive:

Control is not discipline. You do not confine people with a highway. But by making highways, you multiply the means of control. I am not saying this is the only aim of highways, but people can travel infinitely and ‘freely’ without being confined while being perfectly controlled. That is our future (Deleuze 1987/2006: 322).

Although the ‘BB.Suit 0.3’ has been tested in the specific and enclosed space of a public lecture room [Figure 63], it clearly has the potential to monitor and surveil the wearer beyond this situation, even more so because the data collected by the garment are free-floating. The surveillance enabled by techno-fashion such as the ‘BB. Suit 0.3’ is not confined to a physical space, context, or system but has an open, continuously variable and fluid character. As the gathered information is registered, stored, and shared through the internet and wireless devices such as smartphones, it is no
longer limited to the enclosed context of the public lecture but instead freed up to operate in limitless networks. Surveillance through techno-fashion, in other words, is “undulatory, in orbit, in a continuous network” (Deleuze 1987/2006: 6). Techno-fashion does not just discipline people to obey rules or a code of behavior (e.g., being active, healthy, productive, social, successful) at a certain time or place but also to ceaselessly control people in order to manage, direct, and regulate their behavior or the general course of events.

Deleuze’s reflection on the control society brings to the fore that contemporary surveillance is not just shaped by closed forms (‘molds’) of the disciplinary organization but, even more importantly, raises the issue of ‘control’ (‘modulation’). The power relations and surveillance practices at work in techno-fashion are in fact “multiple, unstable and lack (...) discernable boundaries or responsible governmental departments” (Haggerty and Ericson 2000: 609). Whereas ‘plain’ non-technological fashion leaves wearers in control of how, where, and to whom they reveal their body and identity, techno-fashion complicates the issue by adding several mechanisms of control.

On the one hand, techno-fashion may diffuse power by multiplying the options to control what/whom the garment monitors and shows, and thereby problematizes the idea of a single-handed controller. Understandably, this raises concerns about losing control over technology, safety, security, and privacy. After all, what happens to our privacy if other parties than the wearer will be able to control the visibility and accessibility of data? On the other hand, techno-fashion may also centralize and increase control, and self-control or self-care in particular. Its technological functionalities can, for example, aid the wearer in gaining (more) control over her personal space (e.g., Wipprecht’s ‘Spider Dress 1.0 and 2.0) (see chapter two)), physical performance (e.g. Van Dongen’s ‘Phototrope’ (see chapter four)), or health and safety (e.g. the ‘Aegis Parka’ by Nieuwe Heren [Figure 18 and 58 in the Appendix]). In that sense, wearable and mobile technologies can turn surveillance into a practice of mutual empowerment rather than asymmetrical control: they provide space for wearers and their spectators “to engage with each other, to resist attempts to position them in certain ways and to challenge power relations” (Lupton 2012b). In short, Deborah Lupton argues, they allow their wearers to both individually and collectively ‘talk back’ to those who may be attempting to change their behaviors (ibid.).

Although the notion of control is very helpful in exploring the power relations involved in surveillance through techno-fashion, it is, as Don Ihde argues, “senseless” to linger on the popular question of control over technology (1990:140). Techno-fashion,
postphenomenology and new materialisms teach us, can never fully be controlled because it is never ‘merely’ instrumental or implicitly neutral and may always retain some of its material agency, as I discussed in chapter three. One has to recognize and acknowledge that techno-fashion is not simply configured by its wearer, but in turn shapes its wearers in various ways by creating new ways of thinking, feeling and being. The wearer may control the situation to the extent that she handles the controller, can decide to turn the technology off, or may regulate the data flows, but the garment always provides the material context and restrictions for such actions in the first place. As the material basis of the interactions between techno-fashion and people, the garment itself will always at least have some control over the wearer. Yet, Ihde notes, the fear that technology can become completely uncontrollable and autonomous makes no sense either. Once technologies are incorporated into everyday use, they are transformed, adjusted, or appropriated to fit into certain routines and practices.

The ‘BB. Suit 0.3’ exemplifies how the wearer of techno-fashion, indeed, is never fully in power nor fully overpowered. The sweater can be used to gain control of a public performance in the sense that it stimulates him to stay alert but might at the same time lose control over his performance if the technology would hamper or if the audience would interpret the data as signifying stress rather than engagement levels. “To enter any human-technology relation is already to both ‘control’ and to ‘be controlled’,” Ihde, therefore, writes (Ihde 1990: 140). The question of surveillance through techno-fashion can thus be reformulated in terms of how power and control are always relationally distributed and redistributed among different actors (e.g., among garment, wearer, and audience), at different times, and in different contexts.

**Living by Numbers**

The ‘BB. Suit 0.3’ exemplifies the type of techno-fashion that influences the wearer’s experience, performance, and actions in positive ways by providing meaningful data for self-reflection and self-awareness. Indeed, many examples of techno-fashion are explicitly presented as a form of care, self-care or rehabilitation. From a Foucauldian perspective, however, they are rather an instrument of social control designed to govern the health and wellness of people, as well as to cut costs on healthcare and medicine. Even if ‘smart technologies’ – be it techno-fashion, driverless cars, smart thermostats, or drones – to help us protect and improve our lives, safety, environment or wellbeing they also inevitably raise concerns about the loss of control and power (Galdon-Clavell 2013). Such concerns resonate with the continuous debate on
the blurry boundary between privacy and security, and the recurring critique that the welfare state has been eclipsed by a safety state that entirely relies on the collection of personal data (Lyon 2007: 184).

Foucault developed the term ‘biopolitics’ to emphasize that the impulse to categorize and classify human life reflects new forms of social control that are used to make bodies politically and economically useful (Tynan 2016: 187). Despite nurturing an image of care, self-improvement, protection, and empowerment, the design and use of techno-fashion should also be understood against the background of this broader socio-political desire for control, governance, and profit. As many techno-fashion designs combine the promise of a better quality of life with practices of surveillance, they can also be viewed as tools for social control, governance, policing, and commercial gain. A garment that monitors your posture or emotional state, for example, may effectively help to take better care of your body or psychological wellbeing yet can also act as a medium to prevent expensive medical treatments or long-term sick leave. Techno-fashion, in other words, can easily turn into a bio-political tool that supports the powers that be in making and keeping people sufficiently disciplined (i.e., healthy, active, productive and profitable) (Van den Eede 2015: 148; cf. Lupton 2012b). Therefore, the classification, visualization, quantification, and monetization of wearers’ personal data through techno-fashion requires special attention. In order to address these systems of data-collection at work in techno-fashion, I want to discuss three interrelated and critical debates: the quantification of human life (1); the issue of self-surveillance and self-tracking (2); and the importance of ‘the human touch’ to technology (3). In the remainder of this chapter, I will highlight the importance of ‘critically accompanying’ (Verbeek 2010) the development, use, and social embedding of techno-fashion in light of these three debates.

**From Surveillance to Dataveillance**

Although Deleuze’s text was written well before the first experiments with wearable computing took place, he mentions some technological developments that seem of prophetic value in light of the advent of wearable technology:
The conception of a control mechanism, giving the position of any element within an open environment at any given instant (whether the animal in a reserve or human in a corporation, as with an electronic collar), is not necessarily one of science fiction. Felix Guattari has imagined a city where one would be able to leave one’s apartment, one’s street, one’s neighborhood, thanks to one’s (dividual) electronic card that raises a given barrier; but the card could just as easily be rejected on a given day or between certain hours; what counts is not the barrier but the computer that tracks each person’s position – licit or illicit – and effects a universal modulation (1987/2006: 7).

This citation can be seen as a timely argument for a socio-technological study of the mechanisms of control. Deleuze here points to the emergence of computerized forms of mobile surveillance that, in his example, continuously monitor the position of any given human or nonhuman element within an open environment. He accurately predicts that such tracking technology would become boundless, and at a certain point turn into a continuously modifying and controlling force. Equally valuable in relation to wearable surveillance mechanisms is his emphasis on the crucial role of computation, digital media, and ‘code’ in contemporary surveillance practices. “The numerical language of control,” he postulates, “is made of codes that mark access to information or reject it” (ibid.: 5). This fittingly describes a society in which access to information has become the newest currency (Van Dijck 2014). In the field of techno-fashion and wearable technology, this is most noticeable in the gathering of personal data for commercial use, classification, and social control.

Foucault already noted that the systematic classification, hierarchizing, and ranking of human life functions like a power of normalization that homogenizes but also individualizes “by making it possible to measure gaps, to determine levels, to fix specialties and to render the differences useful by fitting them one to another” (Foucault 1977: 184). To a certain extent, the same tendencies can be recognized in practices of surveillance through techno-fashion, especially those collecting data from the wearer’s body. The ‘BB. Suit 0.3’, for example, connects to software that quantifies, charts, and ranks the wearer’s performance in terms of ‘levels of engagement,’ ‘acceleration on axis’ and heart rate [Figure 64]. Most fitness, health, and activity-tracking wearables, moreover, involve a mobile or online app “through which one can consult the ‘result’ of one’s measuring activities” compare it to the ‘norm,’ average, and data of others (Van den Eede 2015: 143).
As part of his theory of societies of control, Deleuze reflects on how the computational and digital accounts of human life turn individuals into ‘dividuals’: the collected information is separated from the human body, turning it “into masses, samples, data, markets, or ‘banks’” (1987/2006: 5, original emphasis). Inspired by Deleuze’s thinking in conjunction with Félix Guattari, Kevin Haggerty and Richard Ericson develop the concept of ‘surveillance assemblages’ to describe the increasing convergence of once independent surveillance mechanisms (2000: 609). They argue that contemporary surveillance “is driven by the desire to bring systems together, to combine practices and technologies and integrate them into a larger whole” (ibid.: 610). The concept of ‘surveillant assemblage’ (Haggerty and Ericson 2000) points to the disconnected, computational, and semi-coordinated character of contemporary surveillance. In other words, contemporary society has moved from surveillance to data-veillance (Clarke 2003).

The power relations produced by techno-fashion are characterized by a complex interaction of technologies, data, and bodies and the ability of certain actors to integrate, combine, and coordinate various data systems and components. Techno-fashion does not only construct users as personally responsible for their own health, performance, productivity, and success but functions as part of a heterogeneous network of actors, including various technologies, companies, governmental organizations but also friends and contacts. The concept of assemblages recognizes the heterogeneity of objects, which combine to form certain types of bodies/selves as well as their constantly shifting and dynamic nature. It also acknowledges the role played by non-human actors such technologies in producing bodies/selves (Lupton 2012b).

Symptomatic of the emergent surveillance assemblage, according to Haggerty and Ericson, is the proliferation of interconnected information and data gathering techniques that break the human body down and then reassemble them through series of discrete data flows (2000: 611). Following Deleuze and Guattari, they believe that contemporary surveillance technologies do not monitor people qua individuals but instead, operate through processes of disassembling and reassembling. People are broken down into a series of discrete informational flows, which are stabilized and captured according to pre-established classificatory criteria. They are then transported to centralized locations to be reassembled and combined in ways that serve institutional agendas. Cumulatively, such quantified information about our body and behavior constitutes our virtual and informational profiles that circulate in various computers and contexts of practical application (Haggerty and Ericson 2006: 4). “The result,” Haggerty and Ericson postulate, “is a decorporealized body, a ‘data double’ of pure virtuality” (2000: 611).
Techno-fashion that tracks or monitors wearers or their environments constantly creates and recreates ‘survillant assemblages’ in the sense that it derives information via surveillance technologies (e.g., sensors or wearable cameras) and then reassembles the data into ‘data doubles’ or ‘data selves’, which can then be scrutinized, monitored and used for various purposes. The ‘BB. Suit 0.3’ illustrates this type of ‘data-veillance’ (Clarke 2003). First, the sweater breaks the wearer’s body down into parts and uses sensors to gather data from each of these parts (such as the heartbeat). The different sets of data are then transferred to a computer programme that reassembles them by translating the combination of data into a virtual and ‘decorporealised’ double that, in this case, represents the alertness and engagement of the wearer. Yet, following Deborah Lupton, I want to stress that it may also be argued that the body as it is surveilled and produced via techno-fashion is far from being ‘decorporealised.’ While the abstracted ‘data-double’ produced through biometric measurements and wearable surveillance technologies, this data-double feeds back information to the wearer in ways that are intended to encourage the user’s body to act in certain ways. The flow of information, therefore, is not one-way, disembodied or static: it is part of a continuous loop of the technologically mediated data and the effect of these data on the wearer’s embodied experiences and actions (Lupton 2012b).

Challenging the common belief that the quantification and datafication of human life disembodies the subject, techno-fashion supports a reflexive, self-monitoring awareness of the body. As Valérie Lamontagne notes in relation to the work of Danish design studio Diffus, wearables allow for “an emphasis on materiality [that] subscribes to the project of the re-embodiment and re-materialization of the technical object, as opposed to screen and data streams (…) reposition the body at the center of the technological question (2017: 184). Indeed, the body is hardly able to disappear when its functions, movements, and habits are constantly monitored, and the user or wearer of techno-fashion is continually made aware, via feedback, of these dispositions (Lupton 2012b).

Self-surveillance and the Quantified Body

“As the body becomes increasingly monitored by the fashion world, it creates a parallel culture of self-surveillance, in which individuals must also scrutinize themselves to monitor their social acceptability,” Bradley Quinn writes (Quinn 2002: 58; 2003: 18). I noted earlier in this chapter that this practice of self-tracking adds a new perspective to the field of surveillance studies, targeting the wearer him or herself as the source of information. I want to end this chapter with a discussion of self-tracking
through techno-fashion, again using a combination of postphenomenological and new materialist perspectives.

Self-tracking – also known under the rubric of personal analytics, personal informatics, or the quantified self – is done mostly in function of optimizing one’s “performance,” be it in sports, professionally, or more broadly speaking in terms of well-being. In a medical context, it is also deployed for treatments that require quasi-constant monitoring of certain physiological variables (Van den Eede 2015: 143). Of course, the activity of self-tracking is not entirely new as people have always sought to improve their condition or performance in these contexts by keeping track of variables of all sorts (Schüll 2012). Yet, Yoni van den Eede argues, “as a plethora of devices is now becoming available that enable the accumulation of heretofore inaccessible data (e.g., brain activity), easier storage, aggregation of different data streams, analysis and display of data by way of algorithms, et cetera, we may speak of, in postphenomenological terms, an intensified technological mediation of the ‘generic’ act of monitoring and tracking oneself” (2015: 144).

Van den Eede considers the postphenomenological conceptual toolbox particularly useful for analyzing self-tracking for two reasons. First, self-tracking concerns the “enmeshment of bodies, technology, and perceptual experience,” which he connects to the postphenomenological interest in human-technology-world relations and to embodiment (ibid.). Second, Van den Eede notes that “the sober but open-minded” postphenomenological ‘method’ helps to look at the possibilities of current self-tracking technologies beyond marketing and cultural presuppositions (ibid.: 144). Although I believe that the same applies to the tracking of others through techno-fashion, I agree with Van den Eede that its attention to embodiment and the cultural facets of human-technology relationships makes postphenomenology a suitable framework for understanding wearable surveillance technologies. I, therefore, follow his example by looking at how the self-tracking enabled by techno-fashion can benefit from postphenomenological insights and, conversely, how some of postphenomenology’s concepts should be extended on the basis of what can be learned from self-tracking through techno-fashion (ibid.).

Self-tracking, according to Van Den Eede, takes part in all four relations identified by Ihde: embodiment, hermeneutic, alterity and background relations. I will again take my case study, Byborre’s ‘BB. Suit 0.3’, as an example. The biomonitoring sweater is embodied because the wearer adjusts his performance and demeanor under the influence of the data. It also involves hermeneutic relations because the data are visualized and
displayed through graphic interfaces and visual readouts including an app. Additionally, the ‘BB. Suit 0.3’ can acquire the character of alterity, then, as the wearer may start to regard the sweater including the connected interfaces as a kind of personal trainer or prompter that provides instructions during the presentation (Van den Eede 2015: 146). Companies producing self-tracking devices often play on such alterity relations, Van den Eede explains, by building in goal-attaining or coaching functionalities. Finally, ‘BB. Suit 0.3’ may also temporarily withdraw from the wearer’s attention and take on the character of a background relation, for example when the wearer is so focused on delivering the presentation that he is no longer aware of the sensors in his sweater and momentarily forgets about the data it tracks. Even if the wearer no longer consciously experiences the self-tracking data, however, the garment may still unconsciously influence his performance and on-stage behavior (ibid.).

In chapter two of this dissertation, I discussed the difference between direct sensorial perception (microperception) and hermeneutic, cultural perception (macroperception) that Ihde identifies (1990). In relation to self-surveillance it is interesting also to address an even more specific distinction that he makes: that between “body one” and “body two” (Ihde 2002: xif). Ihde uses the term body one to refer to the sensory, fleshy, perceiving body from which we experience the world around us (ibid.: 69). Connected to body one is body two: “the culturally fixed and acted upon body of Foucault” (ibid.: 26). This second body is the body as constructed and informed by culture and society, the body that we are invited or pushed to shape according to cultural fashion, politics, expectation, rules, and norms (ibid.: 70). Traversing both, Ihde adds, “is a third dimension, the dimension of the technological” (ibid.: xi). He uses this third dimension to account for the ways in which technologies and material artifacts mediate how we experience and re-experience our bodies on both a socio-cultural and fleshy perceptual level. This latter insight is of particular relevance in connection to self-tracking through techno-fashion, because it reveals that “[b]odily reactions cannot be separated from social relations, even if people wish they could be” (Ruckenstein 2012: 15, quoted in Van den Eede 2015: 147).

The bodily signals (i.e., galvanic skin response, activity, and heart rate) recorded by the sensors in the ‘BB. Suit 0.3’ cannot be separated from the social context in which they are measured. The public presentation at which Borre Akkersdijk’s wore the self-tracking sweater was organized by the Centrum Wiskunde & Informatica (Centre for Mathematics and Informatics, CWI), meaning that most of the audience members were technical experts. For Akkersdijk this had the effect of making him feel confident that
his audience would easily understand the technical specificities of the garment while reassuring him that little could go wrong as he was the only textile and techno-fashion expert in the room (Interview BA 2017). The bodily signals tracked and shown during his presentation have to be understood in relation to this specific social context. Akkerdijk’s heart rate and galvanic skin response remained relatively calm throughout most of the presentation because he felt at ease with his audience and the situation. At the same time, the social context explains why Akkersdijk’s biosignals began to show signs of stress at one point in the presentation. Due to the fact that he was presenting his work in front of a “mega smart audience,” he narrates, he became nervous when he temporarily lost his focus, and the biosignals started to show that the public’s attention was dropping (Interview BA 2017). When it concerns practices of self-tracking through techno-fashion, the influence of what Ihde terms macroperception (i.e., the cultural-hermeneutic level of perception) is thus crucial. The tendency to check, control, and monitor the body through technology, Yoni van den Eede convincingly remarks, should be understood in light of our “Western, (post)modern culture of fitness, physical competence, and performance” (Van den Eede 2015: 147). All those new self-tracking devices, including wearables and techno-fashion, are marketed as tools with which to improve one’s performance, efficiency, fitness, or health. Yet, “[t]hey would be hard to situate, let alone understand if not for this surrounding constellation of norms, habits, and expectations” (ibid.). Each of the case studies in this dissertation – be it a self-defending robotic dress, a goosebump amplifying garment, an illuminated interactive running shirt, or a self-tracking sweater – reflect social, political and cultural norms, habits and expectations. From this perspective, self-surveillance through techno-fashion is just another manifestation of our tendency to live up to the unattainable ideal of having a perfect, healthy, successful, social, productive, and happy life.

Burden or Blessing?

When it comes to the collection of personal information through techno-fashion, the tricky question is, as with any form of dataveillance, which ratio of involuntarily to voluntarily provided information is acceptable to the wearer. The new surveillance enabled through techno-fashion is of social concern partly because of its ability to gather information secretly and involuntarily. Many wearers of wearable surveillance seem fine with a certain amount of involuntarily collection data, as long as the ratio stays constant or even moves toward an increase involuntarily provided information. The case of Byborre’s ‘BB. Suit 0.3’ demonstrates that the purpose and effects of (self-)surveillance are not necessarily negative or misleading in the sense of influencing, managing or regulating people or things. Wearable surveillance through techno-fashion, Borre
Akkersdijk shows, can also be used for the sake of pleasure, fun, playful interaction and self-expression. Wearable surveillance thrives on (initially) voluntarily collections of data, but it is hard to guarantee that it will remain voluntary under any condition as its purposes and applications may be ambiguous and shifting. “[T]here has never been more informed consent in our society and the amount seems to be increasing (...”), Marx notes, [y]et we must also ask just how “voluntary” such recording is” (Marx 2002: 22).

There is a risk that the power exerted by wearable surveillance practices becomes so ubiquitous, that its application becomes taken for granted and its consequences go un-noticed. It seems impossible to control the collection and accessibility of personal data at all times, because “[a]s data travel silently across international boundaries, between national states and within transnational corporations, the impact of surveillance becomes even harder to identify, regulate and debate” (Surveillance Studies Network). No matter how good and promising it potential may be, wearable surveillance is thus always at risk of having undesirable consequences. Wearable surveillance allows us to see ourselves as a machine, measurable in terms of productivity and efficiency. Techno-fashion, in particular, is well-suited to monitor signals ranging from biological functions to personal relationships. This can have far-reaching positive as well as damaging effects. Insurance companies, health care providers, employers, or banks, for example, might be sifting through the personal records of wearers, leading certain groups to obtain special treatment based whereas those deemed ‘less valuable’ fall by the wayside (Marx 2002: 22).

Following the postphenomenological premise of the non-neutrality of technology that runs throughout this dissertation, the key question is what wearable surveillance can do: what transformations does surveillance through techno-fashion bring and will they be a burden or blessing once they become part of our everyday lives? According to Van den Eede, it is important to recognize that self-tracking devices are brought to the market “with the deliberate aim of effectuating, exactly, transformations: they serve to change one’s behavior in such manner that one starts to live more healthily and efficiently” (2015: 149). The ‘BB. Suit 0.3’ may have changed Akkerdijk’s presentation skills for the better but, like many other wearable technologies, it also simplifies rich, lived experiences to stats and graphs. Just as the ‘BB. Suit 0.3’ teaches its wearer a certain way of presenting; other techno-fashion may (voluntarily or involuntarily) propagate a certain way of living: a perfection and efficiency aimed way of “living by numbers” (ibid.: 149). While embracing the many positive transformations that the phenomenon of wearable surveillance technologies may bring about in our lives, we should thus
remain critical and aware of the fact that it hides a technocratic idea of what a perfect human body and human life should be and presents that idea as a model to live up to (Verbeek, interviewed in Heijne 2015).

Conclusion
Understanding techno-fashion in terms of surveillance adds a critical perspective to the study of its embodied, material, and performative character. This chapter not only addressed how techno-fashion offers new ways of monitoring and controlling the body but also why this may have positive or negative implications on a broader societal level. Techno-fashion brings surveillance closer than ever before: as a prime instance of wearable technology, it by definition resides in close proximity to the body but also allows us to take surveillance into our own hands. With techno-fashion, we can track others and ourselves at any time and any place, which means that surveillance shifts from abstract systems of disciplinary organization toward embodied and everyday practices of control. Whereas the “overwhelming presence” of surveillance in contemporary western societies implies that the behavior and actions of people are already constantly monitored, wearable surveillance allows for direct and continuous tracking by gathering data on, about and from the perspective of the body (Mann, Nolan and Wellman 2003: 247). In the specific case of techno-fashion, moreover, there is the added possibility of monitoring larger parts or multiple signals of the body at the same time. This means that the details gathered are, by definition, highly personal, intimate, multisensorial, and embodied.

Surveillance through techno-fashion has a sinister side. “Even if the surveillance is designed not to control but to care and secure, the awareness that one is under scrutiny, or that one might potentially be under scrutiny, can change behaviors in unintended ways” (Bennett and Regan 2004: 453). Techno-fashion forces us to rethink the notion and meaning of surveillance, as the kind of monitoring and tracking it enables cannot adequately be captured with the analytical category of ‘surveillance’ (Haggerty and Ericson 2006: 21). Techno-fashion allows for a constant distribution and redistribution of powers, of multidirectional gazes, and of resistance. In that sense, it is fundamentally different from traditional types of institutional surveillance.

Techno-fashion turns surveillance towards the wearers themselves and thereby enables new forms of self-surveillance. It would, therefore, be misleading to represent the use of techno-fashion for surveillance purposes as simply oppressive, coercive or
in other ways limiting of individuals’ agency and freedom. The notion of control helps to explore the power relations involved in surveillance through techno-fashion. Yet techno-fashion can never fully be controlled because it mediates power relations in a non-neutral way and may always retain some of its material agency.

Surveillance, as exerted by techno-fashion, is diffuse, elusive, spread over many networks, operating not only from state agencies but also manifold non-government organizations and individuals such as the wearer herself and her friends and contacts. Power may also be viewed as productive, bringing certain kinds of subjectivities and embodiments into being. Individuals are not coerced into providing information or downloading tracking apps, which remind them to exercise, eat well or take their medications. They do so voluntarily and willingly in their efforts to improve their health or physical fitness, reduce their consumption of alcohol, give up smoking or lose weight. As part of presenting the self and disciplining and shaping one’s body, citizens adopt public health injunctions or warnings in their own best interests, to produce their ‘best selves’ (Lupton 2012b). Techno-fashion is the technological tool to counter surveillance technology; it helps you be aware of your body, to mind your body, to take care of yourself and others. In that sense, it is about control rather than surveillance, about being in control or having the power to decide who gets to be in control of your behavior and body.

While living in a society of control can feel incredibly liberating and empowering at times, it also comes with increased surveillance. Techno-fashion and wearable technology are freeing in that they provide us access to information, but they also exhibit new forms of control because they are always collecting data based on our actions and interactions with the technology. Unlike disciplinary societies, societies of control and the technologies embedded within them thus provide freedom in that we are more mobile, can work and communicate in more flexible ways, and have constant and direct access to a vast amount of services, data, and information. This means that those of us living in societies of control often find it difficult or even impossible to find a way to disentangle ourselves from professional and interpersonal communication. Deleuze’s analysis of societies of control cautions us that the freedom promised by such mobilities as techno-fashion are perhaps much less liberating than we may initially think or are led to believe.

To conclude, the new forms of surveillance offered by techno-fashion provide new capacities, embodied experience and subjectivities. In a dynamic and constantly shifting process, they configure and reconfigure assemblages of idealized entrepreneurial consumers who are amenable to the monitoring, surveillance and disciplining of their
bodies by way of individualized automated messages and the feedback and sharing of biometric data (Lupton 2012a). Techno-fashion, on the one hand, acts as a harness that shields, aids, helps, empowers, supports the wearer to be safer and healthier; more social and active; and, ultimately, to live a better life. On the other hand, self-monitoring techno-fashion may also threaten the health, privacy, social relations, and autonomy of the wearer. Wearable surveillance through techno-fashion is as much about empowering wearers to gain control over their bodies and lives, as it is about controlling and exerting power over them.
Conclusion

*Wearing Technology* anticipates that techno-fashion is no longer merely the sort of futuristic thing that one will only encounter in science fiction or superhero movies. A scenario in which we wear technology on a daily basis may still sound futuristic, but so did using a smartphone back in the nineties. The growing presence, success, variety, and popularity of techno-fashion indicate that its definite breakthrough is more feasible than ever. From the theatrical showpieces worn by celebrities and performers to the more mundane and functional designs intended for everyday use, techno-fashion offers a whole new array of possibilities, meanings, materials, applications, and functionalities for fashion and clothing. The case studies and examples featured in this dissertation demonstrate that the potential of techno-fashion is real. Although its current use is still relatively marginal compared to wearable technologies such as activity trackers and smartwatches, *Wearing Technology* values and presents techno-fashion as a worthwhile object of academic study. By exploring some of the main social and cultural dimensions of techno-fashion, this research foresees that these peculiar garments will become a mainstream part of the fashion and technology industry – and hence of our everyday lives – in the foreseeable future.

Previous studies of wearable technology and techno-fashion have predominantly addressed the technicalities and practicalities of its design and applications. My research attended to the broader social and cultural implications of integrating fashion and technology, considering the existence of techno-fashion in our contemporary and future society a given. Academic literature has so far concentrated on the basic conditions and possibilities for the design and application of techno-fashion but in order to understand what it entails and implies, I argued, it has to be thought through and researched beyond its infant stage as well. While I acknowledge the continuous relevance of studying how to make techno-fashion more seamless, successful, and wearable from a practical point of view, I believe it is important to also develop a theoretical basis for the in-depth and critical analysis of techno-fashion. Bridging the fields of cultural studies, fashion studies, and the philosophy of technology, this dissertation aimed to complement and advance scholarly studies of techno-fashion and to reflect on the emerging phenomenon of techno-fashion from a theoretical and critical meta-perspective.

Most literature on techno-fashion is characterized by a predominantly positive and advocative tone. Over the years, the research field has attributed many extraordinary
and even revolutionary possibilities to wearable technology, and techno-fashion in particular. It has been applauded for enhancing human sensory capacities; offering new expressive potential; transforming the materials and meaning of fashion; and improving our social interactions, health care, and lifestyles. Starting from the idea the issues is much more complicated, my research further explored and critically assessed these presumptions about the (positive) impact of techno-fashion. On the one hand, I showed that techno-fashion might indeed have profoundly positive implications for our culture and society. The case studies central to this dissertation indicate that techno-fashion is capable of instigating new experiences of body and self, extending our expressive and communicative abilities, transforming the embodied experience and materiality of fashion, and may even affect our relation to fashion and technology altogether. On the other hand, it became clear that the same capacities that allow techno-fashion to empower wearers and to monitor their bodies and actions are at risk of having undesirable long-term implications for our physical privacy, social relations, and autonomy.

Wearing Technology delves further into both the potential and problematics of techno-fashion, investigating its socio-cultural implications through four thematic perspectives that I distilled from the existing literature: (1) embodied experience, (2) materiality, (3) communication and self-expression, and (4) surveillance and biomonitoring. These four interrelated perspectives manifest how techno-fashion transforms fashion from the micro level of embodied experience and materiality to the macro levels of interpersonal communication and social control. Together, the four dimensions informed the set-up of my research as well as provided the key to answering my main research question:

How can we understand the ways in which techno-fashion materially mediates the relations between the human body, technology, and fashion?

The research question was informed by the hypothesis that techno-fashion mediates people’s relations to themselves and to the world in a material way. My first empirical findings indicated that techno-fashion strongly affects how people communicate and behave and influences the ways in which they relate to themselves as well as to others. It follows that the addition of technological materials to the otherwise relatively passive substance of fashion (e.g., textiles or synthetic fibers) can have far-reaching effects on our everyday lives. By acknowledging the importance of a better and deeper understanding of these material effects, my research aims to investigate how techno-fashion
transforms relations between the human body, technology, and fashion. To achieve this aim, I focused on four different case studies from the field of techno-fashion, each of which represents one of the thematic perspectives I formulated on the basis of my initial empirical findings and literature review:

1. Anouk Wipprecht’s robotic ‘Spider Dresses’ helped to explore the ways in which techno-fashion shapes and reshapes embodied experiences and fosters intimate relations between body and technology;
2. The goosebumps-imitating ‘AWE Goosebumps’ dress by Sensoree allowed for an in-depth analysis of the ways in which techno-fashion transforms and activates the materiality of fashion;
3. The illuminated ‘Phototrope’ running shirts designed by Pauline van Dongen served to gain insight into how techno-fashion affects processes of embodied communication and self-expression;
4. and Byborre’s ‘BB. Suit 0.3’ enabled me to investigate further how techno-fashion instigates new forms of surveillance and biomonitoring.

This conclusion will provide an overview of my findings and key arguments per chapter while addressing the interconnections between them. First, I will address the importance of concise terminology by explaining, defining and positioning techno-fashion in relation to the broader field of wearable technology. Based on my analysis of the four case studies, I will subsequently reflect on the theoretical and methodological approach to my research. Such meta-reflection allows me to highlight the main theoretical and methodological contributions of my research to the academic study of techno-fashion and offers a framework for further research on the phenomenon. Second, I will synthesize the two main arguments of this research by combining the insights gained from each chapter. Finally, this conclusion will offer an integrated answer to the central research question, allowing this dissertation to come full circle.

**Terminology and Theories**

The first step towards gaining a better understanding of techno-fashion is to get a better grip on what it and how it can be defined. Chapter one ‘Thinking Through Techno-Fashion’ therefore started by sketching the development and background of techno-fashion in relation to the broader field of wearable technology. Discussing the many different yet related terms currently in use to define the phenomenon of techno-fashion, I noted that this terminological confusion stands in the way of grasping
what it actually is. Attempts to define and consolidate the position of fashion in relation to the field of wearable technology, I noted, have so far led to a plethora of ambiguous neologisms ranging from techno-fashion (Quinn 2002), cybercouture (Quinn 2002; Smelik 2012, 2017), fashionable technology (Seymour 2009), and computational fashion (Amitai and Seymour eds. 2014); to smart clothing or smart textiles (Cho ed. 2010; Kettley 2016; Mattila 2006; Schneegass and Amft eds. 2017), e-textiles (De Rossi 2007), soft wearables (Tomico and Wilde 2015), and advanced textiles (O’Mahony 2011). In my view, this terminological overkill reflects serious confusion about how to define the integration of fashion and technology as well as signals the need for a better understanding of the consequences.

In the first chapter, I argued for a more consciously applied terminology that acknowledges and illuminates the connections between wearable technology and the realm of fashion. Defining techno-fashion as a group of technology-infused garments that combine the functionalities of technology with the aesthetic, expressive, critical and/or communicative role of fashion, I emphasized the importance of recognizing techno-fashion’s intimate relation to the body and the embodied practice of dressing (Entwistle 2015). The term techno-fashion, I explained, demarcates a more fashion-oriented subcategory of wearable technology that merges the domains of technology and fashion – both terminologically and practically. The concept of techno-fashion explicitly connects the practice of wearing technology to the material and immaterial practices of producing, consuming, distributing and representing fashion. Although the container term wearable technology is widespread and popular, it lacks a solid definition and coherent identity. I thus note the significance of complementing this blanket term with more specific terms that help to define and distinguish the different sub-categories of the still elusive phenomenon of wearable technology.

In the next section of chapter one, I presented a theoretical framework for studying techno-fashion by introducing the scholarly literature and concepts that form the basis of my research. Multiple scholars have anticipated that techno-fashion will have profound social and cultural effects, but often without providing the critical and theoretical tools to think them through systematically. As a result, our understanding of the impact of techno-fashion on a socio-cultural level is still limited. Proposing to use and combine the theoretical approaches of phenomenology, postphenomenology, and renewed materialisms, I noted that the socio-cultural effects of techno-fashion boil down to the way in which it mediates the embodied, material, communicative, and socio-political dimensions of fashion.
Phenomenology offers a valuable theoretical and methodological approach to techno-fashion because it emphasizes the spatial and physical situatedness of wearers, focuses on embodied experiences, and elucidates how techno-fashion can become the means through which wearers perceive the world. Postphenomenology helps to think through the ways in which techno-fashion not only changes and extends what the wearer experiences but also affects how that experience comes about. Renewed materialisms, finally, help to explore the material agency of techno-fashion, and to understand that its material mediations are characterized by the inextricable entanglement of matter and meaning, human and non-human, subject and object. I will critically reflect on the benefits of this combined theoretical framework further on in this conclusion, where I discuss the main results of my dissertation. Here I will first turn to the methodological approach and implications of my research.

A Methodological Adventure
The tripartite theoretical framework that I developed in this dissertation, also has its methodological implications for the study of techno-fashion. Joining the three theoretical perspectives central to this research together (e.g., phenomenology, postphenomenology, and renewed materialisms), I proposed a research methodology that focuses on embodied experience, materiality, subjectivity and socio-political power. Before any debate on the desirable or undesirable directions for the development and implementation of techno-fashion can take place, I argued, we will first have to assess what kind of experiences, material relations, forms of communication, and power relations it actually brings about. In order to do so, my research methodology combined a literature review with analyses of visual and textual representations, object-based analyses, and semi-structured in-depth interviews and fitting sessions. This mix of qualitative methods allowed me to collect rich data on experiences, material properties and interpretations of techno-fashion, which is key to gaining a better understanding of what it is and can do to or for the wearer and her environment.

Without research data based on actual encounters with and direct experiences of the phenomenon under investigation, the real and potential implications of wearing technology cannot fully be grasped. Inspired by the phenomenological attention to embodied human-object relations, and the postphenomenological approach that takes actual technologies and technological developments as a starting point for philosophical analysis, I started my research from the objects of techno-fashion. Visiting museums, public events and design studio’s, I directly observed and perceived the aesthetic and
material characteristics of the designed objects. Such an object-based approach offered me the possibility to assess and develop theories my direct experiences of seeing, touching, hearing and smelling actual techno-fashion designs. Unlike research methods based on visual or textual representations (e.g., the images, videos and texts that I also consulted for this research), it directed my attention towards the (new) material aspects and materiality of techno-fashion and invited sensorial as well as emotional engagement with the designed objects. In fact, such direct observations led me to include another qualitative research method: the semi-structured interviews that I conducted with both designers and wearers. As literature review and object-based analyses still give relatively little information on what it is really like to wear technology, I noted the importance of also employing research methods that generate data on people’s actual experiences of and interactions with techno-fashion.

Throughout the course of my Ph.D. research, I conducted a series of in-depth interviews with two (sometimes overlapping) kinds of respondents: wearers and designers. Asking wearers about their physical experience of specific techno-fashion designs I was able to gather data on what it feels like to wear technology; a dimension of techno-fashion that is still all too often overlooked in both research and design practice. Bringing the lived, experiential body to the fore, wearers personal descriptions of their encounters with specific designs provided valuable insight into the embodied experiences that techno-fashion evokes. For one of the selected case studies, Pauline van Dongen’s illuminated running shirt ‘Phototrope,’ I acquired data on wearer experiences by interviewing two respondents during what I called ‘fitting sessions’ (see chapter four). This new and experimental research method not only yielded real-time information about embodied experiences and interpretations of specific designs but also allowed me to talk to wearers in the flesh and directly compare their experiences of ‘Phototrope’ with those of other designs. In addition, I worked with the qualitative data that our research team had gathered during several tests with a running team in 2015.1 For the three remaining case studies, I collected data on first-hand wearer experiences by interviewing models in relation to case studies Anouk Wipprecht (chapter two) and Sensoree (chapter three), or by asking the designer about his experience of wearing his own design during a public lecture (case study Byborre, see chapter five).

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1 Within the context of the Crafting Wearables research project, designer Pauline van Dongen and research assistant Marina Toeters organized several user tests with Van Dongen’s illuminated run wear project ‘Phototrope’, including a test after a public nocturnal running competition and a series of tests during the weekly training sessions of a running team. The data gathered during these ‘Phototrope Test Sessions’ (2015) have been used for my case study analysis in Chapter four. A complete and detailed overview of these user tests can be found in the list of interviews in the appendix.
The best way to explore the actual – rather than just the anticipated – impact of techno-fashion is through gaining insight into the points of view, expressions and lived experiences of its (potential) wearers. Figuring out which research methods could grant me access to such data, however, has been quite an adventure. In hindsight, I must acknowledge that the different circumstances and contexts in which my data on wearer experiences were collected make it difficult to draw any general conclusions about what it is like to wear techno-fashion. But then again, embodied experiences and interpretations of garments are always inherently subjective and situated anyway. The flexible and qualitative character of the semi-structured interviews that I conducted allowed respondents to freely express their views, experiences, and thoughts in their own words. The research data that I collected on wearer experiences may therefore not be generic or complete but do offer a unique and insightful sneak peek into how techno-fashion materially mediates the relationship between the human body, technology, and fashion. My research findings, in other words, should be understood as explorative and indicative rather than representative.

In addition to collecting data on wearer experiences, I conducted a total of ten interviews with designers, including the designers of my case studies: Anouk Wipprecht, Kristin Neidlinger (aka Sensoree), Pauline van Dongen and Borre Akkersdijk (aka Byborre). The perspectives, visions, and experiences of these practitioners are a crucial source of information and knowledge for understanding how techno-fashion is conceptualized, designed and developed. Moreover, their insights and expertise facilitated a continuous dialogue between theory and practice, between abstract (philosophical) theory and the empirical matter of techno-fashion.

In sum, the research methodology for this dissertation combined theoretical reflection, empirical object-based research, and interviews in order to build up a coherent body of knowledge and rich descriptive data on the different actors (designers, wearers, objects, and representations) that constitute the phenomenon of techno-fashion. I developed a solid theoretical and methodological framework for further studies of techno-fashion and its socio-cultural implications. As I have experienced the benefits of a research practice that includes designer, wearer (body-in-context), object, and representations as valuable sources of information, I hope that the conceptual and critical tools provided in this dissertation will inspire further research and design practices in the field of techno-fashion. As I am aware that my own research data are based on a relatively small quantity of techno-fashion designers and designs, I would consider more longitudinal and large-scale testing of specific techno-fashion applications a particularly valuable direction for future research.
Embodied Interactions: Between Wearer and World

Throughout this dissertation I have used, fused and further developed two methodological and theoretical arguments for understanding techno-fashion in terms of (1) embodiment and (2) new materiality (see next section). The first argument concerned the extension of phenomenological and postphenomenological theory into the realm of wearable, rather than just instrumental, technological artifacts. Presenting the post-phenomenological notion of technological embodiment as vital for understanding the difference between using and wearing technology, chapter two illuminated how techno-fashion shapes and reshaped the embodied experience of dressing (Entwistle 2000, 2003, 2015) and fosters intimate relations between the body, fashion, and technology.

Using Anouk Wipprecht’s ‘Spider Dress 1.0’ and ‘Spider Dress 2.0’ as case study, I argued that techno-fashion is not just a bodily phenomenon but also an embodied phenomenon that influences our subjectivity and ways of being in the world. I employed the phenomenological insights of Maurice Merleau-Ponty (1945/2002) to analyze and emphasize how the already deeply embodied nature of clothing becomes even more present with the advent of techno-fashion. Moreover, phenomenology provided insight into the transformations that the integration of technology and fashion brings about in terms of human experience and perception. Techno-fashion extends the spatiality and perceptual range of the body; outlines, emphasizes, and enhances the body’s limits and perceptual capacities; and stimulates renewed, enriched and intensified connections between fashion and the body. This philosophical perspective informed the thematic set-up of my research as well as the decision to incorporate interviews into my research methodology.

Combining theoretical reflections on technological embodiment with insights gained from interviews with Wipprecht (Interview AW 2016) and one of her models (Interview WH 2017), I proposed to define and understand techno-fashion for its intimate and particular connection to the body. Studying techno-fashion requires attention to its embodied dimensions on both a theoretical and methodological level. My interviews with designer Anouk Wipprecht and the model that wore her ‘Spider Dress 2.0’, for example, demonstrated the importance of wearers’ physical and psychological experiences of techno-fashion. The real-life experiences of wearers, I stated, offer a valuable and indispensable source of information and inspiration. This argument for a theoretical and methodological focus on embodiment was further developed in the fourth chapter, where I analyzed Pauline van Dongen’s illuminated running shirt (named ‘Phototrope’) as an illustrative example of how techno-fashion allows wearers to communicate...
directly through, about, and on their body. Techno-fashion revitalizes and extends the communicative and performative roles of fashion, adding another layer to the already complex communicative and interpretative social dynamics of dress. Precisely because techno-fashion is worn on and by the body, I argued, it has the potential to radically alter as well as complicate the ways we ‘speak’ through and identify with what we wear.

Paying particular attention to the kind of human-technology relations techno-fashion introduces, postphenomenological thinking also helped me to elucidate how techno-fashion actively mediates and transforms the bodily-sensory experience of wearers. Chapter two revealed that the postphenomenological approaches of Don Ihde (1990, 1991, 2002, 2003b, 2009, 2010, 2015) and Peter-Paul Verbeek (2001, 2005a, 2006, 2011, 2015) offer the theoretical and conceptual tools to extend fashion studies into the realm of science and technology studies. From a postphenomenological perspective, clothing and fashion are inherently technological in the sense that they are integral to our embodied perception of the world. The notion of embodiment relations, in particular, can contribute to a better understanding of how and why fashion is generally incorporated into the wearer’s body schema and enabled me to highlight its inherent involvement with the socio-cultural role of fashion. Since wearing techno-fashion involves the embodied practice and act of dressing (Entwistle 2000, 2003, 2015; Negrin 2013, 2016; Ryan 2014) it not only has an impact on how the wearer perceives herself but also affects how she is perceived by others.

The postphenomenological notion of embodiment relations proved highly fruitful for understanding and analyzing the variability and context-dependency of human-technology relations (Rosenberger and Verbeek 2015; Ihde 1990). For techno-fashion to be embodied in ways that are both useful and interesting for the wearer it has to be designed on, and in perfect harmony with, the body. This means that both the functionality and aesthetics of the design should take the body and social visibility of the wearer into account. To both developers and potential consumers of techno-fashion, attention to this balance is pivotal in determining the added value or shortcomings of wearing, rather than merely using, technology.

The argument that techno-fashion acts as an extension or mediation of bodily perception was taken up again in chapter four, where I connected wearers’ embodied experiences of Pauline van Dongen’s illuminated running shirts to the social and interactive dimensions of wearing technology. Building upon the combination of postphenomenological and new materialist theory central to this dissertation, I focused on
the processes of communication and social interaction that techno-fashion allows for while maintaining an emphasis on the embodied and material dimensions of such processes. Understanding the impact of techno-fashion requires not only the in-depth analyses of what it ‘does’ on an embodied or a material level (see chapter two and three) but should also involve a thorough investigation of how people give meaning to these mediations (Verbeek 2015).

Furthermore, chapter four addressed how techno-fashion not only affects the wearer bodily-sensory experience but also constitutes her sense of self in relation to others, which I consider vital to understanding the impact and potential of entwining fashion and technology. The fitting sessions (Fitting 1&2, 2015) and series of tests with Van Dongen ‘Phototrope’ (‘Phototrope’ Test Sessions 2015) showed that techno-fashion actively expands the scope and nature of the messages and meanings that fashion and clothes convey, adding another layer to their already complex and paradoxical communicative function (cf. Flügel 1930). While wearing ‘Phototrope,’ for example, a wearer can be judged because of how the illuminated shirt is understood as a visual indicator of biological signals, emotions, or physical performance. Again, I noted, this has everything to do with techno-fashions inherently embodied nature. As techno-fashion is worn on the body, it will inevitably be read for clues about the wearer identity and traits.

The various meanings and interpretations that ‘Phototrope’ evoked among different wearers and in different public contexts, supported my argument that – due to the social and cultural visibility of the clothed body – experiences of techno-fashion are always socially and culturally situated. Techno-fashion allows garments to display more, ambiguous, intricate and often very intimate messages on the surface of the body, which implies that it can intentionally or unintentionally communicate something about the wearer’s personality, physical or emotional state, well-being, or mood. Such new form of communication on the body offer interesting opportunities for self-performance and self-expression. This also highlights the reason why celebrities and performers have been notably eager to wear techno-fashion: the eye-catching, shape-shifting and innovative outfits serve to express their distinctive artistic persona.

In chapter four, I used postphenomenology to further explain the connection between techno-fashion’s embodied nature and its particular potential for communication and self-expression. Techno-fashion ‘speaks’ visually, in the sense that its appearance will consciously or unconsciously be interpreted as ‘saying’ something about the wearer. In fact, if ‘speaking’ is defined as the ability to utter a word or message then it may even
be said that techno-fashion has or may be given a ‘voice’ (Ihde 2009). From a postphenomenological perspective, techno-fashion is capable of rendering normally imperceptible or unnoticed things (e.g., heart rate, air pollution or bad posture) perceptible. The robotic limbs of the ‘Spider Dresses’ signal the boundaries of personal space; the illuminated inflatable pockets in ‘AWE Goosebumps’ externalize the intimate sensation of goosebumps; ‘Phototrope’s’ flashing LED lights instruct the running team how to run; and the ‘BB Suit 0.3’ voices the normally hidden bodily signals of the wearer to the surroundings. It follows that each of the specific case studies in this research acts as a technological ‘voice’ that says something to or about the wearer and her environment. The postphenomenological idea that technology allows artifacts to ‘speak’ and gives them a ‘voice’ has also been vital to the second dominant thread in this dissertation: the issue of new materiality.

When Materiality Comes Back with a Vengeance

My second central argument started from the insight that techno-fashion involves a distinctly new generation of smart, interactive, self-organizing and responsive materials. Inspired by the ‘the material turn’ in the humanities and social sciences and the postphenomenological attention to the ways in which technologies materially mediate our lives, I repeatedly discussed the material dimensions of techno-fashion. Like my argument for acknowledging the embodied character of wearing technology, this second argument is both theoretical and methodological in scope. The active matter of techno-fashion not only requires new conceptual and theoretical tools for understanding such ‘material agency,’ I argued, but also necessitates the further development and updating of object-based research methods. Pointing out that the ‘new’ and ‘agentive’ materiality of techno-fashion necessitates a renewing of the theories and methods of materiality scholarship; my research extended the object-based approach from material culture research into the realm of renewed materialisms. I put forward that the new materials of techno-fashion ‘unmute’ the matter of fashion, in the sense that they are non-human agents that actively respond to and interfere with wearers and their environment (Barad 2007; Barrett and Bolt 2012; Dolphijn and Van der Tuin 2012).

Building upon the findings of chapter two in regards to the embodied dimensions and experiences of techno-fashion, chapter three explored the connection between the living matter (i.e. flesh) of the human body and the bold (i.e. ‘flashy’) materiality of techno-fashion. Taking the case of Sensoree’s ‘AWE Goosebumps’ as an example, I demonstrated how the new materials of techno-fashion seemingly equip garments with the
material capacity (or ‘agency’) to self-transform their shape and appearance. By applying a material culture approach to ‘AWE Goosebumps,’ I made clear that techno-fashion is a form of material culture in the sense that it concerns man-made objects that can be studied as reflecting the beliefs of those who create or consume them, as well as the larger society to which they belong. Considering the ways in which it lends new material qualities and capacities to fashion and impacts how garments are able to externalize and materialize certain characteristics of the wearer, however, techno-fashion also challenges existing concepts of material culture and necessitates rethinking materiality.

As my analysis of the case studies indicated, the material experience and effects of techno-fashion are always inherently relational: they involve the intimate relationship between the human body, fashion, and technology. A relational account of material culture allows us to explain why the materiality and meaning of a specific techno-fashion design are not just one and the same thing to everyone. My interview with model Whitney Heleker, for example, revealed that the attacking limbs of the ‘Spider Dress 2.0’ were experienced as attractive rather than threatening by the wearer’s environment. Similarly, the tests with Pauline van Dongen’s ‘Phototrope’ showed how different social situations (i.e., a public competition, an individual test run or a collective running training) led to divergent interpretations of the blinking LED lights. The material qualities and effects of techno-fashion thus change depending on the way in which the garment reveals itself to – and interacts with – different people and environments.

Within this dissertation, I have repeatedly discussed how the philosophical insights of postphenomenology and new materialism can complement each other in building a conceptual and theoretical framework for the study of techno-fashion. I postulated that their common interest in rethinking embodiment and materiality, attention to concepts such as the posthuman and performativity, and similar post-anthropocentric reflections indicate that there are plenty of reasons for them to join forces. My research demonstrates that a combination of postphenomenological and new materialist perspectives holds particular potential for studying the entanglement of animate and inanimate matter and conceptualizing the material properties of techno-fashion. Building bridges between these two approaches enabled me to emphasize the often-neglected role of materiality and technologies in the humanities and social sciences (Ihde 2009), show that the integration of technology turns fashion into animated and agential matter (St. Pierre, Jackson, and Mazzei 2016), and acknowledge the transformative force of techno-fashion (Dolphijn and Van der Tuin 2012).
Another central element of my argument for recognizing the new material qualities and force of techno-fashion revolves around the notion of mediation, and material mediation in particular. In the case of ‘Phototrope’ (see chapter four), for example, it became clear that several material entities and circumstances co-shape and mediate the communication through techno-fashion – including technological ‘mediators’ such as the software, smartphone app and LED technology. In the case of techno-fashion, communication no longer merely refers to the transmitting of information from sender to receiver, it now ‘sticks’ to the body, where it acts as a mediator between the wearer and her surroundings (Calefato 2003). Similarly, my analysis of Byborre’s ‘BB Suit 0.3’ in chapter five revealed that techno-fashion exerts control over the wearer because it mediates power relations in a non-neutral, material and active way.

Further exploring the connections between postphenomenological and new materialist conceptions of matter and subjectivity, this dissertation took a first step towards developing ‘a new materialist phenomenology’ for the study of techno-fashion. In chapter four, I specifically applied such a combined framework to the issue of communication through techno-fashion, arguing for understanding techno-fashion as a performative and posthuman phenomenon that involves both human and non-human matter. Seeing techno-fashion as an abstract system of signification and representation is useful for illuminating its communicative potential but cannot do without recognition of its more intimate and material impact on the wearer’s subjectivity. The concept of performativity points to how techno-fashion, because of its material and embodied character, co-constitutes and expresses the wearer’s subjectivity in relation to others. Techno-fashion can never be considered separately from the body and, hence, mediates meanings in ambiguous and performative (i.e., embodied, material, and socially situated) ways. I went on to connect the performative role of techno-fashion to the issue of posthuman subjectivity, arguing that techno-fashion has powerful and material effects on how human subjectivity is constructed and experienced. The agentive materiality of techno-fashion co-shaped the wearer’s sense of self, as well informs other people’s perceptions of the wearer’s subjectivity. Techno-fashion, in other words, has a powerful impact on wearers because it acts both as an immaterial carrier of meaning (i.e., involving signs and symbols) and as a material thing (i.e., involving bodily, technological and textile matter).

Finally, I used the combined framework of new materialisms and postphenomenology to discuss how different material entities (e.g., fashion, body, and technology) entwine in the cultural practice of wearing technology and jointly become the medium for socio-political control. These more political and ethical considerations were central to
chapter five, in which I connected the experiential, material, and social levels on which techno-fashion operates to the broader socio-political issues of power, safety, and control. Focusing on the example of the biomonitoring ‘BB. Suit 0.3’ developed by Byborre, I stated that techno-fashion literally brings surveillance closer than ever before. Similar to how techno-fashion’s agentive materiality and close proximity to the body allow for it to have particularly positive and/or negative effects on how we perceive and communicate with the world around us, it can also have positive and/or negative consequences for the ways in which we care for and control ourselves and our environment. More importantly, such deeply positive and/or negative implications also count for the ways in which others may think of, care for, and control us.

The fifth and final chapter of this dissertation, therefore, investigated how techno-fashion instigates new ways of controlling and surveilling the body. The chapter explored how surveillance takes shape against the background of the embodied experience, material conditions, and communicative processes of techno-fashion. Techno-fashion literally brings surveillance closer than ever before, not only because of its close proximity to the body but also because it allows individuals to take surveillance into our own hands. With techno-fashion, we can track others and ourselves at any time and any place, which means that surveillance shifts from abstract systems of disciplinary organization toward embodied and everyday practices of control. Whereas the “overwhelming presence” of surveillance in contemporary western societies implies that the behavior and actions of people are already constantly monitored, wearable surveillance allows for direct and continuous tracking by gathering data on, about and from the perspective of the body (Mann, Nolan and Wellman 2003: 247). In the specific case of techno-fashion, moreover, there is the added possibility of monitoring larger parts or multiple signals of the body at the same time. This means that the details gathered are, by definition, highly personal, intimate, multisensorial, and embodied.

Surveillance through techno-fashion has both a sunny and a sinister side. Techno-fashion prompts a rethinking of the notion and meaning of surveillance, as it allows for a constant distribution and redistribution of powers, of multidirectional gazes, and of resistance. Moreover, it turns surveillance towards the wearer or user herself and thereby enables new forms of self-surveillance. It would be misleading to represent the use of techno-fashion for surveillance purposes as simply oppressive, coercive or in other ways limiting of individuals’ agency and freedom. The power relations implicit in surveillance through techno-fashion are not necessarily coercive or repressive. Indeed, my analysis of Byborre’s ‘BB. Suit 0.3’ indicated that wearing techno-fashion may also
facilitate positive, harmless and enriching experiences of wearable surveillance as long as the tracking and sharing of data is voluntary and controllable by the wearer. Wearing techno-fashion can be positive, fun and liberating in that it provides a tool for self-awareness, self-care, and self-reflection. The wearable forms of surveillance offered by techno-fashion provide new ways of understanding and experiencing our bodies and subjectivities. By providing wearers with more and real-time information about themselves and their environments, techno-fashion allows garments to protect, empower, aid and support wearers better than ever before. Yet it is important to recognize and anticipate how the agentive and embodied matter of techno-fashion may also compromise the health, privacy, social relations, and agency of the wearer. The possibility to switch off and control how, when, where, and what techno-fashion surveils, is a prerequisite for realizing its promising and desirable socio-political effects.

**Wearing Technology**

Embodied experience and new materiality are the two central threads in my research and argumentation. Precisely because techno-fashion has the potential to become such a powerful embodied and material actor in our everyday lives and society, we should continue to follow and study this emerging phenomenon. This dissertation has shown that there is plenty of reason to embrace the wonderful possibilities of techno-fashion, as long as this fascination is accompanied by critical analyses of its further development and implementation. Central to this research is the question how to understand the ways in which techno-fashion materially mediates the relations between the human body, technology, and fashion. After exploring the embodied, material, performative and broader socio-political dimensions of techno-fashion, I can conclude that the act of wearing technology has the potential to transform these relations in ways unimagined before radically. Techno-fashion shapes new experiences of body and self, transforms and ‘activates’ the material capacities of fashion, changes our ways of communicating to and with others, and may even have an impact on our sense of freedom and autonomy.

This conclusion is based on my analysis of each of the case studies in this dissertation. The case study ‘Spider Dress 1.0’ and ‘Spider Dress 2.0’ by Anouk Wipprecht revealed that techno-fashion reinforces and complicates the inherently embodied relation between fashion and the human body. Its robotic limbs demarcate and extend the boundaries of the human body, alerting both the wearer and her surroundings of the issue of personal space. The inflatable silicones in Sensoree’s ‘AWE Goosebumps’ externalize and amplify the wearer’s physical sensation of goosebumps, illuminating how
the integration of technology renders new material qualities and powers to the formerly ‘mute’ stuff of fashion. Pauline van Dongen’s illuminated runwear project ‘Phototrope’ showed that techno-fashion could enrich and rematerialize processes of communication, social interaction and self-expression through fashion; affecting the social and cultural visibility of the wearer in both literal and metaphorical sense. The bio-sensing ‘BB. Suit 0.3’ developed by Byborre, finally, demonstrated the embodied, new material and wearable forms of control and surveillance that techno-fashion allows for. The act of wearing technology on the surface of the body thus implies that it becomes one with the embodied, material, and the meaningful phenomenon of fashion.

Through a combination of new materialist and postphenomenological ways of thinking I have illuminated that the materiality and material properties of techno-fashion are crucial to the way in which they are used and experienced. The meanings and interpretations that techno-fashion evokes vary from situation to situation, but their kind and range are always connected to the embodied, material and technological specificities of the garment. The ‘animate’ character of its materials allows techno-fashion to become our companion, rather than the mere instrument or servant of our anthropocentric lives. Its new material qualities and powers not only allow us to perceive, monitor, control, and do better; but also invite critical reflection on our relation to fashion and technology and the desirable or undesirable directions that this relation may take.

A combined framework of postphenomenological and new materialist theory holds great potential for studying these new relations between the human body, fashion, and technology. But for that potential to become fully realized more research will have to be done. The steadily increasing number of designers, institutes, events, and companies jumping on the bandwagon of techno-fashion, signals that this emerging phenomenon is here to stay. It is about time to recognize techno-fashion for both its positive and problematic potential before we wake up in a world where fashion and technology have become irrevocably entwined.


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Appendix

List of Interviews

Designers
3. Aduen Darriba (not included in the dissertation), Café Broodnodiq, Utrecht, 20 February 2015.
5. Pauline van Dongen (Interview PvD 2015), Artist’s Studio, Arnhem, 31 March 2015.
7. Despina Papadopoulous / Principled Design (not included in the dissertation), Artist’s Studio, New York, 17 December 2015.

Wearers

<table>
<thead>
<tr>
<th>Wearer, Fitting</th>
<th>Description</th>
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‘Phototrope’ Test Sessions 2015 (data used for case study in Chapter four)
Conducted by: Marina Toeters and Pauline van Dongen

<table>
<thead>
<tr>
<th>Wearer, Test Run</th>
<th>Description</th>
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<tbody>
<tr>
<td>3</td>
<td>Questionnaire (n=1) after test run while wearing ‘Phototrope’ by designer Pauline van Dongen, Nijmegen, 24 April 2015.</td>
</tr>
<tr>
<td>4-8, Nike Run</td>
<td>Questionnaires (n=5) after running the Nike ‘We Own the Night’ Women’s Run while wearing ‘Phototrope’ by designer Pauline van Dongen, Amsterdam, 15 May 2015.</td>
</tr>
<tr>
<td>9-20, Training 1</td>
<td>Questionnaires (n=12) after running a team training in public space while wearing ‘Phototrope’ by designer Pauline van Dongen, 15 May 2015, Utrecht, 4 November 2015.</td>
</tr>
<tr>
<td>9-11, Training 2</td>
<td>Questionnaires (n=3) after running a team training in public space while wearing ‘Phototrope’ by designer Pauline van Dongen, 15 May 2015, Utrecht, 12 November 2015.</td>
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<tr>
<td>9-17, Training 4</td>
<td>Questionnaires (n=9) after running a team training in public space while wearing ‘Phototrope’ by designer Pauline van Dongen, 15 May 2015, Utrecht, 27 November 2015.</td>
</tr>
<tr>
<td>9-15, Training 5</td>
<td>Questionnaires (n=7) after running a team training in public space while wearing ‘Phototrope’ by designer Pauline van Dongen, 15 May 2015, Utrecht, 3 December 2015.</td>
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</tbody>
</table>
Topic List Semi-Structured In-depth Interviews (Designers)

About the respondent and his/her background
- What is your professional background?
- When and how did your interest in the integration fashion and technology start?
- How do you describe your work / field of expertise?
  Why do you use those descriptions for your work / field of expertise?
- **Artistic practice:** What kind of (wearable tech in particular) projects have you worked on in the past? Which ones are you most proud of and why? Which ones would you like to develop further? What are your current activities and how much time of them goes into the development of wearable technologies and e-textiles? How long do projects run and is there a clear end result or mostly concern work in progress and prototypes? Would you like to change that? Where and how do you present your work and to who?

About techno-fashion/wearable technology in general
- **Definitions and labels:** How do you term your work and the field you work in? What kind of garments and designs do you include in the field? Could you subdivide the field into different strands or segments? To what extent do you care about the idea of a field or discipline that you work in: is it relevant/important? How do you tend to label your work/projects?
- **Peers and role models:** What developments in the field particularly interest you as a designer / expert? Who are important examples in your own practice as a designer? Do you collaborate with others a lot? Who do you work with on a regular basis and why?
- **Community and belonging:** Do you feel you belong to a community of designers and experts? How would you describe your relation with the field? Where and how often do you meet others that do similar work? Do you identify with the work that you do and the field that you work in?
- When you look at how the field has developed, what do you think are the potentials and pitfalls? What are the biggest problems and possibilities you see for WT?
- **Target group:** Generally speaking, do you think there is a specific target group for WT? If so how would you characterize or describe this group? What kind of people could you see wearing this? Do you yourself keep a certain target group in mind when designing?
- **Ethics:** ethical issues: sustainability, gender, privacy and surveillance, control?
Properties of the artifacts (refer to specific projects/designs)

- **Characteristics:** What are the main characteristics of your work (characterize in a few words)? Do these characteristics correspond with what you want them to be?
- **Goals:** Do you have any specific goals as a designer? Design intentions and principles?
- **How would you compare your work** to other designers in the field? What differentiates your work from the work of other designers? How do you distinguish your work from that of others?
- **Function and communication:** If you look at your own designs: what do they mainly express or communicate? What is their function? What do you think they can and should be able to do? What kind of terms do you use to describe and explain them? What do you think or hope your designs communicate and how do you communicate about them?
- **Personal Expression:** What kind of expressions does it allow for? What does it express or help to express and how? Do you think that wearing clothes in general, and specifically wearing these technological garments, allows you to express yourself? How does it differ from normal clothes? What do you express? To what extent does it affect what you express? What do you want to express as a designer? If you look at other’s designs in the field: what do they in general tend to express?

- **Identity & expression:** Do you think that wearing this says something about you? Does it say something about who you are? What does WT allow the wearer to say about him or herself? What kind of communication does it allow for?
- **Aesthetics:** How about the look and aesthetics of the designs: does working with technology lead to a certain form or shape? Does the technology change how you work with textiles? Does fashion change how you work with technology? Are the garments clearly and visibly technological? If so, why/how and do you consider that important? How obvious to you want the technological element to be? How do you integrate textiles with the technology? What are the main challenges?
- **Materials and technologies:** What kind of materials do you work with and why? What kind of technologies? What are the most interesting or important technologies to work with? How would you describe your toolbox: i.e. what do you work with and how do you work? What does your workspace look like? How do materiality and aesthetics relate?
Embodied Experience (questions for designers)

- How do you as a designer (physically) experience the making of WT? When designing WT how does that make you feel? What kind of physical and tacit skills does it require from you? How is it different from making/designing fashion or garments without integrated technology?
- How do you work? Is there a specific order to the way in which you develop a project? What steps to you have to take and what is the end result? Iterative and prototypes?
- Are there certain techniques or crafts you need and had to acquire? Skills and Practice/Techniques involved + where did you learn them?
- What kind of interaction do you want to establish between wearer and garment, if any at all? Have you been successful in doing so? How do wearers/people interact with your work?
- What kind of experience do you want your designs to evoke? What is the role of the body or the senses in that experience? Do you succeed in bringing these experiences about with your designs?
- How important is it for you that your designs will be worn? Have you ever worn them yourself? Do you ever involve actual users/wearers in your design practice? Do you often test the designs with wearers/users?
  - If not, why?
  - If yes, when/how do they react?
- What are the reactions and experiences of people that have come across or even worn your designs?

Future of the field/your practice

- Cultural acceptance: do you think it will become ‘normal’ and accepted to wear this? Do you see it applied more widely? Is that something you hope for with your own work?
- What it should/should NOT become
- In your wildest dreams: what will it be in the future?
- What are your thoughts on the idea of a revolution and a nearing breakthrough for the field of wearables?

Final

- What would you like to get from this research? Any questions you would like to see answered?
- Is there anything you wish to add/emphasize?
- Is there anything you do not want me to include?
- Who else do you think I should talk to?
• What are your plans for the near and the distant future? What are you currently working on?

**Topic List Semi-Structured In-depth Interviews (Wearers)**

**Description of the garment**
- What is your first impression of the garment?
- How would you describe this garment in terms of shape, style, color, aesthetics, and design?
- What materials do you think it is made of?
- What kind of technologies do you think have been integrated into this design? Can you see or feel them?
- Do you know or could you guess what the function of this garment is?
- For you do you think this garment has been designed? Why?

**Wearing experience**
- How does the garments feel, sound, smell, look?
- What is it like to wear this design? Does it evoke a specific kind of feeling to wear this design?
- Based on your physical experience of the garment, how would you describe its material properties such as weight, texture, and flexibility?
- Do you notice where the integrated technology is located? If yes, do you find it obtrusive?
- Do you notice what the integrated technology does?
- Can you mention specific sensations that the garment evokes? Is that a positive, neutral or negative aspect of your experience?
- How do you interpret the behavior of the garment? What do you think the garment’s output (sound, color, movement, light) means?
- Does wearing X affect the way in which you move, position yourself, or behave in the particular setting? If so, in which ways?
- Does wearing X affect the way in which you experience your environment? If so, how/why?
- Does wearing X affect the way in which you relate to the people around you? If so, how/why?
- Are there certain actions or movements that the garment stimulates, restricts, or prevents?
- Does the garment affect how you experience your body? Does it affect the way you think about yourself? If so, in what ways?
Context of wearing

- When would/did you wear the garment? Could you think of situations where you would or would not want to wear this design?
- Does wearing X affect the way in which you feel, behave, or present yourself in relation to others? If so, in which ways?
- Do you identify yourself with the look and feel of this garment? Why (not)?
- Do you feel you attract more or less attention with these garments? If so, how did you notice this?
- Do you think or experience that wearing this garment affects the way others perceive you? If so, in what ways?
- How do others respond to you while you wear this design? How do you expect others will respond when you wear this design? How does/would that make you feel?
- How do you think others interpret the behavior of the garment? What does this garment tell about you?
- Do you feel this garment expresses or communicates something? What do you think it expresses/communicates?

Acceptance and criteria

- Do you think there is a difference between wearing this design and wearing clothing without technologies? If yes, what is the difference? If no, would you prefer there to be a difference?
- Would you want to wear this garment in certain occasions yourself, or even in daily life? If yes, during what occasions or in what context could you see yourself wearing it? If no, why not?
- Would you buy this if it were for sale? Would you be interested in buying this design?
  - If yes, on what conditions? How much would you be willing to pay? What kind of design would you like it to have? Where would you like to prefer/expect to buy it?
  - If not, why not? What would have to happen or change in order for you to be interested in wearing/buying it?

Conclusion

- In your wildest dreams, what kind of functionality or look would you like the garments of the future to have?
- Is there anything you wish to add/emphasize?
- Is there anything you do not want me to include in the research?
- Do you think garments like this are the future of fashion? Why (not)?
Images

5. Anouk Wipprecht and Daniel Schatzmayer, ‘Spider Dress 1.0’ (2012), Photography by Mojmir Bures © Anouk Wipprecht
12. Image courtesy of Beecham Research Ltd. www.beechamresearch.com. All rights reserved.
27. Anouk Wipprecht and Daniel Schatzmayr, ‘Spider Dress 1.0’ (2012), Photography by Anna Cervinkova © Anouk Wipprecht
30. By-wire.net x CRISP, ‘Spine Dress’ (2011/15) Photography by Wetzer & Berends (Studio Huid & Haar) In collaboration with Lantor, Ralf Jacobs and Contrechoc © Wetzer & Berends
35. Byborre, ‘BB Suit 0.2’ (2014) in collaboration with Martijn ten Bohmer (TU/e), Eva de Laat, dspbrg, StudioFriso and WANT. Infographic by Daan Spangenberg. @byborre. www.byborre.com
43. YesYesNo, 'Google Talking Shoe V1.0' (2013)
44. CuteCircuit, Nicole Scherzinger wearing CuteCircuit’s ‘Twitter Dress’ to the EE 4G launch event (2012) © CuteCircuit
46. MOONDIAL, ‘VIEW N°2’ (2008/10) © Moondial. All Rights Reserved
47. Studio Roosegaarde, ‘Intimacy 2.0’ (2011/12) Daan Roosegaarde with the team of Studio Roosegaarde and invited designer Anouk Wipprecht. © Studio Roosegaarde. All Rights Reserved
51. Byborre x CWI, ‘BB.Suit 0.3’ (2015) Graphics: Daan Spangenberg and Lilia Pérez. @byborre, byborre.com
52. Pauline van Dongen, "Vigour" (2015). In collaboration with Martijn ten Bhömer (Eindhoven University of Technology) and Textile Museum Tilburg. Photography by JR Hammond.

53. CuteCircuit, "The Hug Shirt" © CuteCircuit

54. Byborre x CWI, "BB Suit 0.3" (2015) Graphics: Daan Spangenberg and Lilia Pérez. @byborre, byborre.com


56. Emovere, the ‘Exmobaby’


60. Byborre, 'BB.Suit 0.1' (2014) Borre Akkersdijk, In collaboration with Martijn ten Bhömer (TU/e), Eva de Laat, dspbrg, StudioFriso and WANT @byborre, byborre.com

61. Byborre x CWI, 'BB.Suit 0.3' (2015) Graphics: Daan Spangenberg and Lilia Pérez. @byborre, byborre.com


63. Byborre x CWI, ‘BB.Suit 0.3’ (2015) Graphics: Daan Spangenberg and Lilia Pérez. @byborre, byborre.com

Wearing Technology focuses on the emerging phenomenon of techno-fashion: garments that fuse technological functionalities with the aesthetic, expressive, critical, and communicative roles of fashion. Such entwinement of fashion and technology no longer exclusively belongs to a fantasy world but has become the driving force behind a wave of innovations in the field of fashion. Flexible solar cells that turn a coat into a sustainable battery charger, a jacket that warns against air pollution, a shirt that sends hugs over distance, or trousers that help to correct your posture; they now all exist in real life. Scholars and market forecasts agree that this specific subfield of wearable technology is likely to affect our lives on a personal as well as societal level. Yet while the long-term effects of merging technology and fashion are expected to change our relation to ourselves and others, there is little academic research that critically explores how and why this relatively new cultural phenomenon could have such a powerful impact.

This dissertation aims to complement and advance scholarly studies of techno-fashion by bridging the fields of cultural studies, fashion studies, and the philosophy of technology. It combines cultural-critical, philosophical, and sociological perspectives, theorizing and evaluating some of the broader socio-cultural implications of techno-fashion. The research addresses the question how to understand the ways in which techno-fashion materially mediates the relations between the human body, technology, and fashion by using four specific designs as case studies. This central research question is informed by the hypothesis that techno-fashion mediates people’s relations to themselves and to the world in a material way. Wearing Technology acknowledges the importance of gaining a better and deeper understanding of these material effects, combining insights taken from postphenomenological and new-materialist theory with qualitative research methods including in-depth interviews with designers and wearers, object analyses, and analyses of media representations.

The focus on how techno-fashion transforms connections between body, technology and fashion within this dissertation is grounded in empirical explorations of the field as well as in the existing literature on the topic. Inspired by these sources, the research offers four thematic perspectives from which the effects of techno-fashion can be investigated, namely embodied experience, new materiality, communication and self-expression, and surveillance and biomonitoring. Each of these themes informs one of the sub-aims of this dissertation: (1) to understand the ways in which techno-fashion...
shapes and reshapes embodied experiences and fosters intimate relations between body and technology; (2) to explore how techno-fashion transforms and activates the matter of fashion; (3) to gain insight into how techno-fashion affects processes of embodied communication, social interaction and self-presentation through fashion; and (4) to investigate how techno-fashion instigates new ways of controlling and monitoring the body. Each of the four sub-aims is achieved through the analyses of four respective case studies.

Techno-fashion, first of all, thrives on and intensifies the relation between the human body, technology and fashion. When we wear technology on our body it becomes integrated into our deeply embodied and sensorial experience of fashion. Anouk Wipprecht’s robotic ‘Spider Dress 1.0’ and ‘Spider Dress 2.0’ served as the first case study that shows how technologically enhanced garments may invite, emphasize and extend our bodily perceptions, actions and interactions, while limiting and obscuring others. These garments can subtly or radically transform how wearers perceive themselves and the world around them because of how they mediate between the wearer’s body and the world. Moreover, techno-fashion concerns an enriched and multidirectional form of technological mediation: it not only mediates what and how the wearer experiences, but also transforms how others perceive the wearer. When we wear — rather than just carry or use technology — the process of technological mediation thus becomes imbued with ‘fashion aspects’ such as social visibility, appearance, and self-expression.

Secondly, techno-fashion invites a rethinking and reconceptualization of the matter of fashion by opening up a whole new array of materials and material properties. Sensoree’s responsive ‘AWE Goosebumps’ dress exemplifies how such new materials lend garments a fleshy and flashy character, investing the passive and mute matter of fashion with active and agentic qualities. The integration of technological materials allows garments to mimic and externalize the appearance or behavior of living organisms (including human bodies), challenging the dichotomous distinction between inanimate and animate matter. Studying this new materiality is vital to understanding the powerful ways in which techno-fashion can affect the relations between the wearer, the garment, and the environment.

The third insight brought forth by my PhD research, concerns the implications of integrating technology for processes of embodied communication, social interaction and self-presentation through fashion. Techno-fashion revitalizes and extends fashion’s mediating, communicative, and performative roles. With techno-fashion, the toolkit for
self-expression through garments significantly expands. The illuminated running wear project ‘Phototrope’ by Pauline van Dongen shows that techno-fashion allows us to share more, different, intricate, and highly personal information through our clothes. Through output in the form of text, light, colour, movement, or sound, techno-fashion can express something about the wearer’s personality, physical or psychological well-being, sports performance, or mood. This adds another, more intimate, layer to the already complex systems of communication and interaction at work in fashion. Techno-fashion can act like a wearable communication platform, a dynamic material surface around the body that interconnects people and their environment in unprecedented ways.

Finally, the dissertation investigates how techno-fashion instigates new ways of controlling and monitoring the body. Wearer experiences of Byborre’s biomonitoring ‘BB. Suit 0.3’ point out that techno-fashion offers a wearable type of surveillance that can be experimental, exciting, and fun but also has its sinister sides. On the one hand, techno-fashion can function like a harness that protects, helps, and stimulate the wearer in living a better – i.e. safer, healthier, more productive, happier – life. Sensing technology, in particular, allows wearers to monitor, empower, enhance, and care for their bodies in more conscious and effective ways. On the other hand, wearable forms of surveillance and self-tracking are also at risk of compromising the well-being, privacy, and autonomy of the wearer. The possibility to track, quantify, share, and commodify all kinds of information about our own health, body, environment, and emotional state may give us a sense of power and self-control. Yet while enjoying and playfully experimenting with the potential of techno-fashion, it is important to also critically assess the social and ethical issues at stake.

Techno-fashion, in conclusion, materially mediates the relations between the human body, technology, and fashion by thriving on and strengthening their interconnections. A combination of postphenomenological and new-materialist theories helps understand that techno-fashion so powerfully transforms wearers’ relations to themselves and to the world around them, precisely because of its embodied and material character. Wearing technology means to blur the boundaries between who we are, what we wear, and the technological world we inhabit.
Samenvatting

Wearing Technology richt zich op het opkomende fenomeen van de techno-mode: kleding die technologische functionaliteit verenigt met de esthetische, expressieve, kritische en communicatieve rol van mode. De versmelting van mode en technologie is niet langer een futuristische fantasie, maar de drijvende kracht achter een golf van innovatie in de mode- en technologiewereld. Een jurk met flexibele zonnecellen, een jas die luchtvervuiling signaleert, een shirt waarmee je iemand op afstand kunt knuffelen, of een yogabroek die je houding corrigeert: het zijn allemaal voorbeelden van reeds ontworpen en bestaande techno-mode. Wetenschappers en marktonderzoekers voorzien dat deze subcategorie van de zogenaamde ‘draagbare technologie’ ons leven op zowel persoonlijk als maatschappelijk niveau drastisch gaat veranderen. Ondanks dat techno-mode naar verwachting onze relatie tot onszelf en onze omgeving zal gaan beïnvloeden, is er echter weinig wetenschappelijk onderzoek gedaan naar hoe en waarom dit nieuwe culturele fenomeen zo veel impact kan hebben.

Doel van dit proefschrift is om wetenschappelijk onderzoek naar techno-mode aan te vullen en vooruit te helpen door een brug te slaan tussen de cultuurwetenschappen, modestudies en de techniekfilosofie. Het combineert cultuurwetenschappelijke, filosofische en sociologische inzichten om de bredere sociaal-culturele implicaties van techno-mode te kunnen theoretiseren en doordenken. Centraal in het onderzoek staat de vraag hoe de manier waarop techno-mode relaties tussen het menselijke lichaam, technologie en mode medieert, begrepen kan worden. Vier specifieke ontwerpen dienen als casusstudies waarmee de hypothese dat techno-mode de relaties tussen lichaam, mode en omgeving op materiële wijze medieert, tegen het licht gehouden wordt. Wearing Technology erkent dat het van belang is om de materiële effecten van techno-mode beter te doordoen en begrijpen. Het onderzoek verenigt daarom theoretische benaderingen uit de postfenomenologie en het nieuw materialisme met kwalitatieve onderzoeksmethoden, inclusief interviews met ontwerpers en dragers, object analyses en analyses van media representaties.

De nadrukkelijke aandacht binnen het proefschrift voor hoe techno-mode de connectie tussen lichaam, technologie en mode transformeert, is ingegeven door empirische observaties in het veld en de bestaande literatuur over het onderwerp. Geïnspireerd door deze bronnen biedt het onderzoek vier thematische perspectieven van waaruit de effecten van techno-mode onderzocht kunnen worden, namelijk belichaamde
ervaring, nieuwe materialiteit, communicatie en zelfexpressie, en surveillance. Deze thema's liggen elk ten grondslag aan één van de subdoelen van het proefschrift: (1) begrijpen hoe techno-mode belichaamde ervaringen (her)vormt en de intieme relatie tussen lichaam en technologie versterkt; (2) verkennen op welke manieren techno-mode de materialiteit van mode transformeert en activeert; (3) inzicht verkrijgen in hoe techno-mode communicatieprocessen, sociale interactie en zelfpresentatie door midden van mode beïnvloedt; en (4) onderzoeken hoe techno-mode het lichaam op nieuwe manieren controleert en monitorert. Deze vier subdoelen zijn gekoppeld aan de vier respectievelijke casusstudies die in het onderzoek centraal staan.

Ten eerste gedijt techno-mode op de relatie tussen het menselijke lichaam, technologie en mode doordat het die relatie nog intiemer maakt: wanneer we technologie dragen gaat het onderdeel uitmaken van de belichaamde en sensorische ervaring van mode. De robotische 'Spider Dress 1.0' en 'Spider Dress 2.0' van Anouk Wipprecht dienen als de eerste casusstudie in het onderzoek. Het werk van Wipprecht maakt duidelijk hoe met technologie uitgeruste kleding ons waarnemingsvermogen enerzijds kan prikkelen, benadrukken en uitbreiden, maar anderzijds ook kan beperken en verwarren. Doordat deze kledingstukken mediëren tussen dragers en de wereld kunnen ze op subtiele of zelfs radicale wijze veranderen hoe dragers hun eigen lichaam en de wereld om hen heen ervaren. Bovendien verrijkt en verveelvoudigt techno-mode de mogelijkheden van technologische mediatie: het medieert niet alleen wat en hoe de drager de wereld ervaart, maar andersom ook hoe anderen de drager waarnemen. Wanneer we technologie op ons lichaam in plaats van slechts met ons mee gaan dragen, raakt technologische mediatie dus verweven met 'modieuze' aspecten zoals sociale zichtbaarheid, identiteit en zelfexpressie.

van de nieuwe materialiteit van de techno-mode is daarom essentieel om te begrijpen hoeveel impact het kan hebben op de relatie tussen drager, kledingstuk en omgeving. Het derde inzicht dat mijn promotieonderzoek voortgebracht heeft betreft de mogelijkheden en problemen die techno-mode met zich meebrengt op het gebied van belichaamde communicatie, sociale interactie en zelfexpressie. Door technologie in kleding te verwerken wordt de mediërende, communicatieve en performatieve rol van mode nieuw leven in geblazen. Met de komst van de techno-mode worden de manieren waarop je uitleg kunt geven door middel van kleding eindeloos uitgebreid. ‘Phototrope’, de verlichte hardloopkleding ontworpen door Pauline van Dongen, laat zien dat techno-mode het mogelijk maakt om middels kleding meer, andere en zeer persoonlijke informatie met anderen te delen. Door output in de vorm van tekst, licht, kleur, beweging of geluid kan techno-mode iets ‘vertellen’ over de persoonlijkheid, gemoedstoestand, sportprestaties of zelfs emoties van de drager. De technologie voegt een extra, nog intiemere dimensie toe aan het reeds zo complexe communicatiesysteem dat achter mode schuilgaat. Techno-mode kan functioneren als een draagbaar communicatieplatform dat het lichaam omhult; een soort tweede huid die mensen en hun omgeving op ongekende wijze met elkaar verbindt.

Ten slotte onderzoekt dit proefschrift hoe techno-mode nieuwe manieren om het lichaam te controleren en te monitoren in het leven roept. Byborre’s ‘BB. Suit 0.3’ — een sweater die de hartslag, beweeglijkheid en huidvochtigheid van de drager in de gaten houdt — wijst erop dat techno-mode een draagbare vorm van surveillance biedt. Deze draagbare surveillance kan experimenteel, positief en speels zijn, maar heeft ook zorgwekkende kanten. Enerzijds kan techno-mode zich gedragen als een soort harnas dat de drager beschermt, helpt en stimuleert om een beter (dat wil zeggen veiliger, gezonder, productiever en gelukkiger) leven te leiden. Met name sensoiren stellen dragers in staat om hun lichaam bewust en effectief te gebruiken, monitoren, versterken en verzorgen. Anderzijds is het risico van draagbare vormen van surveillance en zelfmeetapparatuur dat ze het welzijn, de privacy en autonomie van de drager ook juist kunnen inperken. De mogelijkheid om allerlei data over onze gezondheid, lichaamsfuncties, omgeving en gemoedstoestand te kunnen registreren en delen kan een gevoel van macht en zelfcontrole teweegbrengen. Terwijl we reikhalzend uitkijken naar de plezierige mogelijkheden van techno-mode is het echter ook van belang om kritisch stil te staan bij de sociale en ethische kwesties die op het spel staan.

De conclusie van dit onderzoek is dat techno-mode de relaties tussen het menselijk lichaam, technologie en mode op een materieel niveau medieert, door die connecties
te versterken en verder uit te breiden. Een combinatie van postfenomenologische en
nieuw-materialistische theorie helpt te begrijpen dat juist het unieke belichaamde en
materiële karakter van de techno-mode maakt dat het een zo krachtige impact op de
relatie tussen drager en omgeving kan hebben. Het dragen van technologie houdt in dat
de grenzen tussen wie we zijn, wat we dragen en de technologische wereld waarin we
leven verder vervagen.
Curriculum Vitae

Lianne Toussaint (1986, Wageningen) studied Cultural Studies at the Radboud University Nijmegen, where she obtained both her bachelor’s degree (2007) and master’s degree (2008) with honors. During her studies she was an intern and part-time project manager at ArtMARK, an organization for cultural education in Nijmegen. After graduating from the Radboud University she enrolled in the international master’s program Photographic Studies at Leiden University, from which she graduated with distinction in 2010. Between 2010 and 2013 Lianne held several positions at Utrecht University’s Faculty of Humanities: she was a project coordinator at the Centre for Humanities, was employed as a project manager at the Humanities Research Support Office, and worked as an assistant secretary to the board at the Department of Media and Culture Studies. In 2009 Lianne returned to the department of Cultural Studies at Radboud University Nijmegen, where she worked as a lecturer and junior researcher, joined the Staff Council of the Faculty of Arts, and obtained her University Teaching Qualification. She started her Ph.D. research in September 2013.

Lianne’s Ph.D. research is part of ‘Crafting Wearables’ (2013–18), a collaborative research project funded by the Creative Industries program of The Netherlands Organization for Scientific Research (NWO). Her dissertation explores how techno-fashion mediates the relations between the human body, technology, and fashion. During her Ph.D. trajectory Lianne was a member of the Research School for Media Studies (RMeS) Ph.D. Council, co-organized the international conference Things to Remember: Materializing Memory in Art and Culture at the Radboud University, and earned her Cambridge Certificate of Proficiency in English. In 2015 she was awarded a Fulbright Scholarship, which allowed her to become a Visiting Research Scholar at the School of Art and Design History and Theory at Parsons, The New School for Design in New York City. Lianne has presented papers at numerous international conferences and published on the integration of fashion and technology in relation to topics such as cultural memory, sustainable fashion, and embodiment. She presently works as a lecturer at the department of Cultural Studies again, coordinating and teaching several courses on fashion, the creative industries, cultural theory, the body in the arts, and image analysis.