Performative Wearables:
Bodies, Fashion and Technology

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Abstract

PERFORMATIVE WEARABLES: BODIES, FASHION, AND TECHNOLOGY
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This thesis argues that wearables are inextricably performative. By this I mean that performance—human *and* nonhuman performance such as those encountered both on and off stage, as well as social performance and the performance of fashion and technology—contribute to the creation and meaning of wearables. With this aim in view, the thesis explores performance from four research angles: a framing of the birth of wearables in a performative context; a theoretical analysis of wearables as somatically, aesthetically, and technologically constituted via the performative; a historical back-dating of pre-computational wearables stemming from Modernist performative fields; and the in-situ case studies of contemporary wearables creations. It is my goal to demonstrate that wearables are performative across transversal timelines, materials, styles, fabrication processes, and body expressions.

Using references from the art-research labs currently involved in developing fashion-tech and wearables—as an important counterbalance to industry's contributions to wearables—I ask this central question: how can concepts of performance elucidate wearables? I look toward performance as a key thread that follows wearables' beginnings to the current, contemporary technological culture embedded in media arts and experimental contributions to the field. Why? Because wearables are more than the sum of the technologies they incorporate, they are the result of their admixtures of fashion, bodies, display, and transformation (in both human and technological form). In short, wearables

are active, (a)live, and hence both the objects themselves and the individuals wearing them participate in the co-creation of their performance. Performance is complex—striding as it does across disciplines from the technological and engineering; to the human and unscripted—and for this reason it is richly suited to the challenges encountered when describing wearables. Performance is the key pathway, in my opinion, through which we can gain stronger insight into the stakes, meanings, messiness, desires, and technological innovations that are being developed in wearables in artistic labs past, present and future.

“What is in fact curious about all these gestures, these angular and abruptly abandoned attitudes, these syncopated modulations formed at the back of the throat, these musical phrases that break off short, these flights of elytra, these rustling branches, these sounds of hollow drums, these robots squeaking, these dances of animated manikins, is this: that through the labyrinth of their gestures, attitudes, and sudden cries, through the gyrations and turns which leave no portion of the stage space unutilized, the sense of a new physical language, based upon signs and no longer upon words, is liberated.”

—Antonin Artaud, *The Theatre and Its Double*

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1.0 Introduction

Fantastic Garments

Flying exoskeletons; cocktail-mixing dresses; garments that alert you to $C0_2$ levels; bodysuits to beckon lighting bolts; garments that generate their own energy when itched, scratched, and pulled; dresses that bleed to change color; disappearing dresses; clothes that quiver when you approach them—no, this is not science fiction, this is the very real and fantastical world of wearables.

Presently, wearables stemming from academic and experimental interactive or media-arts milieux are evolving at the crossroads of material transformation and engineering. New hybrid alliances are heralding as-yet-unconsidered potentials for the function, as well as meaning, of fashion combined with technology. Wearable Tech and fashion-tech are increasingly at the foreground of technological advancement, as well as design concepts. Yet how can this immense shift in sartorial expressivity, technological connectivity, and somatic experience be understood or theorized, both conceptually and technically? In a world where computational and material technologies are re-writing our relationships to almost everything—our homes, government, economics, schools, medicine, and more—wearable technologies are reinventing our relationships to our bodies, our experiences of spaces, social interactions, and self-representation. And this is happening faster than we can even describe it.

There is no denying that wearable technologies are part of the next frontier of computational interfaces and interaction, if not *the* technological platform of the future. The twentieth-century "silicon" revolution has given way to new, exponentially miniaturized, integrable technologies, electronics, and biomaterials. In a very short time span, computers have migrated from our desks to our pockets, and into our socks, hats, earrings, and even skin and bodies.

Even in light of wearables' hype (or perhaps because of it), the field remains fuzzy. The commercial buzz around wearable technologies disseminated on a daily basis through popular news outlets unequivocally celebrates their potential to save: lives, money, time, wars, health, children, relationships, and more.[1] And yet, how exactly do sensors, smart fabrics, responsive surfaces, or networked systems embedded and meshed into our clothes and accessories truly affect or transform our actions? And have we taken a position, socially, culturally, or personally on how we might desire or engage in shaping this techno-somatic transformation? Are wearable technologies an extension and amplification of our bodies? And if so, how, and to what cost or benefit? If wearables are a path to a new, still undiscovered personal or social self, how will this self be defined? Will wearables shape or

[1] On any given day, one may read in the popular media about the potential of wearables to transform our relationship to technology. Much of this discourse and hype comes from tech and startup industry speculators invested in the future of small and portable sensing and network technologies. A sample of trending Web articles on wearables on any given day might look like this: "Wearable Technology Takes on Air Pollution and Smog With Personal Air-Quality Monitors," *International Business Times*, http://www.ibtimes.com/wearable-technology-takes-air-pollution-smog-personal-air-quality-monitors-2018324; "Wearable Tech Gets a Fashionable Spin," CNBC, http://www.cnbc.com/2015/07/18/wearable-tech-gets-a-fashionable-spin.html; "The wearable tech market could reach 385 million people and change how we 'consume and use information,'" *Business Insider*, http://www.businessinsider.com/wearable-tech-could-soon-reach-385m-people-2015-7 (accessed 22 July 2015).

stunt our experiences of real and virtual environments? And, finally, what do we really want and expect from wearables? Safety? Pleasure? Ubiquitous presence? Seamlessness with our lived environments? A mirror that reflects or broadcasts our personalities or moods? All of these questions remain in suspension, as we march on toward adopting wearable technologies.[2]

While there are many practical reasons why we may want smaller, smarter, and more somatically integrated technologies and objects in our day-to-day lives, there remains little analysis—historical, social, contextualized, or critical—of what wearables actually do, both in and of themselves and to us. Now is the time to ask questions; to take stock of how wearables emerged; to consider wearables' links with the history of arts, bodies, fashion, and technology; and, more importantly, to ask: to what effects are we integrating technology onto our bodies, sartorial constructions, and social technologies? In order to do such a thing, a theoretical frame needs to be built that can address this complex and fast-moving target, and the frame that I propose is performance.

Performative Wearables: Bodies, Fashion, and Technology

This thesis examines the performative dimension of wearable technologies at the intersection of bodies, fashion, and technology. It aims to investigate the different sites where performance is present and shapes the wearable object. Specifically, I consider the

[2] A recent news item professed that the future of wearables was "ingestibles." In this scenario, even the locus, or level, of seamlessness of the technology can be debated. However, for the purpose of this thesis, I stop at the skin, and leave the work of diving into the flesh to research in cyborg culture and biotech. See: http://nymag.com/thecut/2015/10/ingestibles-could-be-the-new-wearables.html (accessed 20 January 2016).

theoretical groundwork of performance concepts found within the disciplines of sociology, media arts, fashion, and technoscience as a methodological pathway from which to untangle the multiple effects (both conceptual and tangible) of the wearable *in action*.

I frame wearable technologies as body-worn devices that use electronics to modulate and transform materiality in real time.[3] By performance, I evoke the notion of performance arts and performativity as encountered in sociology, media arts, fashion scholarship, and science studies research. The reasons for examining wearables through the lens of performance—which I unpack throughout this thesis—are multiple and intertwined. To begin with, no encompassing theory of wearables presently exists. However, when we identify the multiple disciplines that converge in wearables—fashion, technology, and the body—a common theoretical thread emerges: performance. Performance as a framework arises because it is one of the few theoretical avenues that can encompass the convergent aspects of wearables equally from the standpoint of the lived body, the dynamic technology, and its expressive aesthetics. It is my intention to follow this performative thread that runs through these three disciplines—the body, fashion, and technology—with the aim of weaving together a theory tailored for wearables. It is also my belief that performance is the pre-eminent commonality running through all facets (materiality, use, design) of the wearable, which permits us to speak of the discipline in a truly holistic fashion.

[3] The primary focus of this thesis is wearables design and fashion, as opposed to military, safety, medical, sport, or other utilitarian dimensions. However, because the technologies and material research from various utilitarian fields often feed, converge, or are challenged by artistic and design research, the distinction and line between the two will at times be fluid.

In order to explore the multiple relationships between wearables and performance, I focus on three key research methodologies: close readings of theoretical texts on performance and performativity; historical case studies stemming from archives; and situated contemporary case studies of wearables ateliers and design practices unfolding at present. I first describe the landscape of wearables scholarship to date, specifically the genesis of the term and current framing of materials impacting the field (Chapter 1). Next, I recount the birth of wearables engineering to reveal a surprising performative undercurrent (Chapter 2). Following, I conduct a close reading of theoretical texts on performance, which have as their principal (and atomic) subjects: bodies, media arts, fashion, and laboratory cultures (Chapter 3). The aim is to later use these separate concepts of performance to formulate a performative theory adapted to wearables. In order to cement the argument that wearables are intimately germane to performance—both historically and in current artistic/design practices—I next describe four historical case studies of pre-computational, modern-era interactive garments stemming from performance and stage contexts (Chapter 4). Here, my goal is to situate wearables within a historical continuum of performance, with or without computational elements, thus firmly cementing the roots of wearables within a performative and artistic continuum, as opposed to the purely technological. Finally, building on the theoretical exploration of performance theory and history, I analyze four contemporary case studies of wearables production, described and explained through the lens of performance (Chapter 5). I conclude the thesis with critique on current dys/utopian notions of wearable technologies, proposing alternate and artistic paths for the future of performative wearables (Chapter 6).

My goal in this thesis is to demonstrate that the contributions of arts-focused and critical wearables can only be truly understood and analyzed through their performative relationships to bodies, fashion, technologies, and the laboratory cultures from which they are birthed. The concepts and applications of performance used in this thesis range widely: the exploration of performative theory as elaborated within scholarship on the body, media arts, fashion, and the laboratory; an analysis of historical antecedents of wearable technologies stemming from Modernist experimentation with garments and bodies in performance contexts; and finally, the specific performative interplay of individuals and apparatuses occurring in contemporary case studies of wearables design ateliers. I argue that wearables are inextricably linked to the history of performance, fashion, technologies, and concepts of the body; are alive with dynamic changes and expressions when performing on and with the body; and are the results of a complex laboratory dance involving matter and mind.

1.1 Wearables: What's in a Name?

A Wearables Spectrum

In this thesis, I have chosen to use the term "wearables" as the primary way of referring to the field of applied electronics and technology situated on the body via garments or other body-specific adornments.[4] However, many competing portemanteau names exist describing the field of wearables from unique angles, including: e-textiles, intelligent textiles, smart fabrics, techno-textiles, future textiles, material futures, fashion-tech, computational couture, and coded couture. Each of these terms—as can be noted in the names chosen—skews the field of wearables in a particular material exploration or niche highlighting and privileging one discipline over another. As the field of wearables is at present so intertwined with other materially rich fields, such as textiles, robotics, fashion, design, computer science, art, media arts, and many more, this next section is dedicated to disambiguating and defining some recurring key terms specifically associated with wearables. The aim of this overview is to name and identify a few contributing fields to the wearables landscape, and classify these both in terms of material contributions and limitations, as well as legacies in influencing contemporary wearables design. This overview disambiguates the terms: wearables, e-textiles, smart fabrics, and fashion-tech. In this way, we will be able to refer back to these terms and disciplines associated with the field of wearables, and use them in a strategic and modular fashion (at times combining them) while analyzing cutting-edge contemporary wearables designers and ateliers.

Wearable Computing

[4] Other than "wearable computing," a few other terms are also used when referring to the use of electronics and computer science designed for the body, including: "tangible media," a term derived from MIT professor Hiroshi Ishii, from the Tangible Media Group, where wearables is but one of many engineered and computational platforms explored; and "physical computing," a term popularized by arts and electronics teacher Tom Igoe, of New York University's Interactive Telecommunications Program (ITP) at the Tisch School of the Arts.

The term “wearables,” first coined by Edward O. Thorp and later used by Steve Mann, both Massachusetts Institute of Technology (MIT) alumni, stems from the legacy of electrical and mechanical engineering and refers to the concept of “wearing a computer on your body” (Mann, “‘Smart Clothing’: Making multimedia computers”; “‘Smart Clothing’: Wearable Multimedia Computing”; “Wearable Computing”; “Smart Clothing: The ‘Wearable Computer’”; Mann and Niedzviecki, *Cyborg*; Thorp, “Invention”).[5] In this thesis, “wearables” are also consistently referred to as the wearing of some form of mechanical or electronic system on the body. The term “wearables” (shortened from the original “wearable computing”) remains flexible enough to accommodate the many parallel and related disciplines and terms that shape and define the field of wearable technologies today. For this reason, I have chosen to privilege the term so that we may clearly focus on garments having dynamic properties that are situated on the body. Wearables, as referred to in this thesis, consistently point to electro-mechanically enhanced garments with the ability to process and receive information, sense the body or environment, and thus create effects (electrical, state-changing, or mechanical), and/or gather information as derived from this system.

Stemming as it does from an engineering context primarily focused on the performance of electrical and mechanical components, however, the term and the field of

[5] I review and analyze in depth both the genesis of wearables and the contributions of Thorp and Mann in Chapter 2. For this reason, I mention their contributions but briefly here, as they are in fact the most foundational and hence deserve a more careful recounting. As to the question of who is responsible for the term “wearables,” because Thorp’s experiments preceded Mann’s (1960s), yet Mann is credited with publishing on the topic (1990s). I choose to refer to them as a common point of genesis.

wearables come with their own legacy of biases surrounding the body and design.[6] In an engineering context, the "wearability" of the garments from a body, fashion, or personal standpoint is often secondary to the technical needs of the electronics and engineering components to "perform." In short, even when designing for the body—as is done specifically in wearable computing—the field of engineering often fails to take into account the very real, tangible elements of the lived body: movement, style, social adherence, and other cultural or design factors. Theoretical frames for explaining and arguing for wearables research in the engineering and computer science communities focus primarily on functionality and technical progress.[7] This legacy—of foregrounding technological optimization above other aspects—continues to inform the ways in which we imagine, develop, and describe wearables today.

Of late, the term "wearables" has also been associated with the Wearable Tech industry, emerging principally from the San-Francisco/Silicon Valley and/or New

[6] Technical associations and conferences focused on engineering linked to wearables include: events sponsored by the Institute of Electrical and Electronics Engineers (IEEE) and the Association for Computing Machinery (ACM); the International Symposium on Wearable Computers (ISWC); Special Interest Group on Graphics and Interactive Techniques (SIGGRAPH); Conference on Human Factors in Computing Systems (CHI); Designing Interactive Systems (DIS); Tangible, Embedded, and Embodied Interaction (TEI); International Conference on Research into the Science, Technology, Applications, and Uses of Mixed and Augmented Reality (ISMAR); Wearable Technologies Conference (WT); and the International Conference on Advances in Computer Entertainment Technology (ACE). Some of these conferences, like ISWC and WT, issue specific calls for papers and demos on wearables, fashion, or smart fabrics; for the most part in these conferences, however, wearable engineering is predominantly presented as applied solutions to problems relating to the health, safety, and defense sectors. From an insider's perspective, and having reviewed a number of wearables papers for conferences such as CHI 2013, TEI 2013, ISMAR 2012, ACE 2009, and ISEA 2009, I can attest to the engineering angle's pervasiveness.

[7] A general perusal of IEEE and ACM SIGCHI (ACM's Special Interest Group on Computer-Human Interaction) conference papers confirms this general observation. This is not to dismiss the important contribution of engineering communities in wearables—as I have mentioned before, it cannot be denied that electrical or mechanical engineering is essential to the creation of wearables—but rather to emphasize that engineering perspectives on wearables generally fall short of considering either the body or fashion aesthetics.

York/Boston/Silicon Alley communities. Wearable Tech designs in this context are often small, wrist-worn devices used to monitor health and well-being, as exemplified in the Apple Watch, launched in 2015.[8] Hence, much of the research and many of the artifacts created within these startup-evangelical communities have adopted the conceptual framework of consumer electronics rather than that of smart clothing. By and large, these designs are made of hard plastics or metals to encase rigid circuits, chips, and sensors. As we can, or will see, such materials often have little in common with fashion or bodies.

The argument that I wish to set in place is that engineering for wearables too often neglects to foreground aesthetics, style, desirability, and the living social body. When designing wearables from an engineering perspective, the body is often introduced to the wearables system as an afterthought and addressed as a single node amongst an array of inputs, outputs, and other contributing factors.[9]

Joanna Berzowska's XS Labs, situated in Concordia University's Department of Design and Computation Arts, is one of the few, unique arts-science research labs

[8] For the last two years, the expression "wearable computing" has increasingly been associated with Wearable Tech gadgets emerging from IT and consumer-products industries. A long list of "quantified self"-focused accessories exists principally to collect data (body-specific metrics like heartrate, breathing, movement, sleep, etc.) and reflect them back to the user via smartphone apps or other wireless interface systems. Companies presently active in the wearable consumer electronics market include: Nike Fuel + Band, Jawbone, FitBit, Misfit, Xiaomi Mi Band, and various emerging startups.

[9] It could be argued that this trend is changing, as popular consumer wearables are entering the market and hence the body's ergonomics or consumer trends and styles are being further considered. However, and too often, aesthetics and the body dimension in wearables engineering are introduced in the later stages of development and are tied to product "saleability" more than valued as integral to design and function. For more on the topic of "ugly" wearables, see: "This Is the Year Wearables Will Stop Being So Ugly," *Wired Magazine*, http://www.wired.com/2015/01/2015-wearables-ces/; "Why is wearable technology so damn ugly?", *Telegraph*, http://www.telegraph.co.uk/women/womens-life/10569007/Why-is-wearable-technology-so-damn-ugly.html; and "Three CES wearables that actually aren't ugly," *The Verge*, http://www.theverge.com/2016/1/11/10742956/ces-2016-wearables-best-smart-watches-fitness-trackers (accessed 25 February 2016).

experimenting at the crossroads of arts/design concerns and fundamental computation and engineering innovation that successfully combines concerns of the lived body with wearable electronics. XS Labs is one of the contemporary case studies exploring wearable computing design that create innovative, performative platforms that engage with technology, the body, and aesthetics in a critical yet playful fashion.

E-Textiles

In spite of the popularity and prevalence of engineering-centric electronic and mechanical wearable devices, as early as the 1990s in the field of engineering we nevertheless encounter research that pointed toward softer, textile-centered, body-aware forms of wearable technologies featuring e-textiles.[10] Specifically, the first IEEE International Symposium on Wearable Computers, held in Cambridge, Massachusetts, in 1997, featured smart fabrics and body-centered prototypes developed (separately) by Maggie Orth and Rosalind Picard (also both from MIT). Expanding on previous cyborg- and gadget-oriented versions of wearables—as seen in the work of Mann and Thorp—this early research focuses on the potential for conductive fabrics and e-textiles to incorporate electronics into garments at a human-body scale (Picard, *Affective Computing*; Post and Orth, "Smart

[10] "E-textiles" refers generally to electronic textiles. Leah Buechley, engineer and designer of the LilyPad Arduino, a DIY circuit designed for embroidering circuits, has been central in the popularization of e-textiles. For more on e-textiles projects and descriptions, see: Leah Buechley, Kylie Peppler, Mike Eisenberg, and Yasim Kafai, eds., *Textile Messages: Dispatches from the World of E-Textiles and Education* (New York: Peter Lang, 2013).

Fabric").[11] For example, Orth's paper, "Smart Fabric, or Wearable Clothing," written in collaboration with Rhemi Post, argues for the fabrication of soft circuits made with commercially available conductive fabrics, yarns, and other textile components, because of their natural "wearability." Post and Orth argue that:

> While wearable computers are empowering fashion accessories, clothes are still the heart of fashion, and as humans we prefer to wear woven cloth against our bodies. The tactile and material properties of what people wear are important to them, and people are reluctant to have wires and hard plastic cases against their bodies. (Post and Orth 1997, 1)

Post and Orth vie for a softer, more "wearable" wearable, an ongoing concern and debate for the design and aesthetics of e-textiles and interaction research.[12] The authors question the 1990s-era enchantment with a Cyborgian future—an imagined future where the body would merge with hard electronics and robotics, and thus liberate itself from the messiness of flesh—and instead point toward the more modest and practical task of embedding electronics into textiles with conductive materials and threads.[13] While Post and

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[11] Although this thesis does not directly address gender issues in engineering, I would be remiss were I not to mention the important contribution of women in shaping wearables. Although one could speculate as to the reasons why women engineers and designers feature extensively in the development of wearables-at-large—is this a "soft" area of engineering where women are more welcome because of the craft or style dimension? Are women more interested in the body, style and design than men?—I leave this subject to another researcher.

[12] Debates around the techno gadget versus the fashionable wearable (or consumer electronic wearables versus textile-based wearables) have been ongoing for many years and continue today. For more on this debate, see: "Amanda Parkes on Why Wearable Tech Is About More Than Gadgets," *Business of Fashion*, http://www.businessoffashion.com/articles/long-view/amanda-parkes-wearable-tech-gadgets; and "The future of wearables is smart fabrics, says Business of Fashion founder," *Wired Magazine*, http://www.wired.co.uk/news/archive/2016-01/12/smart-fabrics-beat-smart-devices (accessed 25 February 2016).

[13] The term *cyborg*, coined by Manfred Clynes and Nathan S. Kline, is short for "cybernetic organism" and and refers to an organic-artificial organism. The year 1997, with the onset of popular use of the Internet and the identification of a "cyberspace," was a key moment for cyborg-related research and popularity in fiction, art, and technological research. For more on cyborgs, see: Anne Balsamo, *Technologies of the Gendered Body: Reading Cyborg Women* (Durham, NC: Duke University Press, 1996); Donna Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature* (London and New York: Routledge, 1991); Bernadette

Orth promote e-textile innovation in their research, however, for the most part they leave the design of the garment (and its fashion aesthetics) out of the equation. Hence, their e-textiles research is limited to the adaptability of textiles and garments to house or construct electronics, and fails to address how one might wear these electronics, let alone feel, move in, and experience them. Orth and Post's primary concern is to construct a viable e-textile interface, and does not take into consideration how this circuit might converge with a lived body or function as a fashion garment.

Picard and Healey's paper, "Affective Wearables," for its part, does engage the body via the use of bio-feedback sensors integrated into wearables (Picard, *Affective Computing*; Picard and Healey, "Affective Computing").[14] However, their interest in the body also remains abstract and computationally driven. The tangible computing research proposed by Picard and Healey expands on the potential for off-the-shelf medical sensing devices embedded into garments to "read" and "calculate" the body. Biometric sensors—measuring respiration, galvanic skin response (skin resistance), blood volume pulse (BVP), and electromyography (EMG) sensors—used in their design proposal build on the concept of a wearable as a structure composed of hard electronics and sensors attached onto garment for functional reasons. Here again, the body and fashion design represent more of an afterthought to the task of solving an engineering problem: sensing the body. This

Wegenstein, *Getting Under the Skin: The Body and Media Theory* (Cambridge, MA: MIT Press, 2006); and Bernadette Wegenstein, *The Cosmetic Gaze: Body Modification and the Construction of Beauty* (Cambridge, MA: MIT Press, 2012).

[14] Affective computing is a branch of research focused on systems and devices that can recognize, interpret, process, and simulate human affects. As an interdisciplinary field, it spans physical computing, computer science, psychology, and cognitive science. Rosalind Picard is founder and present director of the Affective Computing Research Group at MIT.

lopsided approach to wearables continues to guide many of the consumer electronics brought to market today.

As is so often the case in engineering, researchers address the body more as a node in an array of inputs, even when researching affective computing, which presumably focuses on emotional and bodily responsiveness. As Picard and Healey's research does not hinge on the material elaboration of the wearables as full, body-worn, fashionable garments, the body itself is forgotten or set aside. While Orth proposes e-textiles that fail to engage the physiognomy of the body, Picard probes for the affective states of the body without considering the materiality of the wearable. In both cases, the equation of a wearable is truncated at either the physical or material spectrum. It is clear that the technological apparatuses or engineering systems in this early history of e-textiles fall short of considering the somatic experience of the body, or fashion communication, in a way that could unite the technology with the body or garments.

Since the early era of e-textiles, the field's development has been widely documented and disseminated via online networks, fostering a proliferation of "maker" and DIY communities actively involved in creating wearables.[15] E-textiles today are generally

[15] DIY stands for "do-it-yourself," and is part of a late-twentieth-century movement toward renewed interest in hobbyist making and personalized forms of local and rapid manufacturing. For more on the maker movement and DIY, see: Glenn Adamson, ed., *The Craft Reader* (Oxford and New York: Berg, 2010); Christopher Anderson, *Makers: The New Industrial Revolution* (Toronto: Signal, 2012); Maria Elena Buszek, ed., *Extra/Ordinary: Craft and Contemporary Art* (Durham, NC: Duke University Press, 2011); Daniel Charny, ed., *Power of Making: The Importance of Being Skilled* (London: Victoria and Albert Publishing and the Craft Council, 2011); Neil Gershenfeld, *FAB: The Coming Revolution on Your Desktop—From Personal Computers to Personal Fabrication* (New York: Basic Books, 2005); Lucy Johnston, *Digital Handmade: Craftsmanship in the New Industrial Revolution* (London and New York: Thames and Hudson, 2015); Brent Luvaas, *DIY Style: Fashion, Music and Global Digital Cultures* (London and New York, Berg, 2012);

associated with craft practices stemming from the DIY and maker cultures, which build upon open-source electronics combined with conductive thread to create soft electronic textiles.[16] E-textiles have also been an important creative catalyst at MIT's High-Low Group, led by Leah Buechley, creator of the LilyPad Arduino, an open-source hardware platform for e-textile crafting used both within and outside of academia. However, this field of research, predominant among hobbyists and craft communities, is mainly interested in experimenting with new materials or fabrication processes. The limitations of this community lies in an often amateur approach to technology or design, where the wearables are sometimes one-off, techno-craft experiments built more for the pleasure of tinkering, than to accomplish polished results. However, the general public's enthusiasm for craft e-textile wearables at their own skill level has contributed to many creative, playful, and fantastic approaches, adding new voices and perspectives to the practice.[17] As a low-level entry area for experimentation, DIY e-textiles have democratized the field and greatly expanded the popularity and awareness of wearables.

Michael Petry, *The Art of Not Making: The New Artist/Artisan Relationship* (London and New York: Thames and Hudson, 2011); Richard Sennet, *The Craftsman* (New Haven and London: Yale University Press, 2008); Bas Van Abel, Lucas Evers, Roel Klaassen, and Peter Troxler, *Open Design Now: Why Design Cannot Remain Exclusive* (Premsela, Netherlands: Bis Publishers, the Netherlands Institute for Design and Fashion, and the Waag Society, 2011; and Emily Zilber, *Crafted: Objects in Flux* (Museum of Fine Arts Boston, 2015).

[16] For more on the application of e-textiles in the craft community, see: Leah Buechley, Kylie Peppler, Mike Eisenberg, and Yasim Kafai, eds., *Textile Messages: Dispatches from the World of E-Textiles and Education* (New York: Peter Lang, 2013); Kate Hartman, *Wearable Electronics: Design, Prototype and Make Your Own Interactive Garments* (Sebastopol, CA: Maker Media, 2014); and Syuzi Pakhchyan, *Fashioning Technology: A DIY Intro to Smart Crafting* (Sebastopol, CA: O'Reilly Media, 2008).

[17] These types of DIY wearables are often found at large group events like Burning Man, an annual gathering that takes place at Black Rock City in the Nevada desert, or Comic-Con, an international entertainment and comic convention where attendees dress up in elaborately made fantasy costumes. The question of how wearables dovetail with costumes and performance is addressed later in this thesis.

E-textiles are addressed in contemporary case study of my own practice in wearables design (see Appendix), developed through my atelier and label 3lectromode. In particular, I investigate how today's e-textiles wearable can integrate fashionable contributions, as well as body-aware performative actions.

"Smart" Fabrics

E-textiles are just the tip of the iceberg, next to the wide spectrum of research in the field of technical fabrics applied to various industries, ranging from transportation (aerospace, automobile, trains); to urban infrastructures (water pipes, telecommunications cables, roads); and medical fields (antibacterial materials, medical-grade textiles); architecture and structural engineering (building membranes, structural fibers); to product design (new forms of packaging, new-materials integration).[18] Research in smart and intelligent textiles is arguably one of the more important areas of innovation to support and advance wearables, as the products (fibers and textiles principally, although also coatings and processes) influence the potential for these technologies to expand into new material territories.[19] Included in this class of smart fabrics and various threads, fibers, yarns,

[18] Conferences in textile advancement focused on applied uses of textiles in the safety, health, and defense industries include: International Textile Machinery Exhibition (ITMA); International Trade Fair for Technical Textiles and Nonwovens (TechTextile); International Foundation of Fashion Technology Institutes (IFFTI); and International Textile and Apparel Association (ITAA). However, this community is generally not particularly invested in the electrical and mechanical embedding of technologies into textiles. A few new conferences have emerged that blend textiles and engineering research, including: Smithers Apex's Smart Fabrics (since re-branded as WEAR Conference); Ghent University's Smart Textile Salon (STS); an international series of "Wearable Tech" conferences; and the Toronto-based We Are Wearables conference.
[19] For more on the wide range of design examples stemming from smart fabrics and other materials, see: Sarah E. Braddock and Marie O'Mahony, *Techno Textiles: Revolutionary Fabrics for Fashion and Design*

textiles, and ribbons, transformed or applied through various industrialized measures, are: printing, embroidery, appliqué, quilting, weaving, and knitting, with the aim of creating smart fibers and fabrics.

Various research institutions and schools working in engineering textiles and product design have pioneered fundamental research contributing to innovation in wearable technologies, applications, and the integration of electronics into garments. Fibers, textiles, and product-design departments—such as those at Ghent University in Belgium, TU/Eindhoven in Holland (university and city alike are built around the Phillips Research headquarters), and the Shima Seiki Haute Technology Laboratory located in Drexel University's Westphal College of Media Arts and Design in Philadelphia, have been leaders in applying intelligent textiles to various design products, from sport and medicine to engineering and architecture.[20]

(London and New York: Thames and Hudson, 1999); Sarah E. Braddock Clarke and Marie O'Mahony, *Techno Textiles 2: Revolutionary Fabrics for Fashion and Design* (London and New York: Thames and Hudson, 2005); Elizabetta Cianfanelli and Stoffel Kuenen, *Metamorfosi / Metamorphosis* (Florence: Edizioni Polistampa, 2010); Phil Howes and Zoe Laughlin, *Material Matters: New Materials in Design* (Black Dog Publishing, 2012); Sarah Kettley, *Designing with Smart Textiles* (New York and London: Fairchild Books, 2016); Ellen Lupton, *Skin: Surface, Substance + Design*. (New York: Princeton Architectural Press, 2002); Matilda McQuaid, *Extreme Textiles: Designing for High Performance* (New York: Princeton Architectural Press, 2005); Rebeccah Pailes-Friedman, *Smart Textiles for Designers: Inventing the Future of Fabrics* (London: Laurence King Publishing, 2016); Sasha Peters, *Material Revolution: Sustainable and Multi-Purpose Materials for Design and Architecture* (Basel: Birkhäuser, 2011); Marie O'Mahony, *Advanced Textiles for Health and Well-Being* (London and New York: Thames and Hudson, 2011); Macarena San Martin, *Future Fashion: Innovative Materials and Technology* (Barcelona: Promopress, 2010); Madeline Schwartzman, *See Yourself Sensing: Redefining Human Perception* (London, UK: Black Dog Publishing, 2011); Deborah Schneiderman, *Textile Technology and Design: From Interior Space to Outer Space* (Bloomsbury Academic, 2016); Mary Schoeser, *Textiles: The Art of Mankind* (London and New York: Thames and Hudson, 2012); and Susan Watkins and Lucy Dunne, *Functional Clothing Design: From Sportswear to Spacesuits* (New York and London: Fairchild Books, 2015).

[20] Ghent University's textile department has a long and rich history of textile engineering and industry-specific research reaching back more than a hundred years. The school's Department of Textiles participates in national, European, and international research projects with a focus on applying technical and scientific

Furthermore, interest in smart fabrics has increasingly found its way into design/fashion institutions and industries, as they identify new possibilities for design emerging from the inspiration of cutting-edge materials and creation processes. University research bodies like the Central Saint Martins (CSM) Future Textiles department (since renamed Material Futures) focus specifically on textiles and materials research for design, in which smart fabrics play an important role in shaping design ethos, storytelling, aesthetics, and the political positioning of the role of design in innovation.[21] Because of CSM's historical connection to fashion and design, and the speculative nature of the research undertaken at the school, the smart-fabric propositions that emerge from Material Futures often dovetail with art and critical design practices, rather than wearables proper. [22]

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progress to the field of textiles (see: http://www.ugent.be/ea/textiles/en). "Wearable Senses" is one theme, focused on smart textiles, featured in the curriculum of the Industrial Design Department at the Eindhoven University of Technology, The Netherlands. This research cluster works at the intersection of industry and social applications for technologies worn on or near the body (see: http://wearablesenses.net/). The Shima Seiki Haute Technology Laboratory, located at Drexel University's Westphal College of Media Arts and Design, and directed by Geneviève Dion, explores the capacities of knit structures and novel materials to push development in wearable technology in the fields of medicine and science (see: http://drexel.edu/excite/research/shimaSeiki/). There are a number of other international universities working on textile engineering for wearables, such as: Korea Advanced Institute of Science and Technology (http://www.kaist.edu/); Tampere University of Technology, Finland (http://www.tut.fi/); Korea Evaluation Institute of Industrial Technology (http://www.keit.re.kr/); and the Graduate School of Information Science, Nagoya University (http://www.is.nagoya-u.ac.jp/).

[21] Material Futures (CSM), situated as it is in one of the world's most prestigious fashion schools, enjoys key strengths in design and future-forward aesthetics more than fundamental or applied textile research. Other materials research organizations that combine textile research with design include: Material Sense, an independent consulting organization for materials located in Eindhoven, The Netherlands, which produces publications, workshops, and touring exhibitions (http://www.materialsense.com/); and Materfad, a Barcelona-based materials center that researches and consults in the field of new materials for academia and industry (http://es.materfad.com/).

[22] *Speculative design* is a term coined by Anthony Dunne, of London's Royal College of Art, and Fiona Raby, of the University of Applied Arts, Vienna. The concept has opened up the practice of applied, industrial, and interactive design to critical and speculative perspectives on technology, materiality, the future of humanity, and more. For more on speculative design, see: Anthony Dunne and Fiona Raby, *Design Noir: The Secret Life of Electronic Objects* (Cambridge, MA: MIT Press, 2013); Anthony Dunne, *Hertzian Tales: Electronic Products, Aesthetics Experience, and Critical Design* (Cambridge, MA: MIT Press, 2005); and Anthony

An emerging awareness of the need to aestheticize and conceptualize fundamental and technical research in the field of smart fabrics has resulted in budding partnerships between smart-fabrics industries and design studios. Diffus, a Danish studio specializing in material experimentation and interaction design, and run by Michel Guglielmi and Hanne-Louise Johannesen, has for a number of years successfully integrated smart fabrics into new products and designs in direct collaborations with industry. Their wearables have created unique and landmark bridges between function and aesthetics. Diffus is the subject of one of the contemporary case studies (see Appendix) investigating smart-fabrics integration into wearable designs that maintain fashion and somatic integrity while offering a platform for the body to express itself.

Fashion-Tech

In the history of fashion, an element of material innovation has always influenced the industry while creating opportunities for stylistic shifts. The industrial revolution of the early 1900s was in no small part fuelled by a demand for new fashions and textiles, forever linking the history and fate of fashion to those of technology.[23] Modern examples of fashion-material interconnectedness showcase stylistic influences culled from popular science advancement in a desire to reflect current times. For example, concepts of the

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Dunne and Fiona Raby, *Design Noir: The Secret Life of Electronic Objects* (London: August Media; Basel: Birkhäuser, 2001).

[23] For more on the link between the Industrial Revolution and the demand for new fashions, textiles, and consumer fashion products, see: Gilles Lipovetsky, *The Empire of Fashion: Dressing Modern Democracy*, trans. Catherine Porter (Princeton, NJ: Princeton University Press, 1987/1994); and Christopher Breward and Caroline Evans, eds., *Fashion and Modernity* (Oxford and New York: Berg, 2005).

future and space travel were echoed in the stylistic and material choices of 1960s French avant-garde fashion icons Paco Rabanne, Pierre Cardin, and André Courrèges through the integration of non-traditional materials and fabrication techniques in their garments.[24]

Today a few notable fashion-tech designers, moving from inspiration to action, have begun to give technology a central place on their sartorial palettes. Works by designers, such as Cyprus-born, British-based avant-garde designer/artist Hussein Chalayan, Japanese fashion icon Issey Miyake, and Dutch designer Iris van Herpen, have transformed the perception of technology's role to not only inspire fashion but also shape its form, function and aesthetics. These adventurous designers have used technology to change how we communicate with fashion and fabricate clothing, leveraging the use of tech to gain notoriety in the public eye, all the while creating signature styles.

In collaboration with German-UK engineer Moritz Waldemeyer, Chalayan has created dozens of avant-garde runway collection pieces over the years (from "Geotropics," spring/summer 1999, to "Readings," spring/summer 2008), featuring kinetic, electric, dynamic, robotic, and interactive garments.[25] Miyake and van Herpen have used technology to experiment with new production processes, as in the case of Miyake's use of textile origami and Herpen's groundbreaking 3D-printed collections.[26] Miyake pioneered three-

[24] For a short history of fashion design precursors to fashion-tech, see: Suzanne Lee, *Fashioning the Future: Tomorrow's Wardrobe* (London: Thames and Hudson, 2005).
[25] For more on the work of Hussein Chalayan, see: Bradley Quinn, "A Note: Hussein Chalayan, Fashion and Technology," *Fashion Theory* 6, no. 4 (December 2002): 359–68; Caroline Evans, "No Man's Land," in *Hussein Chalayan*, exhibition catalogue (Rotterdam: NAI Publishers and Groninger Museum, 2005).
[26] Both Issey Miyaki and Iris van Herpen have been the subject of comprehensive exhibitions and catalogues. For more on their fashion design, see: *Iris Van Herpen*, exhibition catalogue (Rotterdam: Groninger Museum, 2012); and *Issey Miyake*, exhibition catalogue, (Tokyo: National Art Centre, 2016).

dimensional design through textile engineering, such as in his APOC (A Piece of Cloth) clothing line, featuring all-in-one knitted garments that the wearer is invited to cut out from a single piece of fabric; while van Herpen has become known for her elaborate, 3D-printed garments designed in collaboration with Niccolo Casas ("Hacking Infinity," fall/winter 2015–16), Philip Beasley ("Magnetic Motion," spring/summer 2015), and Materialize, a Belgian-based 3D-printing laboratory. Chalayan's fashion-tech designs are statement pieces created solely for the catwalk, and are not intended as consumer products or bespoke fashion; while for Miyake and Herpen, technology constitutes a defining factor in the production process shaping the aesthetics, but not present in the garment itself.

In the case of fashion-tech produced for runways, such as Chalayan's, an important gap exists between stage pieces elaborated for *haute couture* showings—used a single time, in a single context (the runway), and on a single body type (lithe models)—and those produced for consumer wearables. Chalayan's integration of technology is intended for stage-specific performance effects; while Wearable Tech gadgets, as I will later discuss, are intended for self-monitoring of athletic and lifestyle aspects of day-to-day life performance—two very distinct things. Furthermore, fashion-tech pieces for the runway are built to communicate at the scale of runways, featuring dramatic effects; while consumer wearables are designed to be discreet and fit into the ecology of everyday accessories such as bracelets, shoes, or jewellery.[27] Chalayan is perhaps the only *haute couture* fashion

[27] Design schools (in fashion, textiles, media arts, and more) have begun to explore the potential for the integration of technologies into fashion, design objects, and interfaces, from wearables to the Internet of Things (IoT). In Montreal, L'École supérieure de mode de Montréal at the Université du Québec à Montréal

designer to have embraced technology in his garments, while other designers have timidly integrated Wearable Tech accessories.[28] The problem (and solution) of technology integration vs. using technology to make a fashion statement is one that we will continue to encounter as we discuss fashion-tech.

Beyond electronic and mechanical systems, various material hybrids are also, from a materials standpoint, changing the paradigm of what constitutes technology. Technology is no longer "just" electronics or mechatronics, but now bleeds into biology, chemistry, artificial intelligence, and rapid prototyping. The emergence of more affordably scaled technologies from 3D printing, consumer robotics, drones, and biotech labs is fostering a new DIY wearables community. This cross-pollination of fashion and emerging sciences is present across universities, fashion studios, robotics laboratories, bio-art ateliers, and more. Centers such as Australia's SymbioticA have been working at the cutting edge of biology and art for a number of years, pioneering innovations such as: a vegan, cruelty-free leather, and fungi-based dresses, developed by Donna Franklin. Meanwhile, Fabrican,™ a fabric-

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(UQÀM), where the interactive fashion designer Ying Gao teaches, is an emerging node for research in fashion-forward technology. See: *Ying Gao: Art, Mode, et Technologie* (Musée National des beaux-arts du Québec, 2011). Meanwhile, Concordia University and its Milieux research hub (formerly called Hexagram) have also fostered wearables projects, such as the computational garments of Joanna Berzowska and the e-textile designs of Barbara Layne. In New York City, a number of wearables initiatives at the Parsons School of Design have been fostered by wearables "trendcaster" Sabine Seymour, CEO and CCO at Moondial; Katherine Moriwaki, researcher in wearables and physical computing; and fashion-interaction design scholar Otto von Busch. Sabine Seymour was one of the first authors to situate wearables in a continuum of fashion publishing. See: Sabine Seymour, *Fashionable Technology: The Intersection of Design, Fashion, Science, and Technology* (New York and Vienna: Springer Verlag, 2008); and Sabine Seymour, *Functional Aesthetics: Visions in Fashionable Technology* (New York and Vienna: Springer Verlag, 2010); as well as Dr. von Busch's dissertation, *Fashion-able: Hacktivism and Engaged Fashion Design* (Gothenburg, Sweden: Camino Förlag, 2009); and Katherine Moriwaki and Aneta Genova, *Fashion and Technology: A Guide to Materials and Applications* (Fairchild Books, 2016).

[28] Diane von Fustenberg designed Google Glass for the runway in 2014, while designer Isaac Mizrahi launched a smart watch with HP in 2016.

in-a-can product developed by British-based designer Manel Torres in collaboration with UK chemists, offers artistic and medical opportunities for “instant” fabric deployment on the body. Additionally, designers such as Suzanne Lee, director of the lab BioCouture, have invented cellulose-based textiles that can be grown in the sun.[29]

Finally, the concept of biomimicry is spearheading sustainable and environmentally focused materials and practices that fold back into the research zones of wearables.[30] MIT’s BioLogic Lab recently created responsive, “breathable” clothing inspired by biomimicry, while Neri Oxman of (again) MIT’s Mediated Matter has designed provocative 3D-printed bio-future wearables that may one day create the food, energy, light, and oxygen we need to keep us alive.[31] Finally, innovative new companies are recycling organic and discarded materials, such as milk (Q Milk, Germany), hair (Studio Swine, UK), car tires (Miguel Mesa Posada, Colombia), and algae (Blond & Bieber, Germany) to re-tool material and

[29] SymbioticA is a University of Western Australia research lab investigating bio-art and fabrication methods around biology (http://www.symbiotica.uwa.edu.au/). Manel Torres developed “Fabrican” at the London Bioscience Innovation Centre. First launched as a novelty product that could be used on stage on naked models, it is presently being developed as a medical product, due to its sterile nature (http://www.fabricanltd.com/). Suzanne Lee worked with Hussein Chalayan on his seminal wearables collections, before creating the BioCouture Lab as Senior Research Fellow at Central Saint Martins College of Art and Design (http://www.biocouture.co.uk/). Presently Lee also also heads the international conference BioFabricate (http://www.biofabricate.co/).

[30] Biomimicry is the practice of looking to nature to inspire technical and structural design solutions. For more on biomimicry, see: Janine M. Benyus, *Biomimicry: Innovation Inspired by Nature* (New York: William Morrow Paperbacks, 2002); and William McDonough and Michael Braungart, *Cradle to Cradle: Remaking the Way We Make Things* (New York: North Point Press, 2002).

[31] For more on MIT’s BioLogic lab, see: Sharon Lacey, “A living, breathing textile aims to enhance athletic performance,” *MIT News*, 16 February 2016, http://news.mit.edu/2016/living-breathing-textile-aims-to-enchance-athletic-performance-0216. Neri Oxman is an architect and founder of the Mediated Matter research group, also at MIT. For a brief summary of Oxman’s work, see: http://www.fastcodesign.com/3047486/wears/from-mits-neri-oxman-the-far-flung-future-of-wearables/4 (accessed 15 July 2016).

fashion life cycles as seen in the recent "Utopian Bodies" exhibition (2015–16) in Sweden.[32]

However, it remains the case that the integration of technology into fashion in a meaningful and effective mode has yet to reach a high level of adoption by designers or consumers. Some of the issues revolve around the technical difficulties (or practicalities) of integrating circuits into garments, and the non-convergence of the fashion and engineering industries, while another limitation arises out of a clash in culture. Italian-French fashion theorist Luca Marchetti has argued that until technology can be as immaterial as style and fashion, it will have little place in *haute couture* and will remain a novelty item.[33]

Dutch fashion-tech designer Anouk Wipprecht has taken a bold and different approach to merging fashion and technology, using radically visible technologies to provoke new ways of communicating via the body. Wipprecht is the topic of a contemporary case study (see Appendix) on fashion-tech, which explores how emerging and non-traditional materials for fashion and garments are shaping new discourses for performing through wearables.

1.2 Wearables: A Hybrid Network

[32] Recently a number of fashion and art exhibition have begun to embrace wearable technologies and material innovation in fashion. These include the recent *Utopian Bodies: Fashion Looks Forward* exhibition, curated at the Liljevalchs Konsthall in Stockholm, Sweden (2015–16); *Code_Couture*, held at the Pratt Institute, New York City (2016); and the upcoming *Manus x Machina: Fashion in an Age of Technology*, at New York City's Metropolitan Museum of Art (2016).

[33] Luca Marchetti and Emanuel Quinz, "Invisible Fashion: From the Interface to Re-Embodiment," in *Fashion and Imagination: About Clothes and Art*, ed. Jan Brand and José Teunissen, 116-–25 (Arnhem: ArtEZ Press, 2009).

As I have briefly outlined, wearables are multimedia artifacts necessitating diverse materials, expertise, team know-how, and tools/equipment as reflected in the above hybrid list of research areas. Multiple yet separate fields of technical knowledge come together to produce a garment that can be worn on the body while housing electronics, sensors, interactive interfaces, and more. Combined knowledge in garment tailoring or product design—which might include pattern-making, machine- and hand-sewing, embroidery, knitting, weaving, textile printing, and 3D rendering and printing, among other skills—must converge with the complex, technical requirements of embedding circuits and technology. We do not train engineers to be fashion designers or pattern makers, or vice versa (for the time being). Hence, it would be virtually impossible (or at least very rare) for one individual to have mastered the many fields represented in the wearables production ecology. How can we take into account and analyze the hybrid teams of experts and specialized professional languages that make up the practice of wearables design and construction?

If wearables are the result of multiple intermixed and converging practices, perhaps it is understandable that no coherent body of literature or theory has yet been able to contain and describe them. The complex amalgams of industries, materials, and social cultures that come together in wearables—particularly artistic and experimental wearables—lack a clear definition or focus for analysis. Furthermore, as we have seen from these numerous entry points and descriptions of wearables materiality thus far, wearables require style and bodies, together with technology, in order to be fully formed. Hence, wearables are the result of a particular admixture of bodies, fashion, and technology, which is seeded in the laboratory environment.

For this reason, I also argue that wearables are themselves the result of a laboratory performance. The field of science, technology and society (STS) envisions the scientific laboratory as a locus for the performance of humans and machines.[34] It will be postulated that not only are wearables performative in their active states, but the laboratory in which they are birthed likewise acts as a site of performance in which the interplay of human and nonhuman agencies are negotiated.

[34] STS is a branch of science that considers how social, political, and cultural values affect scientific research and technological innovation in society, politics, and culture. STS also approaches the laboratory as a site of performance, as elaborated in Chapter 3. For more on STS, see: Andrew Pickering, *The Mangle of Practice: Time, Agency, and Science*. (London and Chicago: University of Chicago Press, 1995); and Karin Knorr Cetina, *Epistemic Cultures: How the Sciences Make Knowledge* (Cambridge, MA: Harvard University Press, 1999).

2 GENESIS OF THE WEARABLE

2.0 Introduction

Two Tales

In the previous chapter, we explored the various categories that comprise the diverse terms and research fields associated with wearables. We discovered that not only are wearables composed of diverse materials, research communities, and goals, but for the time being none of these individual areas of research has yet considered wearables from a perspective in which the body, fashion, and technology are considered in tandem. In order to further develop the argument that wearables require a synthesizing theoretical framework, and that the most suitable such framework is performance, I would like to delve into the genesis of the wearable within the fields of electronics and engineering.

Two dominant stories map the genesis of the term "wearables." Unsurprisingly, both stem from the fields of electrical and mechanical engineering, where they refer to the specific concept and practice of wearing a computer on the body. Wearable computing, as approached from an etymological perspective, thus literally means the wearing of a computer device on the body. As previously mentioned, this history of computational wearable systems is linked to two technological inventors, one from the 1960s (Thorp) and one from the 1970s (Mann) and beyond, each of whom in his own way carved out the field, and is thus responsible for its name. These two convergent tales crystallize the birth of “wearable computing” through the lenses of engineering, research, and science, but also highlight new and surprising concerns for performance, fashion, design, and the body.

In the first example, the wearable endeavours to perform a covert function, with the device seemingly invisibly calculating data. In the second, the wearable device is a highly visible head-mounted appendage provoking visceral reactions and interactions from the public-at-large. While both devices were conceived for data collection, analysis, and retrieval purposes, they express an ongoing dual imperative in wearables: on the one hand, a secret, “introverted” device, looping information back onto the wearer, and, on the other, a disruptive technological appendage, or “extroverted” tool for recording, archiving, and visualizing digital information. This theme of inside/outside or visible/invisible will be encountered many times as we move along the timelines of pre-computational wearables’ precursors to current fashion-tech innovations. Yet, no matter the device, inside or outside, the body’s actions and the design factors of the wearable, when combined with technological agency, as we will discover, are intrinsically called upon to perform. Even within this engineering-centric environment of the birthing of wearables, the imperative of performance shapes and informs the wearable object’s meaning through its relationship to the body, design aesthetics, social reaction or acceptance, and its technological functions.

2.1 A Short Genealogy of Wearables from Foot to Head

The Invisible Brain

MIT engineer Edward O. Thorp developed the first wearable device in 1961,[35] the result of a collaboration with fellow MIT professor Claude Shannon, commonly referred to as the "father of the information age."[36] The impetus of their experiment was to create a concealed device designed to beat casinos at roulette (Thorp, "The Invention of the First Wearable Computer"). Thorp, one of the first mathematicians to use a computer simulation for the purpose of gambling, turned toward wearable computing to prove his probability theories *in situ*. Hence, his wearable was born from a need to hide computation power, and render haptic data inputs physically imperceptible to others. The experiment is recounted in Thorp's 1998 paper, "The Invention of the First Wearable Computer," in which he tells the story of his and Shannon's time working together, thinking and tinkering toward a wearable solution to a physics-based problem (Thorp, "Invention").

In the summer of 1955, Thorp was completing a graduate degree in physics at UCLA, when, inspired by Al Hibbs and Roy Walford's exploits with defective roulette wheels, he first got the idea to measure "the position and velocity of the ball and rotor to predict their future paths and from this where the ball would stop" (Thorp 1998, 1). It

[35] Edward O. Thorp earned a PhD in mathematics from the University of California, Los Angeles, in 1958, and worked at MIT from 1959 to 1961. Thorp is credited as having created the first wearable computer in 1961, and describes this process in "The Invention of the First Wearable Computer," *Proceedings IEEE International Symposium on Wearable Computers* (ISWC 1998). Thorp is also a pioneer in probability theory, best known for his bestseller book, *Beat the Dealer: A Winning Strategy for the Game of Twenty-One* (Vintage, 1966).

[36] Claude Shannon was an American mathematician, electrical engineer, and cryptographer. He worked at MIT from 1956 to 1978, where he developed, with Thorp, the first wearable in 1961. His groundbreaking essay, "A Mathematical Theory of Communication," *Bell System Technical Journal* 27 (July, October 1948): 379–423, 623–56, is credited with having imagined the computational communication environments existing today. He is referred to as the "father of the information age" for his contribution to mapping out information science. See: http://www.newyorker.com/tech/elements/claude-shannon-the-father-of-the-information-age-turns-1100100 (accessed 18 July 2016).

would be several years later, in 1961, when at MIT, and with the participation of Shannon, that the project would be actualized both as an engineering research project, as well as *in situ* at the casino.

Because of the potentially contentious nature of the project, and the experiment's tightly regulated, high-security setting—the casino—an important factor for developing this first wearable was the need for concealment. Hence, the impetus to adapt computational technology for the body in the form of a wearable was a practical one, determined to hide its functionality from casino security and staff monitoring the roulette tables. Thorp describes his invention as a cigarette-pack-sized computer hidden in a shoe that was enabled with twelve transistors, which could be triggered by the push of a big toe. Having analyzed and observed the ball on the various wheels, he was able to predict the ball's stopping place based on the combined knowledge of its starting point and velocity. As the ball was launched, the in-shoe wearable device would be activated to begin calculating its velocity and eventual landing point. Once this algorithm was set in motion, the computer then radio-transmitted a musical scale to a hidden earpiece worn by another person in order to communicate the predicted landing slot of the roulette ball.[37]

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[37] "Consideration of a wide range of designs led us to a final version of the computer which had twelve transistors and was the size of a pack of cigarettes. Our big toes input data with microswitches in our shoes. One switch initialized the computer and the other timed the rotor and the ball. Once the rotor was timed, the computer transmitted a musical scale whose eight tones marked the rotor octants passing the reference mark. The computer was 'set' earlier to match the wheel and ball and to optimize prediction for a selected number of ball revolutions to go. We usually chose the range between 3 and 4 revolutions. When the timing switch was first hit for the ball, the tone sequence shifted and played faster. As the timing switch clocked the ball for the second time, the tones stopped and the last tone heard named the octant on which to bet" (Thorp, "Invention": 4).

For Thorp, the challenge at hand was in dissimulating these calculations for the benefit of the gambler. An interesting outcome to this research was the later passage of a Nevada law banning all "use or possession of any device to predict outcomes, analyze probabilities of occurrence, analyze strategy for playing or betting, and keeping track of cards played," something which had never been considered prior to Thorp's "proof of concept adventure" (Thorp, "Invention," 4).[38] Thorp's experiments also influenced a rogue group of 1970s researchers known as the "Eudaemons," who conducted focused research into the "Eudaemonic Pie," and were also heavily invested in predicting the chaotic phenomena of roulette-table ball trajectories (Bass; Mann, "Smart Clothing: The 'Wearable Computer'").[39]

If we consider the mechanical aspect of Thorp and Shannon's device, upon first observation it is clear that this foundational wearable computer shares a close legacy with the ways in which early computers were considered, namely as calculating machines and statistical analyzers. In Thorp's wearable, the input device is not unlike that of the keyboard of a computer, though displaced to the toes and shoe, as opposed to hand and desk. This early wearable did not so much extend or enhance human sensory capabilities, but rather permitted the covert processing of input information. Thus, the device's location

[38] It is interesting to note that with the advent of smart phones and other small, portable technologies, more and more public places, such as airports and other transportation services, museums, and government buildings, are prohibiting their use. On the other hand, we have seen a sharp increase in monitoring of public places via CCTV and other video systems. We will also see later in this chapter how Steve Mann's wearables critique this heavy-handed form of public monitoring.
[39] The "Eudaemons" were a group of graduate physics students from the University of California, Santa Cruz, whose research aim was to beat the casino at roulette via statistical analysis. The group inspired the Thomas A. Bass book *The Eudaemonic Pie* (Houghton Mifflin, 1985).

on the body was a direct result of the particular setting and restrictions of the casino, instead of a response to sensing for, through, or with the body. In fact, we can summarize the device as a concealed keyboard input, computer, and network communication system. Of note, however, is the device's subversive nature, designed as it was to outsmart machines and humans—and, as noted by Thorp, "formidable enough to be outlawed" (Thorp, "Invention," 4).

Thorp's experiments seem directly aligned with current Wearable Tech logic.[40] Then as now, the body is conceived as an input device, and the wearable is an outcome-analysis machine. In this equation of Wearable Tech, the wearable device functions much like a computer: collecting, processing, and outputting data about the body. This vision of wearable computing as a calculating system is echoed in the contemporaneous field of cybernetics research, which was also emerging in the late 1950s and early 1960s. Cybernetics, a field pioneered by American mathematician and philosopher Norbert Wiener, sought a universalizing methodology for predicting, regulating, and controlling various complex systems. The systems targeted by cybernetics could be as disparate in nature as homes, countries, machines, economies, ballistics, biology, or people.[41] Some of

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[40] I distinguish between wearables, the overall topic of this thesis, and Wearable Tech, which refers to the many consumer fitness and activity tracking bands designed for sports, health, weight control, etc. These include brands such as: Nike Fuel + Band, Jawbone, FitBit, Misfit, Xiaomi Mi Band, and more.

[41] Cybernetics is a field of study of systems and control developed by Norbert Wiener in 1948. Weiner was an American mathematician and philosopher, teaching at MIT from the 1920s until his death in 1964. His seminal book *Cybernetics, or Control and Communication in the Animal and the Machine* (MIT Press, 1948) laid the groundwork for the international study of cybernetics as a research methodology for systems including biology, computer science, engineering, management, mathematics, psychology, sociology, education, and art. Also see: Gregory Bateson. *Steps to an Ecology of Mind* (New York: Ballantine Books, 1972).

the main aims for cybernetics were to create a system that could account for the growing complexity of modern society's expanding industries and the emergence of increasingly complex, segmented, and unmanageable knowledge and power structures.

Beyond machines and computers, cybernetic theories of network predictability became highly influential for the creation of "controllable" ecologies of society, machines, economies, and homes. This universalizing and utilitarian perspective on efficiency, control, and predictability is echoed in Thorp and Shannon's view of managing outcomes of roulette balls. The "first" wearable emerges as a tool for the engineering of predictable and quantifiable outcomes similar to that found in the ethos of today's Wearable Tech gadgets.[42]

Current consumer Wearable Tech accessories, such as sport-bands featuring biometric readings of heart rates, body temperatures, distance traveled, and energy consumed, also reflect the cybernetic impetus toward regulating systems and controlling outputs. Ultimately, such devices aim to streamline data—collected from the body or the environment, for instance—process it, and feed it back to the wearer via a Wearable Tech visualization interface with the aim of improving the user's everyday quality of life. The ultimate goal of these consumer devices echoes a self-imposed cybernetic mirror that could be seen as an opt-in form of self-control.

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[42] A parallel can be made in terms of the goals and uses of predictability theories for warfare and wearables technologies. In fact, MIT remains an important site for research that is closely tied to warfare-related goals, wearables, or otherwise, notably through the Institute for Soldier Nanotechnologies, a joint research venture between MIT, the US Army, and various private industry partners. See: http://isnweb.mit.edu/ (accessed 18 July 2016).

This collection of data, seen in current Wearable Tech devices, is expanded by interfaces such as smartphone apps, providing the wearer with goals and benchmark accomplishments that package a systematic view on the body's actions into amusing graphics, motivational quotes, and easily digestible statistics. Chosen as they are to be worn by consumers seeking future outcomes relating to health, well being and awareness, they are aspirational cybernetic systems, more than fully controlling ones.[43]

Current debates around the potential uses of private companies' access to personal data has played out in popular media referencing Facebook, Google, and Apple's use of personal data, and the related potential and as-yet-unforeseeable danger to private liberties or social agency. Furthermore, whistleblower Edward Snowdon's 2013 data leak regarding illegal digital surveillance on the part of the US National Security Agency (NSA) has amplified the debate around data property.[44] The tangle of data collection and its uses is beyond the scope of this thesis; however, I would argue that all devices capturing somatic information, including Wearable Tech, participate in creating new forms of performative

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[43] Currently in the news is the discussion around employers and insurance companies exploring opportunities to monitor and gather information on clients and task forces. How this will impact the wearer, and if this will be accepted by the consumer/employees, has yet to be seen. For more on this debate, see: "Wearable Tech Is Plugging Into Health Insurance" http://www.forbes.com/sites/parmyolson/2014/06/19/wearable-tech-health-insurance/ and "Wearables at work: the new frontier of employee surveillance" http://www.ft.com/cms/s/2/d7eee768-0b65-11e5-994d-00144feabdc0.html (accessed 7 April 2016).

[44] Apple has recently been in an important controversy with pressure to hand over personal data of suspected terrorists to the FBI, which they resisted in spite of the FBI gaining access without the company's consent. See: http://9to5mac.com/2016/03/28/fbi-accesses-data-on-terrorists-iphone-without-apple/ (accessed 22 April 2016). Edward Snowdon was an analyst working as a contractor for the US Central Intelligence Agency (CIA), when in 2013 he obtained and distributed documents recording the NSA's illegal global surveillance programs. He has since been living in exile in Russia, for fear of persecution in the United States.

relationships between individuals, information, and the power structures that have access to this information.[45]

However, it would be shortsighted to describe Thorp's design as being a purely cybernetic system focused on data and control. As much as this first wearable aimed to "calculate" outcomes (in this case, the movement of a ball on the roulette table for monetary gain) it remains a singular system. I would argue, rather, that the moment the sensing and calculating technology was placed on the body and entered the social setting of the casino, it was transformed from a "functional" number-crunching machine into a "performative" one. This parallel reading of Thorp's tech-centric wearable—a reading but rarely afforded importance or analysis—highlights the wearable as a conduit for performance *because* of its technological enhancement, haptic interactions, and use of costume and acting.[46] This reading foregrounds the elements of disguise and performance

[45] Another important theme in the story of wearables, past and present, is big data. The collection, classification, use, and analysis of the data that wearables can collect is a new, potential market driver for advertising and sales. Furthermore, as these wearables are set to enter management cultures at large—from preventing truck drivers from falling asleep to alerting office workers of physical inactivity—new concerns around the access to data and related ethics are currently subjects of heated debate. However, as the scope of this thesis is focused on effects linked to performance, fashion, and the body, I leave the analysis around big data in wearables to researchers such as David Lyon, Queen's Research Chair in Surveillance Studies, professor of sociology, professor of law, and director of the Surveillance Studies Centre at Queen's University, Kingston, Ontario. See: David Lyon, *Surveillance Studies: An Overview* (Cambridge, UK: Polity, 2007).

[46] Here I would also argue that Thorp's work is a precursor to important recent work in the fields of arts and technology on embodied and situated interactions technologies. For example, increased research into haptic inputs for technology in interaction design is leading the field to interfaces that will engage more than a keyboard philosophy or typing inputs—systems such as motion-tracking cameras, as input devices propose new ways of interacting for screen-based platforms. Such technologies include the Kinect, released by Microsoft in 2010; or Max/MSP video-tracking plugins like softVNS, created by David Rokeby in 2002, and Jitter, Max's own plugin launched in 2003. Specifically, in wearables, researchers like Katia Cepena Vega have explored natural gestures and body interfaces developed with the aesthetics and materiality of beauty products, such as RFID-enhanced nails that can trigger music; conductive eyelashes that can trigger outputs like LED when a person blinks; or conductive hair that can take selfies or trigger the recording of

integral to Thorp and Shannon's project, research, and success, without forgetting the contribution of their unnamed wives.

First, if we consider the impetus of Thorp's wearable, the shoe-fitted computer and accompanying camouflaged earpiece were specifically designed for purposes of calculation, non-detection, and body conformity. In this way, this first wearable was born out of the necessity to miniaturize and conceal computational power on the body, and was crafted to accommodate data input and computation via acceptable design aesthetics of clothing and undetectable bodily movement. Too often, Wearable Tech is described and embraced as an agnostic, unbiased tool for calculation, while a whole messy layer of desires (winning at the casino), physical interactions (secret toe tapping), and environmental conditions (the casino as social and gambling context) clearly shape(d) and color(ed) the exchanges between human bodies and this wearable device.

Second, if we pivot Thorp's story by just a few degrees, we see two grown men and women wearing disguises and tapping their toes inside secret shoe chambers. This scene has more in common with the antics of Inspector Gadget and other spy characters of the 1960s (such as Maxwell Smart or James Bond) than with the seamless idea of objective wearables' functionality and control as sold to us by Wearable Tech industries.[47] Indeed,

conversions. In subsequent chapters, we will explore in greater detail the links between new-media arts and the performative wearable. For more on embodied technologies, see: Mark B. Hansen, *Bodies in Code* (London and New York: Routledge, 2006); and Don Ihde, *Bodies in Technology* (Minneapolis and London: University of Minnesota Press, 2002).

[47] *Inspector Gadget* was a 1980s animated television series featuring a cyborg version of Inspector Clouseau. Not surprisingly, the various devices featured in the animation rarely worked successfully, often to the detriment of the clumsy inspector. This image of the cyborg-clown, as per Gadget or the character of Maxwell

the makeup, disguises, and "acting," necessary to undertake the research reveals a very different story. Thorp never explicitly discusses the element of performance and acting in the experiments other than to state these elements' effect on their state of mind, i.e., the nervousness of being discovered. However, we know that performance, costume, and role-playing were important factors in accomplishing the experiment successfully.

To begin with, Thorp's wearables were disguised as everyday garments. Upon one "actor" was a switchboard concealed in the shoe that could be toe-activated; and upon the other "actor" was an earpiece requiring makeup and hair glue to be dissimulated onto the wearer's natural head and hair. Next there were the "wives" acting as "covers," in the hope of making Shannon and Thorp less conspicuous. One can only imagine what kind of acting was required on the part of the wives to run interference and cover for the gamblers' illegal activities and experiment. Finally, the attitudes of Thorp and Shannon, who needed to conceal their emotions by acting calm while actually quite nervous during this process of duplicity, also impacted upon their social performance.

There is no doubt that all the members and elements of this project—including the wives who acted as lookouts, the dynamic calculating outcomes, and the design aesthetics enhancing the "invisibility" of the wearable device—contributed to the "performance" of the experiment. It is worthwhile to consider that, in spite of Thorp and Shannon's desired scientific approach to the wearable as a tool of statistical analysis, the design and human elements of the wearable articulated through the use of costume (fashion) and bodily action

Smart in the 1960s television series *Get Smart*, continues to prevail in popular culture, with the "serious" James Bond 007-style detective at the spectrum's other end.

(containing nervousness) bubble up to the surface and betray the wearable to be more than "just" science. Even with the best of intentions in creating a "predictability device" like Thorp's wearable, the element of performance was central to how the wearable cloaked, interacted with, and transformed their experience.

Hence, even in the case of this first wearable—seemingly a sober scientific and economic tool—we encounter a whole carnivalesque series of postures, costumes, technological communication, and social masquerade.[48] This element of performance will continue to reveal itself when discussing wearables, as it is a catalyst when combining technology with body-situated design. Perhaps we might even come to think of other calculating devices as proposed by Wearable Tech industries as being more than calculating or controlling machines, but rather also tools of performance.

The Self-Awearable

Themes of control and surveillance, and the inevitable role that performance plays in the field of wearables—such as we saw arise in Thorp and Shannon's work—also appear in the concept of body imaging developed between the late 1980s and 1990s by Steve Mann, then a researcher at MIT. This second account of an early wearables engineering innovation revolves around Mann's ongoing experiments with worn or body-based video- and image-

[48] The term *carnivalesque* refers to critic Mikhail Bakhtin's notion of transgressive social acts and encounters/events wherein the norm is disrupted through comedy, chaos and, resistance, thus offering an opportunity for social breakage and change. Thorp's wearable can be thought of as a "carnivalesque" tool, as it proposes to disrupt the normative progress of casino gambling through play, deceit, and performance. For more on the carnivalesque, see: Mikhail Bakhtin, *Rabelais and His World*, trans. Hélène Iswolsky (Cambridge, MA: MIT Press, 1968).

recording systems. Between the 1970s and the 1990s, Mann worked to develop what he coined the *WearCam*, a body-based camera system designed to augment the wearer's experience and tap into the Internet. This device was designed as a "visual memory prosthetic" and aimed to improve awareness of one's environment, as opposed to reduce or alter awareness, such as in the case of virtual reality and personal sound systems such as the Walkman (Mann, "'Smart Clothing': Wearable Multimedia Computing"). Later iterations of the design were named *WearComp*, *WearCam*, *EyeTap*, *Personal Imaging, Visual Memory Prosthetic*, and "existential computers"—yet all were built upon a similar concept of in-situ image/video recording, storage, and retrieval systems connected to the Internet.

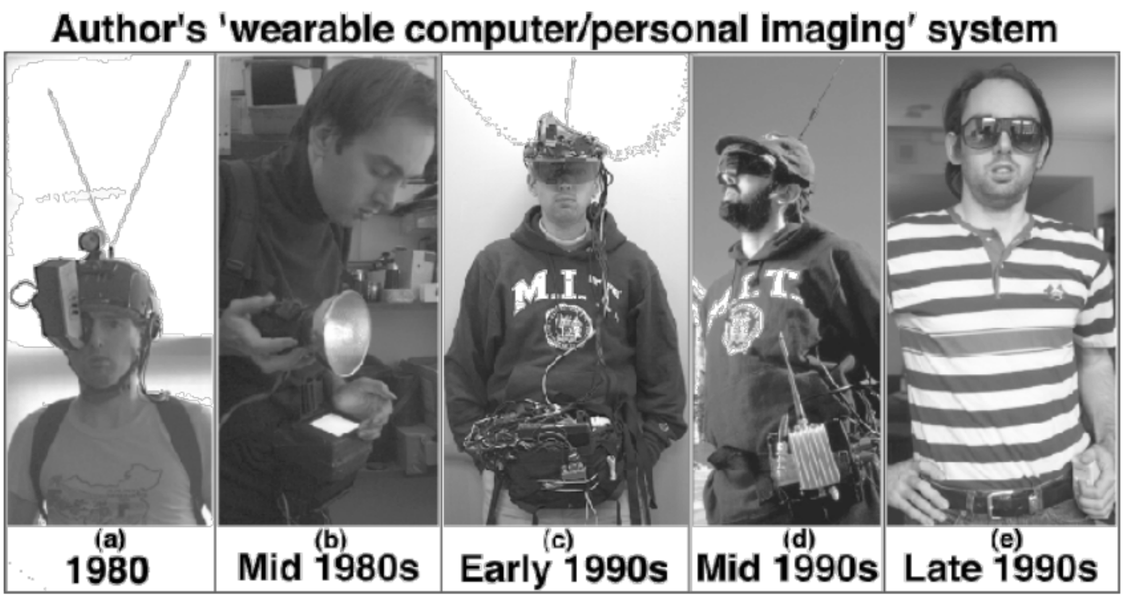

Figure 1. Wearable computer systems designed and built by Steve Mann for experiments in personal imaging (Mann, "'Smart Clothing': Wearable Multimedia Computing").

Mann's papers written while at MIT in the 1990s outline this early wearables research and technical experiments in finding a solution for how to "wear" a computational device in an era before Wi-Fi, cloud computing, portable computers, smart networked phones, and the radical miniaturization of circuits and electronic hardware.[49] Highly advanced at the time, Mann's first designs consisted of very bulky head-mounted displays that were enabled with camera recording devices, processing systems, and antennas on the head to connect to ad-hoc wireless systems and access data networks.

Admittedly, one can only imagine the public's reactions at seeing a large head-mounted apparatus made of metal, electrical wires, and circuits (and obscuring a portion of the wearer's face) as anything but shocking, either in the 1990s or today. This transformation of the human figure via such visible-head mounted electronic circuits and cameras placed on the body, and specifically the face, did not go unnoticed. As notes Mann,

> there was something markedly different in the ways others perceived a system attached to my body than having it carried in a briefcase or the like. But for me, there was tremendous sense of self-empowerment, for it seemed as though it was more part of me than a separate tool. (Mann, "'Smart Clothing': Making multimedia computers," 23)

As a pioneer in the field of mobile video-capturing technologies designed for the body, Mann's research straddled virtual- and augmented-reality innovations, and yet was

[49] The wearing of a computational device was a profound shift for electronics, engineering, and computer science in general. Before Thorp and Mann, computers had not yet been imagined as portable digital interfaces. A key difference in Mann and Thorp's wearables, however, lies in the question of visibility. In this way, one could argue that Mann put wearables "on the map" by making the device visible and a point of social discussion.

markedly different from other wearable VR frameworks of the 1990s. First, Mann's systems were always situated in real time and real space, as opposed to virtual and augmented reality systems developed around simulated environments or visualizations. Second, his systems were networked via wireless communications and also open to non-wearables users, where, for example, Mann's wife could remotely see whatever Mann was looking at and email him comments about, for example, the fruits and vegetables he was choosing in the grocery store (Mann, "'Smart Clothing': Making multimedia computers," 24). Finally, the untethered nature of Mann's wearable systems—battery-operated and increasingly lightweight with each new iteration—differentiated from the tethered virtual or augmented reality systems dependent on AC power connections and limited to controlled viewing and operational conditions.[50]

Although it is increasingly acceptable to "wear" various forms of technology, as seen in the growing popularity of Wearable Tech, for the most part these follow traditional places and patterns of adornment, such as being worn around the waist or wrist, or on/in one's garments. In this way, the face remains a contested area for the overlaying of technology, especially any type that may transform or obscure the person's identity.[51]

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[50] An important benchmark work in VR contemporaneous with Mann's research is the artwork of Char Davis. Her *Osmose* (1995) work featured immersive environments that could be experienced through a large body-worn device tethered to a plugged-in system. Though responsive to breath and movement, the experience was limited to the specific location of the installation, with the imagery pre-programmed, as opposed to emergent. For more on this work see: http://www.immersence.com/osmose/ (accessed 11 March 2016).

[51] An interesting analogy could be made between the wearing of wearables and changing mores in relationship to bodies enhanced through technologies such as 3D-printed prosthetics. For example, it is becoming more common to see amputee models or athletes invited to wear prosthetics for avant-garde art and fashion events. However, this enhancement/transformation is below the neck, and prosthetics for or that transform the face remain more controversial. For more on the notion of the human 2.0, see: Marquard Smith

Regularly wearing his head-mounted electronics device whilst going about his daily routine in the 1990s, Mann described himself as a science-fiction "cyborg" come to life.

Mann explains that, "[p]eople were shocked by the visceral combination of human and machine" (Mann, "'Smart Clothing': Making multimedia computers," 23). "Wearing of a computer" tapped into a 1990s cyborg-inspired concept of the man-machine made prominent by popular science fiction and cyber theory.[52] Mann's project inserted itself into the growing late-twentieth-century trend of transhumanism, in which flesh and tech were imagined as combined with an aim to enhance humans through artificial intelligence and biomechanical capacities to radicalize human capabilities, both mental and physical.[53] Literature around cyberpunk informed many of the era's ideas around the Internet, digital culture, identity, and notions of where humanity situated itself in an ecology of technology.[54] Mann's view of his wearables is clearly informed by such popular 1990s

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and Joanne Morra, *The Prosthetic Impulse: From a Postman Present to a Bicultural Future* (Cambridge, MA: MIT Press, 2006); O. Vainshtein, "'I Have a Suitcase Just Full of Legs Because I Need Options for Different Clothing': Accessorizing Bodyscapes," *Fashion Theory: The Journal of Dress, Body & Culture* 16, no. 2 (2012): 139–69; S. Sansoni, A. Wodehouse, A. McFadyen, and A. Buis, "The Aesthetic Appeal of Prosthetic Limbs and the Uncanny Valley: The Role of Personal Characteristics in Attraction," *International Journal of Design*, 9, no. 1 (2015), 975–84.

[52] *Cyborg*, short for "cybernetic organism," is a term found both in fiction and theory relating to the concept of an organic and biochemical being. Cyberculture theories have examined how the impact of the Internet, mobile phones, and biotech are creating synthetic "cyborgs." Feminist theory has also considered the concept of the cyborg for reframing questions of gender. For more on the theory of the cyborg, especially from a feminist perspective, see: Donna Haraway, *Simians, Cyborgs, and Women: The Reinvention of Nature* (London and New York: Routledge, 1991); Donna Haraway, *Modest_Witness@Second_Millenium. FemaleMan©_Meets_OncoMouse™. Feminism and TechnoScience* (London and New York: Routledge, 1997); Anne Balsamo, *Technologies of the Gendered Body: Reading Cyborg Women* (Durham, NC: Duke University Press, 1996); and Anneke Smelik and Nina Lykke, *Bits of Life: Feminism at the Intersections of Media, Bioscience, and Technology* (Seattle and London: University of Washington Press, 2008).

[53] For more on transhumanism and the drive for human advancement through technology, see: Nick Bostrom, *Superintelligence: Paths, Dangers, Strategies* (Oxford and New York: Oxford University Press, 2014).

[54] Since the late 1980s and 1990s, "cyberpunk" films, novels, and popular culture have often portrayed a vigilante, "renegade" half-robot/half-human trapped in a control (cybernetic) society. From *Wikipedia*:

science fiction novels and cyberpunk fantasies of half-human, half-machine vigilantes living at the intersection of cyberspace and "real" space.

Unlike Thorp and the Eudaemons, Mann's devices were never designed to be hidden from the general public, and focused more on "functionality and capability than in concealment," resulting in a very visible, body-displayed array of electronics (Mann, "'Smart Clothing': Making multimedia computers," 23). In fact, despite Mann's adoption of technology as an unquestioned tool for human advancement designed to "enhance capability," there is also a not-so-hidden social and political element in its cybernetic admixture of machine and human. Mann's wearables evince a strong positioning vis-à-vis surveillance technology by their highly visible nature as self-actualized, self-directed surveillance mechanisms. In Mann's *WearCam*, we encounter the potential for a counterbalance to the increased video-surveillance capacities (and cybernetic surveillance powers) of governments, which escalated in the 1980s and 1990s in public spaces, work environments, and high-security settings and architectures. Mann's device offered a completely new possibility of conferring the power of observation back into the hands—or, in this case, the eyes and minds—of individuals.

"Classic cyberpunk characters were marginalized, alienated loners who lived on the edge of society in generally dystopic futures where daily life was impacted by rapid technological change, an ubiquitous datasphere of computerized information, and invasive modification of the human body," https://en.wikipedia.org/wiki/Cyberpunk (accessed 10 March 2016). Films such as *Blade Runner* (Ridley Scott, 1982), William Gibson's book *Neuromancer* (1984), and later *The Matrix* film franchise (The Wachowskis, 1999–2003) all depict post-industrial dystopias combined with *film noir* detective plots. A reoccurring theme, in this genre, is the admixture of digital technology with human flesh in the main protagonists.

Figure 2. *WearCams* worn by the "safety net" network at MIT in the 1990s
(Mann, "'Smart Clothing': Wearable Multimedia Computing").

This act of watching the watchers was coined by Mann as "sousveillance"—a wordplay on surveillance, which sought to turn the tables on the cybernetic power of control technologies.[55] Sousveillance suggests a shifting of surveillance power from a centralized (corporate or government) environment-based system to a distributed, self-actualized network. Mann's concept of sousveillance was built around rising concern in the 1990s surrounding "Big Brother" surveillance systems, as seen with the proliferation of street-level cameras, networked information systems such as the Internet, and the digitization and archiving of the tangible world, from databases to the prediction of 24/7

[55] For more on Steve Mann's coining of sousveillance, see: Torin Monahan, *Surveillance and Security: Technological Politics and Power in Everyday Life* (London and New York: Routledge, 2006); and Steve Mann, "Veillance and Reciprocal Transparency: Surveillance versus Sousveillance, AR Glass, Lifeglogging, and Wearable Computing," *Proceedings IEEE International Symposium on Technology and Society 2013* (ISTAS 2013), 1–12.

geolocation systems and face-recognition software.[56] In his seminal work *Discipline and Punish*, French philosopher Michel Foucault had already traced the (pre-computational) legacy and prevalence of governmental surveillance structures though his conceptual, architectural analysis of the Panopticon prison in eighteenth-century England (Foucault; McKenzie).

The Panopticon, a model of penitentiary architecture designed and developed by British philosopher and social theorist Jeremy Bentham, proposed a new model for an omnipresent form of surveillance. This architectural surveillance scheme relied on minimizing or masking the detection of human surveillance by optimizing building infrastructures in favor of the guards' privileged observation points. In this prison structure, a single station was placed in the center of the building, from which a single guard could observe the numerous incarcerated individuals without the latter enjoying the ability to ascertain if they were being observed, or not. Thus, this cloaked and invisible form of observation would impose itself upon each cell resident's psyche and actions, triggering in the prisoner a perpetual self-regulated and self-conscious behavior. This asymmetrical mode of control—one in which a single individual has the privileged relationship of seeing many without being seen—has since been instantiated in today's technological forms of distributed systems of surveillance, from closed-circuit television, Web surveillance, and online data collection, to—now—wearables.

[56] For more on theories of surveillance, see: Thomas Y. Levin, Ursula Frohne, and Peter Weibel, eds., *CTRL [SPACE]: Rhetorics of Surveillance from Bentham to Big Brother* (Cambridge, MA: MIT Press, 2002); and David Lyon, *Surveillance Studies: An Overview* (Cambridge, UK: Polity Press, 2007).

Mann's proposed wearable head-up display (HUD) was developed in direct opposition to and critique of the hegemony of increased surveillance, giving the wearer agency to observe the observer. As Mann explains, "[p]rivacy is indeed an important consideration, and, in fact, part of my inspiration. Indeed, what I envision is an alternative to the proliferation of Orwellian pole-top surveillance cameras" (Mann, "'Smart Clothing': Making multimedia computers," 23). Clearly, Mann saw his device as looking back at the "system" observing "us."

Mann's *WearCam* literally became a second skin for its inventor, blending with his everyday identity and quotidian routine. His wearing of the device in day-to-day contexts and activities, however, caused various conflicts, as in the case of negotiating security zones like airports and other high-surveillance areas.[57] Enabled to record and stream every event that Mann encountered, the device also became a witness, observer, and archive, as well as a retrievable database accessed by the wearer. This device would have been unimaginable without the Internet, which facilitated the transmission of information, and which Mann worked to develop, capitalizing on its growing urban deployment. Indeed, it should be remembered that Mann's *WearCam* pre-dates many of today's social and streaming online media platforms, which are facilitated by access to the Internet and smart

[57] In 2002, Mann was prevented from boarding an Air Canada flight with one of his wearable devices, resulting in a lawsuit against the airline. Mann argued that he was a cyborg, and that the wearable constituted a part of his person, and hence could not be removed. Declan McCullagh, "Cyborgs unite!", *Globe and Mail*, 27 August 2003, http://www.theglobeandmail.com/technology/cyborgs-unite/article22618018/ (accessed 11 March 2016).

devices and are encountered through applications such as Facebook, YouTube, Snapchat, and Vine.

For the most part, Mann's devices approached wearables as a personalized form of computation that could both lend the wearer both insight and autonomy in its engagement with self-organized and unique networks. During his early research, Mann imagined many visionary functions for wearables, from their ability to act as a "visual memory prosthetic" for everyday actions, to proposing new ways to connect with online and networked communities for reasons of safety, or acting as a facial recognizer through database image-retrieval functions. It should be noted that Mann's discourse and stance on wearables involved creating surveillance technologies to support the autonomy of the individual, as opposed to top-down Orwellian or institutionalized structures of surveillance. As Mann further cautioned, "'Smart Clothing' offers an alternative to centralized surveillance. It suggests a future in which people, through prosthesis, might have both improved visual memory and improved ability to share it. But it also suggests a hope that the visual memory be distributed among people, and be less likely to be abused than if it existed in a centralized form…" (Mann, "'Smart Clothing': Wearable Multimedia Computing").

Thus, from this first impetus into wearables on Mann's part, we see a desire for agency for the user, individualization of use, and the creation of networked sub-cultures and communities. In 1997, Mann charted a timeline of early wearables through his *WearComp* device. This timeline is a useful portrait for understanding Mann's perspective and motivation in developing wearables, as well as imagining their evolutionary curve. In

Mann's perspective, wearables begin with cyborg-like electronics and evolve into everyday, embedded, and even "invisible" consumer products.

Generation-1: up to and including 1981 WearComp0, 1, and 2	Generation-2: 1982–late '80s WearComp3	Generation-3: mid 80s–present WearComp4, 5, 6, and 7	Generation-4 (2000++) (far future predictions) ???
Lumped components, heavy, cumbersome	Distributed compute-vest or jacket, wires sewn in	Contained conductive thread (fabric itself as circuit)	Entirely conductive thread (or neuro-prosthesis?)
Short term wear Worn standing, only outdoors Antennae ⇒ can't fit indoors +upright or batt. acid spill	Long term wear Worn seated or standing, indoors or outdoors	Almost always worn, anywhere except bath	Always? Anywhere?
Application: lightpainting (experimental)	App.: personal documentary, etc...	App.: general purpose	Visual memory prosthetic? (and many others)
Uptime in minutes	Uptime in hours	Uptime in days	Uptime in years?
Appearance not an issue (no intent to be seen wearing)	Fashionable (performance art)	"Normal"-looking (visually not detected)	Completely undetectable? (to metal detectors)
Relays, MSI, 6502 processor (Hand-assembled code)	8085 processor (Intel supportstation)	(V)LSI or 80*86 processor (DOS, NOS, Linux)	Biological processor? (Thought?)
Augmented reality	Augmented reality	Mediated reality	Mediated perception?
Communications to/from base station(s) (or other assistants)	Comm. to/from Internet	Comm. to/from WWW (e.g. Wearable Wireless Webcam)	Comm. to/from large variety of other people (simulated telepathy?)
Concept appealed to: (???) (no real appeal to others)	Appealed to: artists, fringe-groups	Appeals to: engineers, scientists, hobbyists, researchers	May appeal to: broad range of people
Others described idea as: crazy, nonsensical	Described as: "weird" but interesting	Described as: visionary, futuristic	Perhaps will be described as: normal, essential

Figure 3. Generations of the author's *WearComp* built for personal imaging: past, present, and predicted. Note that Gen-2 and Gen-3 overlap substantially. Gen-4 is completely hypothetical (Mann, "Wearable Computing: A First Step").

A number of aspirations and assumptions come to light when we survey Mann's position and vision of wearables via the *WearComp* device timeline. To begin with, the form factor of the wearable design as mapped by Mann evolves from a wearable composed of "lumped components, heavy, cumbersome" to one made of "entirely conductive thread (or neuro-prosthesis)." Hence, we go from what one may refer to as "hardware" to, potentially, "wetware."[58] Yet, as we know, wearable devices are still very far from having accomplished "invisibility" or the merging of electronics and flesh, although breakthroughs in some miniaturized circuits and EEG devices has pushed the field closer to this goal. Indeed, with most of the popularly reported and marketed Wearable Tech, we remain very much in a "hardware" mindset and design ethos. Perhaps the most marked revolution has been in placing the hardware exactly where and how we normatively place hardware on the body: on the wrists and ears, and shaped as accessories such as jewelry.

Mann next considers what kinds of repetitive or everyday uses the device would be engaged in. This evolution is unsurprisingly charted from a "short term wear," adapted to "standing or outdoors," to an "always," "anywhere" scenario. To be sure, the anywhere/always scenario has come to full realization, and is a growing trend with mobile and smart devices.[59] With the rapid expansion of online and mobile data networks, access to information and connectivity at all times is probably the biggest shift in technology, together with miniaturization. Interestingly, where most of the devices used in smartphone technology capitalize on ubiquitous, peer-to-peer communication—along with the ever-important filters of social media networks and data collection and analysis—Wearable

[58] The concept of "wetware" was popularized in cyberpunk literature and often made allusions to the brain as a kind of computer. In cyberpunk novels, however, the notion of the cyborg would blend computational and artificial systems with biological and "natural" ones. For novels that use the concept of wetware, see: Rudy Rucker, *Wetware* (Toronto: HarperCollins Canada, 1997); and Michael Swanwick, *Vacuum Flowers* (Arbor House Publishing, 1987).
[59] Mann predicts that one day we will think that leaving the house without a wearable would be like leaving naked (Mann, "'Smart Clothing': Wearable Multimedia Computing"). The recently coined term *nomophobia* designates the fear of being without a mobile phone. See: http://www.scientificamerican.com/article/scientists-study-nomophobia-mdash-fear-of-being-without-a-mobile-phone/ (accessed 18 July 2016).

Tech devices have, for the most part, remained proprietary, self-contained systems. By this I mean that where the smartphone paradigm involves seamlessly connecting all information to all people (i.e., via the World Wide Web and online social platforms), wearable devices are still very much focused on what the device itself can gather from the wearer, as opposed to tapping into distributed networks that could be used by many. If we compare the potential uses and connections that can be made on a mobile phone against a Wearable Tech device, we see different philosophies at play.

For the most part, Wearable Tech is a consumer product that reflects the wearer's personal data activities, while mobile phones reflect data sets.[60] Setting the technical limitations of Wearable Tech aside (i.e., its ability to display more information, bigger screens and form factors for interactions), what this highlights is the difference in relationships and philosophy implicitly expounded via these unique platforms. Where the mobile phone continues to expand on the possibility to connect individuals (and now information) across space, the wearable (as conceived in today's Wearable Tech devices) continues its recombinant loop to reflect the wearer back to him/herself. The difference could be qualified as that between a broadcasting device (mobile phone or microphone) designed to speak over distances versus a sensing/observation device (microscope/sensor) used to see more deeply into the body. Although, of course, either of these two operational modes may be integrated into Wearable Tech devices, what is interesting is the fact that

[60] At this time, all Wearable Tech devices, from the Fitbit to Misfit Wearables, presently occupy more or less the same platform of engagement: personal biometric data collection, data visualization and storage via an app, or potential for sharing on device-specific apps and platforms.

they do not do so more often. I would argue that it is not technical limitation that has shaped and continues to shape our intimate approach to wearables, but rather their philosophical roots as devices deeply anchored in reflecting and expanding the body.

Also important for Mann were the wearable device's social acceptability and potential fashionability. Here, Mann traces an evolution that begins as a "non issue," subsequently passing through a "Fashionable" phase, to "Normal Looking," to "Completely Undetectable." Hence, the dream of the "invisible" wearable is upheld in Mann's imagined timeline. As we saw in the work of Thorp and Shannon, invisibility (non-detection of the device) was key to the wearable's success. The same could be said in regard to other forms of wearable devices that monitor the body in covert ways.

Yet, this notion of invisibility does not in fact apply to the work and evolution of wearables used by Mann. In one of his earlier papers, "'Smart Clothing': Making multimedia computers and wireless communication more personal—a paradigm shift in wearable computing," Mann argues that in order for wearables to be attractive, they need to be personalized. "There is a fundamental difference in the way that people feel about their own clothing as compared to a uniform. Although people can become quite familiar with their uniforms, whether worn in prison, the military, certain workplaces, or old fashioned schools, the individuality of personal clothing, and the pleasure associated with its selection and wearing should be extended to computing" (Mann, "'Smart Clothing': Making multimedia computers," 24).

Since Mann's 1980s and early-1990s research, the space of wearable computing, as well as augmentation and mediation technologies for the body, has evolved significantly, specifically in the realm of consumer-directed products. Wearable Tech gadgets launched in recent years, like Nike Fuel + Band, Jawbone, Fitbit, Misfit, and Xiaomi Mi Band, offer sensor-monitoring feedback systems similar to those developed by Mann. Most notable in terms of building on Mann's research is the recently failed launch of Google Glass (2013), which has rightly been compared to Mann's *EyeTap* system. Mann's prescient innovations in ubiquitous computing, like *EyeTap*, are closely aligned to Google Glass, and could even be considered the idea's first iteration, if not its origin.[61] The many similarities between *EyeTap* and Google Glass include: devices worn in front of the eyes as glasses; mounted cameras recording immediate surroundings; superimposed computer displays generating and inserting imagery or text onto the original scene; and network/data-analysis capabilities. In both cases, the eye-device design allows the user's eye to see both the immediate surroundings and have access to additional augmented information and images.[62]

However close the two devices' technologies (Mann's and Google Glass), their conceptual motivations were and remain completely divergent, critically and politically. In the case of Mann's device, the *EyeTap* is aligned with a practice known as "cyber-logging," or "glogging," in which the user's life and quotidian events are recorded for

[61] For Mann's critique of Google Glass, see: http://spectrum.ieee.org/geek-life/profiles/steve-mann-my-augmediated-life (accessed 18 July 2016).
[62] The recently failed Google Glass reproduced much of Mann's research in networked, camera-based devices worn on the face. Interestingly enough, the same limitation is highlighted in Mann's own, well-documented account of the discomfort amongst the general public upon seeing him wearing his *EyeTap* system.

future access and use.[63] Cyber-logging also contributed to the actualization of practices of "sousveillance" as previously discussed, in which the device becomes an oppositional force to governmental and other top-down surveillance systems. This activity is now often referred to as "lifelogging" and has become a distinctly more apolitical and narcissistic activity in which everyday consumers engage with live-streaming their day-to-day activities via the uploading of videos and photos to services such as YouTube, Facebook, and Instagram. If we compare Mann's *EyeTap* to Google Glass, while they technically resemble one another, we see that they were built with very different goals in mind. Where Mann's device created a spectacle and a statement about state surveillance and the control of information, Google Glass aims to provide a consumer product to access information for entertainment and daily use, while likely collecting a substantial body of data on the user.

Perhaps most interesting is the fact that Google Glass was a monumental consumer product failure.[64] When first launched, Google Glass was marketed as an experience augmentation device, and was harshly criticized for its lack of connectivity with the "experience" of wearing it. Later attempts at promoting the device saw the glasses marketed as a "fashion" statement, such as in the 2014 collaboration with Diane von Furstenberg. Ultimately, what Google failed to assess was the social impact that such a device placed on the face would cause, both to the user and those around him/her. Google

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[63] One example of a recent lifelogging consumer product comes to us courtesy of Swedish company Memoto, which has created the Narrative Clip, a small, coin-size camera device that can record all of one's life events. See: http://getnarrative.com/.
[64] For more on the downfall of Google Glass, see: Nick Bilton, "Why Google Glass Broke," http://www.nytimes.com/2015/02/05/style/why-google-glass-broke.html (accessed 30 April 2016).

Glass developers underestimated the device's impact, visually and socially, on everyday and natural interactions, by creating a layer of distraction and thus potentially discouraging the user from normal social interaction. Likely, Google hoped their device would "pass" as conventional glasses, as seen with the Diane von Furstenberg collaboration, which was probably aimed to "normalize" the device. However, by its very nature Google Glass transformed social interaction, and thus failed to become "invisible"; instead, it was ridiculed widely.

In fact, Mann had it right from the start. Nothing about a face-mounted network-connected device is subtle, invisible, or "normal"—at least for the time being. Perhaps in the future this might become acceptable, but for now it remains that the potential for split attention and fragmented interaction cannot but be noticed when such a device is worn. Although he hoped his device would reach the point of invisibility, the reality is that much of Mann's political position was formed through the action and experience of displaying the device on his body. I would even argue that the inventor and engineer Mann thus became the performer and social disruptor Mann.

Examined from another angle, what Google failed to account for was the social and performative aspects of wearing such a device.[65] Mann clearly understood and harnessed the full complexity of wearing a recording device on his face. Thorp, too, recognized that his wearable would not go unnoticed, and so he hid them. Both researchers recognized,

[65] The backlash against Google Glass became so extreme that people wearing them were known as "Glassholes." See: Dana Schuster, "The revolt against Google 'Glassholes,'" *New York Post*, http://nypost.com/2014/07/14/is-google-glass-cool-or-just-plain-creepy/ (accessed 30 April 2016).

however, that the wearable is present, and will thus transform the individual user's (and potentially others') experiences through its enhancement capabilities. Where Google imagined an invisible, seamless device—Mann and Thorp both recognized the social impact, as well as the ethics, of wearable technologies.

In the introduction to his book *Cyborg*, Mann explains the powerful effects of wearable technologies, both for the wearer and others:

> The more I fuse with the machine, the more I am aware of the extent to which our society and our individual lives are fused with technology that is out of our control. As I was developing new ways to live through and with technology, I was also developing an ambivalence— even a fear —of technology's place in our lives. I was in the process of becoming a cyborg—at a crossroads in my personal pilgrimage to the post-human world. But did that mean I was legitimizing a vast array of controlling technologies—from surveillance cameras to corporate-endorsed "smart" suits? The reluctant cyborg is an individual determined to harness technology's potential, but not at the expense of freedom and singularity. We can use wearable computers to enhance our lives, we can create a permanent connection to borderless cyberspace communities, we can permanently interface with the machine, so long as we retain our awareness of how our choices will affect our selves and our world. (Mann, *Cyborg*, 7)

At least, we can credit Mann for being aware not only of the potential missteps of wearables from the standpoint of social interaction, but also of the potential benefits and dangers of such a technology. In short, Mann's wearables are tools *for* interaction between users united together in a secret society pursuing an anti-establishmentarian "good." Since the 1990s, Mann has continued to develop the ways in which wearables can benefit interaction, social resistance, and emancipation from the "grid" or "system." In all these cases, the wearable is a tool for performance: the performance of beliefs, of resistance, of interconnectivity, and of interaction.

Wearables shape us, and they do so through the act of wearing them. This I consider performance. They shape us because they change how we act, and resonate with the kinds of interactions we have, both with the people we encounter and the environments we occupy or pass through. Mann's wearables transformed him into a cyborg. Thorp's wearable transformed him into a human calculator. Both of these wearables pioneers were aware of the impact of their devices upon their actions. Both understood that to wear a wearable was to perform it, to own it, and hence, to be transformed by it.

Interestingly, Wearable Tech design trajectories have for their part moved in quite the opposite direction from becoming invisible devices, instead embracing visibility through the propagation of luxury- and status-focused wearables.[66] Although wearables are not as yet actively considered as fashion, this is only a matter of time. Increasingly, we are seeing discussion around aesthetics and desirability, as companies seek to capture the imagination of consumers via Wearable Tech.[67] In this way, wearables, as they are situated on the body and construct our identity, our "look," will need to be considered on a spectrum of fashion statements, if they are to be embraced. Furthermore, as the technology is active, present, and communicating with the wearer, wearables also enter into the realm of dynamic electronics performing in tandem with the body. Seen from any angle, these early pioneers of wearables created not "mere" technologies, but new social interactions and actions (or even deviations) that continue to resonate in wearables today.

[66] For example, Apple has been launching a series of increasingly luxurious watches, including the Hermès design edition, which retails for several thousand dollars.
[67] For some examples of luxury smart watches, see: https://www.businessoffashion.com/articles/fashion-tech/will-luxury-smartwatches-work (accessed 19 July 2016).

2.2 Conclusion: We Are Not in Silicon Valley Anymore

This chapter has charted the work of two engineering pioneers in the field of wearable technologies. While Thorp capitalized on the potential of a dissimulated wearable to foster extra computational insights, Mann chose to display his identity with bold, body-worn surveillance technologies. In both cases, the authors, engineers, and designers of these wearables chose to wear, and hence, *perform* with their wearables. In both cases, their social interactions were not left unmarked by these devices. And in both cases, the devices' aesthetics were well considered in relation to their use, their meaning, and the contexts (social and built) within which they were used.

In telling of the roots of wearables engineering, I have aimed to elucidate how the birth of wearables converged with concerns about performance related to the individuals who designed them, the bodies on which they were placed, the contexts in which they were used, and the goals pursued by their users. Wearables are not mute filters or recorders that we put over our bodies or the world; rather, they are catalysts for re-shaping interaction and experience. In short, wearables were not invented (nor do they operate) in a social vacuum, but emerged instead from personal research interests (in Thorp's case, a fascination with roulette, and in Mann's, a desire to connect his body to the Internet and other people). In both cases, the road to accomplishing these outcomes involved considerations of technological functionality, body awareness, and an element of social performance. In the case of Thorp, the functionality was anchored in the "invisibility" of computational analysis. In that of Mann, the functionality emerged from a cyborgian desire to be connected to information, images, and others via the Internet.

These early wearables, while historically described as engineering feats, are much more complex than this. With their presence on the body, their context-aware designs, and their resonating power to change a wearer's actions, these wearables were performative. As we will discover in the following chapters, the concept of performance can help to nuance our understanding of the human and nonhuman agencies at play in the field of wearables.

3 PERFORMATIVE WEARABLES: BODIES, FASHION, AND TECHNOLOGY

3.0 Introduction

From Performance to Performativity

In contrast to the representation models of indexing, archiving, and documentation, performance and performativity—both as theory and practice—have increasingly been taken on as paradigms for the modality of knowledge production occurring in the arts and humanities, as well as in technoscientific discourse. This shift can be traced to a general concern for "action," which has permeated twentieth-century culture and science, and is echoed in a variety of disciplines, including linguistics, anthropology, sociology, media arts, fashion, and laboratory research. This marks a turn away from fixed representational documents as knowledge depositories and toward the investigation of event- and time-based structures as forms of knowledge themselves, in which performance is key.

Although in the previous chapter we touched upon the notion of performance in relation to the birth of wearables, we have yet to explain or expand on what we mean concretely by performance and performativity. The aim of this chapter is to formulate a theoretical ground for the concept and practice of performance, and develop a series of lenses and tools with which we may analyze wearables. My goal is to argue that wearables are not only best understood through performance concepts, but are also materially and practically situated within a rhetoric of performance as encountered through the spectrum of sociology, media arts, fashion, and science, technology, and society (STS). This rhetoric is composed of multiple, overlapping fields that use performance as a base from which to analyze both human and nonhuman activities, not just in the arts and humanities, but also within the sphere of technology. Here I wish to peel off the various conceptual layers that envelop wearables, making a trajectory from the inside out, and tracing performativity from the body outward, through technology, via the garment, and finally into the laboratories in which wearables are birthed. By mapping out how and where performance occurs and is theorized in society, arts, and science, we can better situate wearables within an ecology of performance as linked to their use and effects on the body; their design and aesthetic choices; and their technological expressivity. Such a path will permit us to appreciate how performance is present within the many tangible and theoretical phases of the wearable.

The first section of this chapter investigates the legacy of the "performative turn" through sociological texts that expand the notion of performance beyond the theatrical stage, in which language, identity, and social dramas are constructed through and with performance. I argue that concepts (and practices) of performance have bled into everyday actions, which, when combined with tangible and symbolic objects (props, costumes, architectural contexts, and other non-traditional forms of performance staging) shape meaning and impact the individual. Thus, sociological perspectives of performance propose germane frameworks to look at questions of the formation of the self that occur through the wearing of wearables.

The second section investigates theories from media arts that engage the body. I look at how the body and materiality have been problematized in media arts thus far—via hardware to software, as well as interfaces. Specifically, I question how wearables, a tentacle of media-arts research, propose new forms of bodily and material interfaces that have not (yet) been fully considered in media-arts scholarship. With this goal in mind, I investigate media-arts theories influenced by phenomenological perspectives wherein active bodies shape the technology.

The next section examines fashion's ability to construct meaning through the visual orchestration of bodies and garments within performance and event-based contexts related to fashion, including the performative contexts of runways and the street. Fashion theory has much to say on the topic of how we display, communicate, and act out our identities, gender(s), class, and desires through the various aesthetic choices that we make via our clothes and body adornments. Because wearables are embodied within garments, which themselves become fashion statements, it is important to understand how fashion constructs these performative expressions.

Last, I explore the laboratory's contributions in forming performative research structures as seen through the lens of STS literature. Laboratories house their own performative logic, in which various research rituals, tools, and human/nonhuman interactions come to shape materiality and knowledge. We explore how notions of "action," performed by human and nonhuman contributors, inform wearables through the performance of the laboratory's epistemic culture.

While cutting across different domains, this performance-focused analysis—spanning sociology, media arts, fashion, and STS—serves as a foundation from which we may investigate the links and continuities between the bodies, fashions, and technologies of the wearable. My aim is to demonstrate how performance is present everywhere that the wearable is present: from the body that it rests on, to the fashion designs that house and frame its technology, and to the laboratories where they are built. By doing this, I hope to convince my reader that performance, via its many facets, is the most appropriate and transversal theory with which to consider wearables.

3.1 Performative Bodies

A "Performative Turn"

The last fifty years have seen an increase in the use of the terms *performance* and *performativity* in non-theater/stage-associated research fields, such as linguistics, anthropology, ethnography, and sociology. The "performative turn," a paradigmatic shift in humanities and social sciences from the 1960 to the 1980s, adopted performance-inspired methods and situations as subject, object, and research methodology. These utilized grounded, intimate, and embodied practices to source experiences and material from which to understand society at large. The modes of research employed stemmed principally from first person and everyday interactions, observations, and analyses, while embedded within an intimate social context, thus stepping away from representational and symbolic models of inscribing the "real" world. This type of research methodology can be seen in the work of numerous linguists, sociologists, and anthropologists, like J. L. Austin, Erving Goffman, Victor Turner, and Dwight Conquergood.[68]

The performative turn's uniqueness was through an exploration of methodologies and sites of analysis, which began first with language and then moved into action—from rituals, play, games, sports, identity, and all forms of performative practices in society—wherein action and performance are foregrounded as key to shaping culture. This mode of research, which involves engagement, observation, analysis of spoken language's effects (Austin), the construction of the social self (Goffman), and participation in social rituals and games (Turner, Conquergood), constituted a new "in-action" and "in-situ" method of understanding the human being in society. These notions have since gained mainstream acceptance in the everyday parlance of our actions, where the ideas of identity construction and social rituals are accepted elements in society.[69] However, these concepts have yet to be applied or used in the practice of understanding and analyzing the admixture of fashion

[68] For more on the anthropological/sociological view of society as performative, see: Dwight Conquergood, "Poetics, Play, Process and Power: The Performative Turn in Anthropology," *Text and Performance Quarterly* 9, no.1 (1989): 82–95; Christopher L. Salter, *Entangled* (Cambridge, MA: MIT Press, 2010); Richard Schechner, *Between Theater and Anthropology* (Philadelphia: University of Pennsylvania Press, 1985); Richard Schechner, *Essays of Performance Theory: 1970–1976* (New York: Drama Book Specialist, 1977); Richard Schechner, *Performance Studies: An Introduction* (London and New York: Routledge, 2002); Richard Schechner, *Performance Theory* (London and New York: Routledge, 1988/2008); Victor Turner, *Dramas, Fields and Metaphors: Symbolic Action in Human Society* (Ithaca, NY: Cornell University Press, 1975); Victor Turner, *From Ritual to Theatre: The Human Seriousness of Play* (PAJ Publications, 1982); and Victor Turner, *The Ritual Process: Structure and Anti-Structure* (Aldine Transaction, 1969/1995).

[69] Although I do not discuss performance art in this thesis, mention should be made of this field's important contribution in problematizing the body. See: Amelia Jones, *Body Art, Performing The Subject* (Minneapolis: University of Minnesota Press, 1998); Allan Kaprow, *Essays on the Blurring of Art and Life* (Berkeley and Los Angeles: University of California Press, 1993); Marcel Mauss, "Techniques of the body," *Economy and Society* 2, no. 1 (1973): 70–88; Peggy Phelan, *Unmarked: The Politics of Performance* (London and New York: Routledge, 1993); and Rebecca Schneider, *The Explicit Body in Performance* (London and New York: Routledge, 1997).

combined with electronics, otherwise referred to as wearables, especially as the latter come to shape body movement, awareness, actions, and the social dramas that may unfold in wearing them. Hence, I aim to devote some consideration to how sociological frames can shed light on wearables.

Acting as Meaning

It was the British philosopher of language J. L. Austin who first introduced the notion of performance in language. In the 1960s, Austin introduced the concept of "utterances," in which the "uttering of a sentence is, or is a part of, the doing of an action…" wherein meaning is constructed through the act of speaking (Austin, *Words*, 5). Austin explored the effects of language in *producing* meaning and change through the utterance of words.[70] What becomes important in the uttering of the text, as Austin notes, are that "the *circumstances* in which the words are uttered should be in some way, or ways, *appropriate*" (Austin, *Words*, 8). What this posits is that the context and elements accompanying the uttering of the words—which may include the tone of the speaker; the physical setting where the utterances are taking place; the way the person is dressed; the audience; and other, accompanying events occurring at the time of the utterance—impact and create the meaning of the words. In short, Austin argued that words shift their meanings depending on the speaker, location, delivery, receiver, and intent. Austin further

[70] Austin's student, John Searle, builds on Austin's theories in *Speech Acts: An Essay in the Philosophy of Language* (Cambridge, UK: Cambridge University Press, 1969). For the purpose of this thesis, however, I will limit my analysis of speech acts to those discussed by Austin.

notes how these "performative sentences" or "performative actions" do more than "just say something," they in fact *create* something (Austin, *Words*, 7). The importance of Austin's theory is that it seeded the notion that language's meaning was fundamentally transient and malleable depending on environment and context. In this regard, Austin's concepts set off a whole re-evaluation of the construction of meaning through events in the fields of sociology and anthropology, which came to inform most of twentieth-century scholarship around society, politics, gender, culture, and now wearables.[71]

Constructing the Social Self

One of the performance theories most germane to the field of wearables comes from Canadian-American sociologist Erwin Goffman, who conceptualized the construction of social identity.[72] Akin to Austin, Goffman believed that it is through action that self/identity is socially formed. Echoing Austin's theory of "performatives," Goffman posited that our social identities were willingly shaped through directed and intentional actions. How we behave and choose to present ourselves in the everyday—in attitude, dress, and utterance—constructs our identity and suggests a script from which others may "read," or situate us socially. By observing and analyzing the ways in which our social actions are modulated by

[71] Feminist gender theorist Judith Butler was highly influenced by Austin's concepts. However, while gender theory as approached by Butler is a rich and complex topic, it will not be discussed in this thesis. For more on the link between Austin and Butler, see these works by Butler: *Bodies That Matter: On the Discursive Limits of Sex* (London and New York: Routledge, 1993); *Excitable Speech: A Politics of the Performative* (London and New York: Routledge, 1997); *Gender Trouble: Feminism and the Subversion of Identity* (London and New York: Routledge, 1990); and *Undoing Gender* (London and New York: Routledge, 2004).

[72] For more on Goffman's theories of social construction, see: Goffman, *Frame Analysis: An Essay on the Organization of Experience* (London: Harper and Row, 1974); and Goffman, *The Presentation of Self in Everyday Life* (New York: Anchor Books, 1959).

context, social affiliation, and the projection of desired effects on others, such as seeking social acceptance, status, sexual desirability, economic standing, and other characteristics, Goffman argued that our identities were, in fact, a performance.

Goffman characterizes our social actions as a form of theater in which two interlocking layers of performance occur at once: the first is the desired, or "constructed," performance of the individual; and the second, is the "perceived" performance of the individual by others. Any gap between the "constructed" self and the "perceived" self only further exacerbates a failure of successful identity projection. From Goffman's perspective, identity construction is predicated on an agreed-upon adherence to collective meaning and social believability, mixed with an acceptable degree of personal or aspirational "construction."[73]

Thus, "collective representation," as described by Goffman, includes implicit and explicit expectations of the roles the individual plays for and about herself/himself in conjunction with the expectations of the public. Professional roles come with set expectations of public display that include a uniform, types of interaction, geographic or architectural settings, and other features. Any encounter that diverges from these standards of "collective representation"—a doctor impersonating a clown, for example, or vice versa—would violate these expectations of "collective representation."

In this way, "collective representations" contribute to what Goffman calls the "front." The "front" is composed of associated elements that present an expected image.

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[73] Goffman notes that it will always be easier for the outside viewer to see the discrepancies in our constructed selves/performance than it will be for us to judge for ourselves (Goffman, *Presentation*, 9).

Today, when we say that we are "putting on a front," it implies that we are lying or faking.[74] However, many of the ways in which we construct our social identities are predicated on this "front," a social convention that is a fabrication (maybe even a little bit of a lie, or wish fulfillment), which we, as a society, collectively agree to accept. Hence, the manner in which Austin's "utterances" are contingent on a set of complementary conditions is contiguous with the way identities are also dependent on changing but "coherent" sets of social conditions.

This front, or performance of identity, informs both the actions (gestures, modes) that we engage in when in social contexts, as well as our outer layer of garment, style, and appearance. This is important to the topic of wearables, because it argues that, as social beings, we continuously straddle our desired projections and the implicit judgment of others. How wearables might participate in this construction of self is something that many are testing and developing today. To be sure, given the intimate and body-specific nature of wearables, it is inevitable that they will become active as indicators and constructors of our social and collective selves (if they aren't already). Less well known is how wearables may betray or run counter to these desired projections and constructions, or otherwise betray us. An example of this failed double layer of social performance can be seen in Google Glass,

[74] Efrat Tseëlon argues that the "Goffmanesque self is postmodern in that it consists of surfaces, or performances." Tseëlon, "Is the Presented Self Sincere? Goffman, Impression Management and the Postmodern Self," *Theory, Culture & Society* 9 (1992): 121. Although I do not address the "postmodern condition" as argued by Jean-François Lyotard in this thesis, in all "conditions," postmodern or otherwise, the self is described as constructed through performance.

wherein the outer and inner social layers could not align, thus creating a gap between the two, and hence a rejection of the device by either the individual, or the collective, or both.[75]

Social Drama

As I have suggested, wearables, as a greater social project, are not apolitical. They are, however, often presented to us as "necessary" elements of safety or wellbeing. For example, health-tracking devices are marketed to us as adding value to our workout or diet regime. What might happen, however, when these devices are introduced in the workplace or school? How might wearables become expressions of power, or even tools of coercion? And how might the social drama of wearables' collecting of physiological data and tracking of human activity reflect political and social tensions?

These are questions rarely asked in the context of a utopian, positivistic drive toward the technological. And yet, when we wear a wearable, such as Wearable Tech, we participate in the greater political landscape of our time. Wearables, because of their intimate link to our bodies and our actions, highlight the stakes at hand in the social drama of a perceived "smart society," and how our participation may play out into the different power dynamics of governments, corporations, and individuals. For now, we have but few tools to identify or explain such moments in which tensions arise when wearing a wearable.

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[75] It could be argued that Google did not consider, to an important enough degree, the type of public performance that the wearers would be engaged in, and that performance's effects upon others around him/her. Of note is the fact that mobile telephones offer many of the same communication functions as Google Glass, but does not create the same effect. I believe that the discrepancies in effect lie in the fact that the Google Glass is worn on the body and transforms the wearer's face, and hence his/her relationship to others.

Identities, though they are constructed as fronts and are negotiated socially, are also ripe for conflict. For as much as we may attach meaning to utterances, or to the intentional construction of our social identities, larger political and social pressures beyond the individual may further impact and shape our everyday actions and interactions. The social climate of our time influences not only how we think of our bodies and identities, but also the objects we place on them and the meanings we associate with them.[76] Cultural anthropologist Victor Turner argues that our actions as citizens and community members—including political struggles, ethical dilemmas, and governmental compromises—are inscribed in what he has coined "social dramas." For Turner, life—everywhere—is imbued with social dramas that cycle through four phases: breach, crisis, redress, and *either* reintegration or recognition of schism (Turner, *Ritual to Theatre*, 69).[77] Turner describes these social dramas like this:

> "I tend to regard the social drama in its full formal development, its full phase structure, as a process of converting particular values and ends, distributed over a range of actors, into a system (which is always temporary and provisional) of shared consensual meaning" (Turner, *Ritual to Theatre*, 75).

Thus, social drama, for Turner, is a collective transformation. It is even perhaps a revolution, a shift, or a *zeitgeist*. He describes social dramas as "humankind's thorny

[76] A wonderful example of the politics of symbolic association can be found in the evolution of jeans. In Tom Wolfe's introduction to René König's *A La Mode: On the Social Psychology of Fashion*, trans. F. Bradley (New York: Seabury Press, 1974), he describes the ascent of blue jeans from radical chic to socialite hip. Influenced by the Black Panthers and other social revolutionaries, the blue jean, which stood for the proletariat and counterculture, was quickly appropriated by the middle- and upper-class "hippies" of the 1960s wanting to identify with social change.

[77] Victor Turner was highly influenced by Dutch/German/French ethnographer Arnold van Gennep's *The Rites of Passage*, trans. M. B. Vizedon and G. L. Caffee (London and Chicago: University of Chicago Press, 1960 (1908)), particularly in Turner's text *The Ritual Process: Structure and Anti-Structure* (Aldine Transaction, 1969/1995).

problem" through which we articulate "where power and meaning lie and how they are distributed" (Turner, *Ritual to Theatre*, 78). Turner builds on Dutch/German/French ethnographer Arnold van Gennep's idea that rites of passage construct an "in-betweenness" akin to a border or threshold between crises. Turner describes this ritual process as "liminal," or existing in a transitional state (Carlson, *Performance*; van Gennep, *Rites*). A "liminal" state is experienced in traditional cultures when, for one example, a boy becomes a man. During this transitional period, the individual is neither quite boy nor yet man (Turner, "Betwixt and Between").

For Turner, "liminal" activities are characterized as "anti-structure," opposing the structure of everyday cultural operations in which work and play are clearly divided (Carlson, *Performance*, 19). However, Turner recognizes that many activities in industrialized society—such as sport, leisure, and art—no longer operate at a clear divide between play and work. These variegated zones of activity, like professional sport or theater acting, according to Turner, provide an opportunity for social and cultural disruption and resistance, which create what he calls a "liminoid" space. The primary difference between "liminal" and "liminoid," is that the former refers to a major life-transforming event, ritual, or crisis, such as a birth or marriage, while the latter describes experiences that contain characteristics of the liminal but do not involve a sharp resolution of a personal crisis or major rite of passage. Hence, "liminoid" is a more complex and nuanced transitional space, which does not provide clean breaks in the passage from one state to another, but rather vacillates at the intersection of an "in-between" transformation.

We can use this concept of the "liminoid" to express how micro-ruptures happen through devices such as wearables, where the human wearing it is neither fully working nor at play, neither fully participating or not participating in the wearable. The "liminoid" accurately describes this passive, parasitic quality of wearables and other body-worn devices in their capacity to collect data, energy, etc., without immediate awareness or visualization thereof. An example of this "liminoid" loop can be seen in Anouk Wipprecht's *Agent Unicorn*, a work developed in collaboration with the Ars Electronica Center in Linz. This device, designed and 3D-printed to look like a unicorn horn, records attention spans through electroencephalogram (EEG) readings for children with attention deficit hyperactivity disorder (ADHD) to self-identity when and under what conditions they are focused, or not. Offering a self-perception of states of attention, which are programmed for change, *Agent Unicorn* proposes to highlight the transitional state of concentration in a manner that is both play and work, and provides a high degree of open-endedness in terms of success ratios.

When body-garments begin to react pre-emptively and shape our personal expressions for us, we can no longer relegate their roles to something we construct or control autonomously, however politically or socially motivated. Such a dynamic, sensitive sartorial interface—which is in synch with the environment and with the body's physiology, for example—did not exist before wearables. We have yet to construct a language or theory for how technologized fashion on the body can and will propose new forms of identity constructions, social dramas and political intrigue, or gender formations. However, I aim to argue that as wearables shape these new selves, experiences, and interactions, the best method to underscore these changes and situate their impact is through the lens of performance.

In this overview of sociological and theoretical frames of performance, I have tried to outline how the body (both individually and collectively) performs in context. Bodies have meaning that is formed through social, political, and physical standpoints. As we have seen, the body is never a mute or unscripted terrain. Rather, bodies are part of an intricate performance in which the curating of "utterances" (Austin), constructions of collective identities (Goffman), and social dramas or "liminoid" moments (Turner) push and pull at them. Yet, when we wear a wearable, or place a wearable on a body, we add an extra layer to this performance and construction of the social individual.

3.2 Performative Media

Second Skin

The media philosopher Marshall McLuhan viewed technology as an extension of the body, wherein our senses were solicited to interpret and experience media. He noted that, "the electric age ushers us into a world in which we live and breathe and listen with the entire epidermis" (McLuhan, *Understanding Media*, 122). This epidermis, by which McLuhan means the outer layer of the human skin that protects the flesh, can be used as a metaphor for the second skin that is wearable technologies. As techno-fashion researcher Sabine Seymour has noted, digital displays from mobile to networked environments are merging with the organic epidermis of our bodies through wearable technologies (Seymour, *Fashionable Technology*; Amitai and Seymour, *Computational Fashion*). Hence, our bodies have increasingly been solicited by interfaces, mediated through technologies from interactive art to handheld and embedded devices. This techno-organic epidermis is constructing new relationships with technology, in which the body is ever closer, ever solicited, complicit, and active. Increasingly, the design of technological objects, such as Internet of Things (IoT) objects, is jumping the gap into everyday objects, from cars, to architecture, and floors, to toasters. Furthermore, intentions and uses of technology are blurring the traditional division of activities between work, entertainment, education, and information. As the concept of McLuhan's mediatized "epidermis" is pushed closer and closer to reality, our ideas about the relationships we forge with technology—its uses, and presence of our somatic selves—require further investigation and clarification.

Embodied Media Arts

New media as a theoretical framework is not only new but inherently diversified in its combination of technological and artistic investigations, which include the moving image, sound, photography, the Web, code, and physical computing. The general field of media arts has contributed considerably to the analysis of the role of the body via two major strands related to the body: interaction and interface design; and notions of embodiment in mediated art spaces and technologies. Interaction or interface theories in media arts, for the most part, have questioned: legacies of screen design (Lev Manovich, *The Language of New Media*); the cultural ramifications of online identities and life (Sherry Turkle, *Life on the Screen*; *The Second Self*); and power and political dimensions of networked culture

(Alexander Galloway, "Protocol"; *The Interface Effect*; and Mathew Fuller, *Media Ecologies*).

Meanwhile, theorists touching upon embodiment, such as Don Ihde and Anna Munster, approach the question of the body as a virtual (space) problematic (Ihde, *Bodies in Technology*: Munster, *Materializing New Media*). A strong current of posthumanist media theory continues to dematerialize the physical body into digital screens, avatars, and data. For example, Munster proposes that new-media technologies offer a new "fold" through which the body reproduces itself into digital realms (Munster, 64). When the tangible body is called forth to act with technology, it often does so via performances showcasing provocative cyborg-inspired body modifications, such as those of Stelarc and Orlan (Ihde; Munster, 20).

Although these concepts can be useful in creating a philosophical framework for the body *in* technology, they scale difficultly to computation devices worn *on* the body. Media theorist Mark Hansen is perhaps closest to the mark on the question of wearables as an area of investigation. In his *Bodies in Code: Interfaces with Digital Media*, which draws from Merleau-Ponty, Hansen considers the mingling of "bodies" and "technology," where "technics of the body" (Bernard Stiegler) and "bio-techno-phenomenologism" (Gilbert Simondon) inform his arguments (Hansen, *Bodies*, 84). However, when Hansen comes to the subject of wearables, he surprisingly expands the field to include "wearable spaces"—notably connoting architecture—again, as though the body *with* (as opposed to *in*) technology was incompatible (Hansen, *Bodies*, 175).[78] Hence, notions of technologies on and with the body require specific attention with regard to the field of media arts in order to fully situate the media interfaces of wearables.

Cultural Wearables

Susan Elizabeth Ryan, professor of art history at Louisiana State University, has argued in her comprehensive overview *Garments of Paradise: Wearables Discourse in the Digital Age*, that wearables can already be situated as a subset of media arts practices—what she refers to as Wearable Technologies (WT).[79] Via Ryan's point of view, we can understand wearable technologies as cultural interfaces seen through a prism of media and cultural theories, including those of Theodor Adorno, Manuel De Landa, Paul Dourish, Mark Hansen, Lev Manovich, and Anna Munster. While some of the aforementioned theorists do engage with the body and materiality from an interaction and media-arts standpoint, none of them (other than Ryan), as we will see, have done so explicitly via the body-situated technologies encountered in wearables and fashion-tech.

Ryan's primary concern lies in elucidating how "[c]lothing and other kinds of ornamentation make the human body culturally visible" (Lemoine-Luccioni 1983). In her

[78] Given that Hansen strives to create an inclusive theory of the body in technology, it is perplexing that he chooses to focus on "wearable spaces," which for the most part are understood as referring to modes through which digital and virtual environment contain and activate avatars and representations of the body, as opposed to situated technologies on the body as developed through wearable technologies and fashion-tech. See: Mark B. Hansen, *Bodies in Code* (London and New York: Routledge, 2006).
[79] Ryan has also used the term Wearable Technology Art (WTA) to describe her area of research, which should not be confused with the similarly named World of WearableArt (WOW), located in Nelson, New Zealand, which operates an annual costume award and exhibitions. See: Suzie Moncrieff, *World of WearableArt* (Nelson, New Zealand: Potton and Burton, 2013).

path toward defining "cultural visibility" for the body, she casts a wide net that includes wearables but also non-technological garments, portable digital devices, screen culture, and more. As an overarching theoretical framework, however, Ryan falls back on a semiotic model of analysis through which we encounter the wearable as a crystallized symbol of culture-at-large, as opposed to an object in and of transformation. While important, Ryan's contribution—bringing together numerous works, and various historical currents under one cover—remains problematic in considering the active and performative dimension of wearables. Ryan's oeuvre (see Bibliography) does, however, succeed in mapping a historical path through a variety of cultural references that initiate a conversation around a deeper meaning for wearables within media-arts scholarship.

Phenomenological Wearables

One place to look for the inclusion of the active body within media arts and wearables is in the work of dance and media philosopher Susan Kozel. A professor of new media at Malmö University's Medea Research Lab, and with hands-on experience as well as theoretical clout on the subject of wearables, Kozel is a key contributor to the visionary "Whisper[s]" (2001–03), an ambitious wearables research project developed in collaboration with Thecla Schiphorst, associate director and professor at the School of Interactive Arts and Technology at Simon Fraser University.[80] Her book *Closer:*

[80] For more on the project, see: Thecla Schiphorst, "Breath, Skin and Clothing: Using Wearable Technologies as an Interface into Ourselves," *International Journal of Performance Art and Digital Media* 2, no. 2 (2006): 171–86.

Performance, Technologies, Phenomenology, is one of the few texts to take on wearables from a philosophical perspective. Using Maurice Merleau-Ponty's later writings on phenomenology—such as those presented in his *The Visible and the Invisible*—as a departure point, Kozel explores the body-techne relationship experienced though interactive interfaces, responsive systems, and affective computing networked with wearables devices and garments.[81]

In Kozel's analysis, Merleau-Ponty's phenomenology posits a foundational role for the body in perception and engagement with the world, breaking with a long tradition of privileging consciousness as the central source of knowledge. Considering our relationship with technology, Kozel argues how it "became clear that the perspectives of dance and philosophy provide an *authentic* stance from which to reflect upon the wider implications of human bodies using digital technologies, filing a gap in scholarship and in broader cultural discourse around digital technologies"[82] (Kozel, 12).

In *Closer*, Kozel formulates a dual agenda, one in which the "positivistic reduction of science" is questioned alongside a "chiasmic, embodied, and first-person methodology" of technological use (Kozel, 16). In many ways, this position resonates with my own desire to further problematize technoscience—and specifically, in this case, wearables that embody an enmeshment of actions (performance) and materials (body, fashion, and

[81] Merleau-Ponty's version of phenomenology was developed in the mid-twentieth century as an important philosophical drive to understand consciousness through an awareness and consideration of the body. For more on phenomenology, see: Maurice Merleau-Ponty, *Phenomenology of Perception*, trans. Colin Smith (London and New York: Routledge, 2003 (1945)); Maurice Merleau-Ponty, *The Visible and the Invisible*, trans. Alphonso Lingis (Evanston, IL: Northwestern University Press, 1969).
[82] Author's emphasis.

technology). If in *Closer* we encounter the body as central to our understanding and experience of technology, there is, however, little analysis of the design and aesthetics of very tangible interactive garments. As Kozel's stake is in analyzing the body through technology, she is particularly concerned with re-situating action (movement, dance, and physicality) into system interfaces. By using performance—in this case principally through examples culled from dance and movement workshops/events conducted in black-box environments—Kozel examines how the body is shared though diverse interfaces of digitized signals that span telematics, motion capture, responsive architecture, *as well as* wearable computing.

Kozel's theoretical framework thus posits a body-technology relationship wherein the contributions of design objects—be they wearables, fashion-tech garments, or tangible user interfaces—remain either invisible or unavowed. It is as if the media-body relationships brought forth in *Closer* begin with the body (the essential starting point of Merleau-Ponty's phenomenology), and then quickly jump into the disembodied digital landscape of the computer screen, negating almost all material resonances or contributions of the design artifact.[83]

For example, motion-capture technologies, which interpolate the body's movement more or less directly into "immaterial" digital inputs, are used by Kozel to build her

[83] Friedrich Kittler has argued for the physicality of code as embedded in computer systems. However, within the context of this thesis and in regard to wearables, I draw a sharper distinction between material and immaterial, casting screen and digital media as more on the *immaterial* spectrum and wearables as *material*. For more on the materiality of computers and code, see: Friedrich Kittler, "There Is No Software," *CTHEORY: Theory, Technology, Culture* 32 (1995), http://www.ctheory.com/article/a032.html.

theoretical framework. This means that the technology—and the body, for that matter—are (re)presented mostly within screen and capture mechanisms. A trained dancer and philosopher—as opposed to engineer or fashion designer—Kozel's insistence on body and meaning is arguably acceptable, but it is too limited for a full consideration of wearables. Indeed, what Kozel leaves out, or neglects to engage with, is how materiality—a garment's fabrication, aesthetic choices, colors, materials, and more—also perform on the body, as well as with the technology. For example, when Kozel discusses her project "Whisper[s]," she is chiefly interested in how the garment creates new connections between people, yet no explanation is made for the garments' aesthetics or (con)structural choices/limitations.

Although we remain optimistic for McLuhan's vision of an integrated techno-skin, the problematics of a suitable theoretical framework for wearables from within media arts lies in the limitations of the frameworks used thus far. While embodiment too often refers to representations of bodies in technology—and a semiotic model ossifies wearables (or fashion, bodies, and technology) into static and categorizable symbols—phenomenology casts the body as preeminent and other apparatuses (fashion, technology) as secondary. A useful theory of wearables is one that can accommodate change, and a democratic interplay of the three elements that come together within it: technology *with* fashion *and* bodies.

3.3 Performative Fashion

Sartorial Codes

Performance theories discussed thus far have been predominantly concerned with the creation of meaning through frameworks highlighting the body in its social and cultural context, or with technology as an interface that connects to the body. Fashion discourse, for its part, is *specifically* focused on the garment's contribution to the construction of social meaning. Fashion has its own set of theories and modes of interpretation attached to the adornment of the body addressing the individual, as well as society. These theories differ from those stemming from performance studies and media arts, as the production, wearing, and dissemination of clothing and style is their primary departure point of analysis, as opposed to the body, or the body in technology/culture, even though body and clothing are almost always intertwined.

In fashion theory, the emphasis is placed on understanding social codes and influences as expressed through sartorial choices that include personal expression, social and economic codes, and allegiances to various subcultures. I will contrast three theoretical forms explored in fashion theory—emulation, psychology, and communication—in order to provide a richer ground from which to discuss the performativity of fashion in wearables.[84]

[84] Although the scope of this thesis cannot address this topic, it is important to note that recent theories and exhibitions have begun to analyze fashion from an art perspective. This idea could have interesting resonance with wearables and fashion-tech of a more art-related nature. See: Markus Bruderlin and Annelie Lutgens, eds., *Art and Fashion: Between Skin and Clothing*. (Bielefeld, Germany: Kerberg Verlag, 2011); Diane Crane, "Boundaries: Using Cultural Theory to Unravel the Complex Relationship between Fashion and Art," in *Fashion and Art*, ed. Adam Geczy and Vicki Karaminas, 99–110 (Oxford and New York: Berg, 2012); Isabelle Gray, "The Latest Fashion: On Art as Fashion and Fashion as Art," in *Fashion and Imagination: About Clothes and Art*, ed. Jan Brand and José Teunissen, 44–57 (Arnhem: ArtEZ Press, 2009); Alice Mackrell, *Art and Fashion: The Impact of Art on Fashion and Fashion on Art* (London, UK: Batsford, 2005); *Reflecting Fashion: Kunst und Mode seit der Moderne* (Vienna: Museum Moderner Kunst Siftung Ludwig

The Emulation of Style

Theories around dress and fashion begin with the garment itself. However, emulation theories address the ways socio-economic systems dictate what clothes go on which bodies. Texts by turn-of-the-century German sociologist Georg Simmel postulate that styles began at the top of the social hierarchy, with the elite forging a distinctive style of dress, which is then emulated by the lower classes, hence triggering a "trickle-down effect" (Simmel, *On Individuality and Social Forms*). Theories of emulation rely heavily on a unidirectional social flow from rich to poor, leaving little opening for individual "expressiveness" in fashion or for stylistic "reverse engineering." Simmel describes the fashion landscape as such:

> Fashion is the imitation of a given example and satisfies the demand for social adaptation; it furnishes a general condition, which resolves the conduct of every individual into a mere example. At the same time it satisfies in no less degree the need for differentiation, the tendency for dissimilarity, the desire for change and contrast, on the one hand, by a constant change of contents, which gives the fashion today an individual stamp as opposed to that of yesterday and of to-morrow, on the other hand because fashions differ for different classes—the fashions of the upper stratum of society are never identical to those of the lower; in fact, they are abandoned by the former as soon as the latter prepares to appropriate them. (Simmel, 296)

Emulation also proposes tensions in expressions of individualism versus collectivism; a creative push-and-pull still at play today between the classes (Simmel, 308). As we have seen since the mid-twentieth century, fashion now increasingly flows in both directions,

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Wien (MUMOK), 2012); Mitchell Oakley Smith and Alison Kubler, *Art/Fashion in the 21st Century* (London and New York: Thames and Hudson, 2013); and Chris Townsend, *Rapture: Art's Seduction by Fashion* (London and New York: Thames and Hudson, 2002).

and the desire to "fit in," as well as "stand out," resonates in today's stylistic choices.[85] Comparing Simmel's observations on fashion emulations to Austin's "utterances" reinforces the idea that fashion is continuously constructed anew from existing cultural paradigms that re-surface and are re-structured. Specifically, one can understand how the admixture of fashion and technology, as seen both from Simmel's perspective and from the standpoint of the performative turn (Austin, Goffman, and Turner), plays upon known, citable categories of fashion and culture that are re-mixed to create new meanings about social adherence and expression. A clear example of emulation of style, as discussed in Chapter 2, is Mann's understanding of the *EyeTap* design as influenced by popular concepts of cyborgs and cyberpunk posthumans as presented in 1990s popular media.

Psycho Dress

Although we have so far mostly pondered social construction of fashion (and the body), a strong psychoanalytical current runs through both. In fashion, we discover a formulation of "social regulating system(s)" entwined in personal psychology and collective desires found at the chasm of disruption and change. In the 1970s, German sociologist René König argued that fashion, as a psychological dimension of humanity, has an expressively transformative power on the wearer:

[85] Although this thesis does not aim to probe very deeply into the role and popular ascent of subcultures, it is certain that one of the most vital forces of cultural influence since the mid-twentieth century has been youth culture. One can today see the flow of influence in reverse, with subcultures trickling up to the mainstream, as shown in the recent exhibition *Punk: Chaos to Couture* (2013), organized by the Metropolitan Museum of Art in New York, which traces the influence of punk culture on *haute couture* collections.

> We must destroy here and now the widely held prejudice that fashion is only concerned with the outer cover of man in dress, jewellery, and ornaments. Since it is a general social institution it affects and shapes man as a whole. … In reality fashion is a universal, formative principle in civilization, capable of affecting and transforming not only the human body but the modes of expression. (König, 40)

Furthermore, for König, fashion is part of a cycle of acceptable and deviating enactments of styles that constantly (and somewhat contradictorily) buttress up against one another to produce newly acceptable forms of sartorial expression. In this way, stylistic change occurs when there is a disruption or deviation, which is quickly assimilated into new styles, which subsequently become accepted, and so on. Perhaps the body's most dependable marker is the ways in which it is adorned, which change constantly to express current trends, beliefs, and economics over time. As notes König:

> Fashion, as a regulator in its own right becomes a pacemaker of social change, in the course of which customs and the tradition of style reach their end and new possibilities are opened up. (König, 45)

In this way, fashion "occupies the dividing-line between the past and the future, and consequently conveys a stronger feeling of the present, at least while it is at its height, than most other phenomena" (Simmel, 303). Understood literally, fashion is the dividing line between past and future, and yet, like time, it is always "in the now." Taking its cues from personal choices and social trends, König describes how fashion is part of a social cycle of change and in/stability—or acceptable deviation—in which "the spread of fashion is closely dependent on the existence of a 'scene,' a stage on which the novelties are displayed" (König, 57).

One example of this time-based, destabilizing form of fashion is Anouk Wipprecht's *Pseudomorph* dress, which is designed to work as a disruptive and unruly “action painting.” The work performs by creating a one-time event on the garment, where, at a given moment, the wearable begins to bleed purple liquid, irrevocably staining the front of its pristine, white felt structure. This aberrant event (is anything worse than a stain on the front of your garment?) becomes the aesthetic of the dress itself, as well as a very concrete marker of time, thus, in one squirt, rewriting the limits of acceptability in fashion.

How then might König’s theories of acceptance and deviance further relate to wearables fashion? Indeed, wearables are often referred to as “not fashion.” Few designers have gained mainstream acceptability in integrating technology into their collections, and in most cases, these have been for the purposes of runway show theatrics, as opposed to actual clothes that you and I would (or could) buy. And yet, if we accept that everything we place on our bodies participates to some extent in the fashion discourse—deviant or not—one must also accept that wearables need to be considered as part of today’s fashion discourse. Wearables, to be sure, are part of a timely transformation of the materiality and stylistic dimension of clothing.

Communicating Fashion

Recently, communication theory, based on post-structural readings of clothing and their social codes, has been informing how theorists think and write on fashion (e.g., Malcolm Barnard, Fred Davis, and Anne Hollander). For example, some texts, such as Roland Barthes’ *Système de la Mode*, focus on a strict system of semiotic meaning to explain fashion through print, and close readings of fashion magazines. For cultural theorists Barnard and Davis, semiotics constructs a theory of fashion in which clothing is read as a series of “signs” (Barnard, *Fashion as Communication*; Davis, *Fashion, Culture and Identity*).[86] Building on the work of cultural theorist John Fiske, Barnard describes two modes in which this communication takes part: “denotation” (signifier) and “connotation” (signified). While in communication theory clothing acquires the ability to be “read,” again there is the danger of reducing clothing to sign (or semiotic signal), divorced of bodies, action, and performative (temporal) “events.” The general problem with semiotics as an approach to understand the dynamics of social codes in fashion, as previously mentioned, is its reduction of material things, such as bodies and garments, to “texts.”

We may find no better example of a garment “communicating” than the design collective Diffus’ *Climate Dress*, which alerts its wearers of ambient $C0_2$ concentration levels through a series of embroidered lights. There is also the example of wearables, which literally “speak,” as in the case of XS Labs’ *Sound Sleeve* project, which emits synthesized sound through embedded speakers. Yet, surely, one would agree that the expression and the meaning of the garments extend beyond these “messages.” While communication theory provides a system from which to unpack expressions attached to styles, it does little to provide a platform for the dynamic interplay that occurs when environmental sensors are intertwined with body actions and engineering effects.

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[86] Barnard explains Ferdinand de Saussure’s “sign” as such: “For Saussure, the sign is made up of two parts. Those parts are called the ‘signifier’ and the ‘signified.’ Saussure is concerned with language and for him ‘signifiers’ are the physical part of signs, they are the sounds or the shape of words. The ‘signified’ is the mental concept to which that signifier refers. It is the meaning of the signifier. Together they form the ‘sign’ (Saussure 1974, 65–7)”; Malcolm Barnard, *Fashion as Communication* (London and New York: Routledge, 2002), 81).

Furthermore, as carriers of messages, wearables can very often shift their messages based on context, use, or the ability to decode or visualize the messages.

Performing Fashion

Cultural theorists Luca Marchetti and Emanuele Quinz note that the landscape of fashion has changed from an "aesthetic of signs to an aesthetic of experience," where old theories of static symbols are no longer suitable to describe how fashion is used to express ideas about ourselves and the world (Marchetti and Quinz, 119).[87] They remark how "clothes and the constellation of images and signs that they impose on the body (sexual, social and political) no longer warrant a stable identity. Rather, they become interchangeable symbols in a fluid, unstable game" (Marchetti and Quinz, 118). In today's fashion community, fashion signs are constantly in flux; and via the process of its re-construction by different social groups, ethnicities, and subcultures, "[i]dentity is no longer crystallized in images: it is configured precisely as a fluid dimension, nomadic, in constant transformation, in constant migration. It is no longer a sign: it is, just so, performance" (Marchetti and Quinz, 120).

Analyzing fashion (and wearables) from a performance (and experience) context thus permits us to include the many elements that are combined to render them meaningful. Perhaps even, performance reveals how the development of wearables as a form of social

[87] Also see: Ginger Gregg Duggan, "The Greatest Show on Earth: A Look at Contemporary Fashion Shows and Their Relationship to Performance Art," *Fashion Theory* 5, no. 3 (2001): 243–70.; and Marga van Mechelen, "The tête-à-tête of performance in fashion and art," in *Fashion and Imagination: About Clothes and Art*, ed. Jan Brand and José Teunissen, 104–15 (Arnhem: ArtEZ Press, 2009).

expression may be even more important than their material results—or, as Marchetti and Quinz note, "a different notion of fashion is emerging, linked to the immaterial dimension of experience, beyond clothes and even bodies. In this movement, while art gets closer to fashion in its mobility and as a game of identity, fashion for its part takes possession of art's media in order to assert itself as a mechanism that facilitates the migration of identities" (Marchetti and Quinz, 122).

Anouk Wipprecht's speculative work *Intimacy 2.0* proposes this very idea of immateriality in the form of a garment, which, when approached, has the ability to become invisible! The polymer-dispersed liquid crystals (PDLC) from which it is made change from opaque to transparent when charged with electricity. The effect is both risky and provocative, as it counters the basic function of clothing, which is to cover and protect the body, both for comfort as well as modesty, and further challenge how we may construct our identities within a shifting terrain of stylistic mores—even mores that are disappearing.

3.4 Performative Laboratories

Performativity in STS

In the final section of this exploration of the lenses and modes of performance—traversing sociology, media arts, and fashion—I will examine how the studio/atelier/laboratory that produces the wearable is also engaged in its own form of performance. As these sites cultivate the materials, technologies, and modes from which wearables and techno-fashions are developed, they further stage the ways in which these objects become culturally, technologically, and somatically performative. In order to follow and engage with the particular techno-cultural design praxis that is wearables, I will examine the ways in which science, technology and society (STS) theories of laboratory research and knowledge production have used performance as a platform from which to situate laboratory practices and cultures.

This "performative" lens is used to analyze laboratories in which individuals and materials are actively bound up in the co-productive process of shaping research outcomes. Laboratories and their operational structures—sites where science, technoscience, and techno-artistic research are produced—have arguably materialized as one of paradigmatic loci of STS analysis. To better understand the processes of knowledge production, the performative contributions of human (scientists and researchers, or, in the case of artistic wearables, fashion designers and engineers) and nonhuman (materials, machines) agencies—or, as French philosopher, anthropologist, and sociologist of science Bruno Latour has called them, *actants*—will be considered as inter-connected in the process of research. Above having materiality intermixed between the organic and the mechanical is the notion that "man" no longer stands at the center, directing scientific outcomes (Latour, *We Have Never Been Modern*).

As previously outlined, wearables are complex designs bringing together expertise from the disparate fields of garment-making, textiles, engineering, computation, and somatic knowledge. One way of examining such intertwined collaborations contributing to the design and technological innovations of wearables is through the optics of performance-directed research as proposed by STS. The advantage of using STS performance theories has two principal purposes: a) these theories provide an opportunity to look at the epistemic cultures of the studios/ateliers/laboratories producing wearables, wherein a varied spectrum of contributing factors (individuals, material sciences, technologies, and social organizations) shape them; and b) they foreground the performative narratives unfolding *in situ*, in action and in time, in the process of wearables development. In this way, STS perspectives on wearables studios/ateliers/laboratories reveal the nuances of the epistemic cultures of individuals (scientists, designers, engineers) and materials (tools, matter, technologies) that form and inform these objects.

Epistemic Cultures

Epistemic cultures of research, as defined by sociologist Karin Knorr Cetina, make the case for investigating specificity in research that takes into account the "messiness" of knowledge production. Knorr Cetina argues that contemporary Western societies have become "knowledge societies," where diverse yet specific cultural ontologies generate clearly unique internally referential systems, which are specific amalgams of societies, practices, and scientific tools. These epistemic cultures—or "amalgams of arrangements of mechanism" situated in laboratories, dis-unify and diversify the project of scientific knowledge-making (Knorr Cetina, *Epistemic Cultures*, 1). Thus, Knorr Cetina advocates for an "emphasis to knowledge as practiced—within structures, processes, and environments that make up *specific* epistemic settings" (Knorr Cetina, *Epistemic Cultures*, 8).

In other words, science produced in a laboratory is the result of specific tools, cultures, beliefs, goals, and expertise, which Knorr Cetina holds separate from *discipline* or *scientific specialty*, that emphasize situated human and nonhuman exchanges. Knorr Cetina's analysis of various labs has unveiled how knowledge is cross-pollinated over disciplines and practices to produce unique outcomes. For example, in her research into high-energy physics, she discovered a propensity for technicians to engage with machines as if they were "physiological beings"; meanwhile, a molecular biology lab proposed a radically different perspective on organisms, which they characterized as "machines." This is akin to when a wearables designer thinks of her/his designs as having slightly human but robot-like personalities, while the model who will wear them is asked to act like a blank canvas (a clear inversion of agency, if ever there was one).[88]

Physicist and feminist STS scholar Karen Barad, building on Latour's concept of actants and nonhuman agency, proposes a radical theory of research called "agential realism," which she describes as "an epistemological-ontological-ethical framework that provides an understanding of the role of human and nonhuman, material and discursive, and natural and cultural factors in scientific and other social-material practices, thereby moving such considerations beyond the well-worn debates that pit constructivism against realism, agency against structure, and idealism against materialism" (Barad, *Meeting the Universe Halfway*, 26). Accordingly, Barad creates a bridge between general research

[88] Anouk Wipprecht describes her wearables as animals, and her models as "comatosed." See interview in Appendix A.

polarities, which historically divide along the fault lines of "real" versus "constructed" things.[89]

When considering the wearables atelier—with its seemingly schizophrenic aggregation of art, craft, DIY, real science, fashion, performance, and experiments—we are confronted with not only a jumble of parts but also an inconsistent, unfamiliar meeting of agencies. Instead of relegating the material to the stubborn, the mute; and assigning the immaterial to the vision of the designer, it may be more useful to recognize shared, and at times exchanged, roles of agencies. Most times, designers and scientists/technologists working together to build wearables—negotiating, fighting, and infecting one another with their logic—do so in a completely unscripted manner. Diffus' approach to research, for example, combines craft techniques with the collaboration of textile manufacturers, as well as a series of stakeholders from universities or researchers. In this way, the path or outcome is changed with every new project, as is the composition, nature, and direction of the studio. Furthermore, the tools, materials, processes, and know-how from within the field of wearables are both emergent and ever evolving as technologies and practices become rapidly disused, obsolete and quickly replaced. Perhaps we can call this environment a form of "agential realism" inasmuch as it bestrides the real challenges of rubber, metal, cotton, plastic, electricity, motors, paints, and switches with cultural and scientific

[89] Barad's concepts are richer and more complex than can be discussed to their merit in this thesis; however, they warrant mention, as they develop the notion of human-nonhuman performance into an ontology of action that sets the ground for performative laboratory. See: Karen Barad. "Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter," *Signs: Journal of Women in Culture and Society* 28, no.3 (2003): 801–31; and Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham, NC: Duke University Press, 2007).

aspirations about the body, adornment, science, and innovation. If anything, wearables are strange machines birthed through a labour of intuitive experiments (of humans and nonhumans) at which we cannot help but marvel.

Agency of the Lab

It is arguably in the work of sociologist, philosopher, and historian of science Andrew Pickering, and his performative theory of scientific research in action, that is most apropos for thinking through the concept of the wearables laboratory as performative. In *The Mangle of Practice: Time, Agency and Science* and *The Cybernetic Brain: Sketches of Another Future*, Pickering postulates that scientific research should be understood as a performative process. Investigating topics such as particle physics, or the quirky British vein of 1950s cybernetics engaged in topics from psychology to psychedelics, Pickering makes a case for the laboratory as a performative space inscribed in cultural frameworks (Pickering, "The Mangle of Practice," 3). Two relevant themes run through Pickering's research analysis: first, his notion of *posthumanism* in scientific research culture; and second, the role of *temporal emergence* in developing this research.

Pickering aligns himself with concerns found in STS and the work of recent materialism theorists (e.g., Karen Barad, Jane Bennett, and Bruno Latour), who are pushing away from anthropocentric agendas of knowledge construction to reveal posthumanist entanglements with nature, science, and society. Though Pickering's posthumanism is indebted to the actor-network theory (ANT) of Latour and Callon, which proposes that the roles of human agency be considered alongside those of nonhuman agencies like machines, matter, and nature (Callon, “Society in the Making”; Pickering, “Mangle,” 373), his performative science diverges from Latour, et al., in his questioning of their proposed symmetry of human and nonhuman agencies (Pickering, *The Mangle of Practice*, 15). Rather, Pickering proposes a schema by which human agency’s intentionality is mediated through nonhuman agencies of matter, machines, and things. Although still adhering to a decentering of human agency, Pickering posits an asymmetrical schema that retains human intentionality tempered through the process of experimentation with stubborn matter.[90] Thus, where Barad’s “agential realism” can be see as a more ontological (and even cosmic) form of laboratory performance, Pickering remains in the practical realm of pushing research along.

This bring us to the second, and interrelated, element of Pickering’s performative theory, that of *temporal emergence*, which describes the process through which research must be lived and must unfold *in time*. Pickering proposes that research remains unchartable (and hence, playfully unpredictable) in its outcomes, as only the process of time, and the “dance of agency” between human and nonhumans, can produce the results. He summarizes his position as such:

[90] Pickering describes this asymmetrical relationship of human and nonhuman agency as a *dance of agency*, as described in the following passage: “As active, intentional beings, scientists tentatively construct some new machine. They then adopt a passive role, monitoring the performance of the machine to see whatever capture of material agency it might effect. Symmetrically, this period of human passivity is the period in which material agency actively manifests itself. Does the machine perform as intended? Has an intended capture agency been effected? Typically the answer is no, in which case the response is another reversal of roles: human agency is once more active in a revision of modelling vectors, followed by another bout of human passivity and material performance, and so on”; Andrew Pickering, *The Mangle of Practice: Time, Agency, and Science* (London and Chicago: University of Chicago Press, 1995), 21–22.

> My basic image of science is a performative one, in which the performance—the doings—of human and material agency come to the fore. Scientists are human agents in a field of material agency which they struggle to capture in machines. Further, human and material agency are reciprocally and emergently intertwined in this struggle. Their contours emerge in the temporality of practice and are definitional of and sustain one another." (Pickering, *Mangle*, 21)

Again, although Pickering's argument is larger and richer than can be covered here, it remains useful to consider how analyzing laboratory research as performative—in time, and action, and as driven by intention—can shed light into the granular facets of wearables development. More important is the fact that this "dance of agency" cannot predict outcomes. In this way, we may understand that wearables taking shape in the studio/atelier/laboratory do so with intent, but cannot be scripted. Furthermore, wearables, and the performative process by which they are invented—which includes human and nonhuman agencies—cannot be scripted or even fully controlled in terms of outcome. Joanna Berzowska from XS Labs, at Concordia University in Montreal, has described her studio environment as imbued with a kind of open-ended temporality of process, in which research has intent, but not always a strictly definable outcome.[91] It is with this (the unfolding of science through time and action) in mind that Pickering convinces us that the laboratory is in fact a theatrics of knowledge and creation. Hence, Pickering's performative theory of science permits us to situate wearables research in the flow of emergence, through time, action, and a negotiated intention.

3.5 Conclusion: Are Wearables Performative?

[91] See the contemporary case-study interview with Joanna Berzowska in Appendix D.

We have drawn broad strokes over an expansive field of performance scholarship that maps its relationship to the body, media arts, fashion, and finally, laboratory contexts. We began by looking at the field of sociology to uncover how performance shapes meaning through speech acts (Austin); which are further taken up in the construction of the social self (Goffman); and how society and self are constructed through rituals and breakages as experienced in the "liminoid" process (Turner).

Next we probed how media-arts analysis of interfaces and embodiment could include either the body—or, even better, the body and the wearable (Hansen, Ihde, Munster). We also investigated how the body in action has been problematized within the media-arts milieu, in particular situating wearables within a continuum with media arts and culture-at-large (Ryan), and how phenomenology can structure a better understanding of wearables (Kozel).

We then outlined how fashion has connected with the notion of performance via theories that include the practice of class emulation (Simmel); how psychoanalysis opened up more personalized readings of fashion (König); how contemporary fashion may be inscribed in a practice of social communication (Barnard; Davis); and, finally, how the entire enterprise of fashion has transformed into a digital, social, and cultural event (Marchetti and Quinz).

Finally, we argued that the laboratory also constitutes a site of performance, which reunites influences of epistemic research cultures (Knorr Cetina); and that STS can provide a framework for the negotiations of human and nonhuman agencies (Barad, Latour); as the crux of this research unfolds in time and action through a “mangle of practices” and a “dance of agency” (Pickering).

In this chapter, I have shown how performance may inform the many movable parts and steps that constitute the making, using, designing and socially activating of wearables. Furthermore, I have outlined, described, and activated several tools that might be applied to wearables analysis and a deeper understanding of their place and function in society, culture, media dynamics, and research contexts. As cultural products, as objects of invention and transformation, as innovative technology, and as second skins, wearables only reveal their full logic through a performative lens that can focus on the details of their soma, styles, and modes of construction, and the machines that come alive through them.

4 HISTORICAL CASE STUDIES: PRE-COMPUTATIONAL WEARABLES

4.0 Introduction

Modern in General

While the majority of studies focus on wearables as birthed in the age of computing, this chapter adjusts this perspective historically by planting the roots of wearables within the pre-computational era of Modernist artistic practices (1891–1922), wherein the coupling of bodies, garments, and technology first came together. In this chapter, I argue that technology-enhanced, as well as technology-inspired clothing, from its earliest onset, emerged from artistic and performance-centered cultures, predating the engineering innovations of the later twentieth century. This Modernist legacy is critical to the history of wearables, as we will discover in exploring the science-art-fashion experiments of the early century.

The first section of this chapter looks at the literature analyzing the cultural and technological changes taking place in Modern society. It examines the impact of rapid technical changes taking place in the changing "Modern" cultural and social landscape that altered society, experiences, and notions of self (Berman, *All that Is Solid*; Kern, *Culture of Time and Space*). The subsequent four historical case studies further unveil specific and timely examples of costume-technology admixtures that have contributed to concepts and design of fashion-technology-performance today. We will later overlay these historical examples of wearables onto contemporary ones to trace the connections and legacies.

I argue herein that these landmark Modernist techno-artistic designs and art practices, nascent at the prehistory of computational engineering, are key to an understanding of contemporary wearables. They are key because they demonstrate the performative drives underlying technoscientific explorations in fashion, costume, art, and culture. The artists I have selected to reflect on this pre-computational era of wearables are: Loïe Fuller, with her use of stage lights and apparatuses for the body and costumes featured in her multimedia *Serpentine Dance*; Paul Poiret's multidisciplinary and pioneering use of technologies of promotion, fabrication, and performance, aimed at creating *haute couture* fashion, and social/stylistic shifts; Giacomo Balla's *Antineutral Suit*, which broke with sartorial convention by seeking dynamic and changeable forms of clothing with a performative and transformative edge; and, finally, Oskar Schlemmer's *Triadic Ballet*, which echoes today's posthumanist notions of man-machine through its use of unconventional materiality and posthumanist body transformation for costume and choreography.

The era of the Modern signified change, at once concrete and conceptual, in regard to humanity's rapport with technology, the social fabric of the everyday, and the potential for innovation and reflection in arts and culture. The materials and beliefs that came to be re-thought and re-invented in this era need be explored in order to understand this palpable Modern shift, especially how they seeded the ground for pre-computational wearables. The era of consideration for this research—along with much of focus of the literature pertaining to style and fashion referenced herein—is situated within the late-nineteenth-century industrialization of Europe and America from the 1890s until the few years following the

First World War (1922). Within this very mutable era, various never-before-seen (or imagined) technologies irrevocably changed daily existence for the general population. New technological apparatuses—ranging across the worlds of business and industry, the fabric of the home, urban infrastructures, educational systems, modes of communication, manufacturing, and more—shifted the modalities under which individuals perceived, conceived, and lived their quotidian activities (Berman, *Solid*; Kern, *Culture*).

Of the many Modern technological innovations and apparatuses to arise from this period, all of them may be understood as tools for the extension and enhancement of the human experience. Specifically: sound- and image-reproducing technologies extended the representation, perception, and experience of the self to new frontiers. In this way, many Modern technological devices can be categorized as catalysts for the control, extension, or promulgation of particular types of body experiences: seeing, hearing, touching, etc. For example, the image-reproducing technologies of photography and cinema proposed new ways of experiencing the self outside of the self, time, context, or even reality, as seen in the playful films of Georges Méliès. Meanwhile, sound-based communication devices, such as the telephone, offered presence over large distances, while the phonograph and radio grouped large, networked audiences in synchronous and asynchronous time over wide geographical regions. Other inventions like the X-ray provided unheralded access to the inner workings of the body, in effect exploding the perception of interior self; while various modes of transportation extended the lived environments of individuals at an accelerated pace. These new and diverse sensory experiences—at once diverting, exhilarating, transformative, informative, and even, at times, frightening—converged with the body. Of these many shifts in experience of time and space and self, none left the body (or person) mute or unchanged, but rather viscerally changed the body's position via its outer and inner worlds through these various technological shifts (Berman, *Solid*; Kern, *Culture*).

Charles Baudelaire famously described the Modern experience of late-nineteenth-century Paris as "ephemeral," "fugitive," and "contingent" (Baudelaire, *Painters of Modern Life*, 13), while Walter Benjamin cites Baudelaire's description of the crowd as "a reservoir of electric energy" (Breward and Evans, 2; Evans, "Enchanted Spectacle").[92] Hence, Modernism was at once a celebration of progress and innovation, as much as it was (and is) a system that undermined its own permanence through built-in cycles of ephemeral constructions, which are in conflictual opposition/romance with the past. For this reason, the domain of fashion offers rich insights into "Modernism's" schizophrenic relationship with a "permanent impermanence," as seen in expressions and outcomes of material and conceptual flux. In Ulrich Lehmann's analysis of Modern fashion, *Tigersprung: Fashion in Modernity*, the fleeting and evanescent qualities of "mode" and "modernité" are described as emerging as a result of their unique trans-historicity:

> [L]a mode et la modernité are inextricably linked. Each needs to seek out the poetic and eternal element, the expression of permanence—not to lend it artistic or historical gravity, but to explain its metaphysical impact. Without the sublime in fashion's dialectical aesthetics, the ephemeral as its opposite and predecessor cannot exist; without the connotation of antiquity, modernity loses its raison d'être—its adversary and point of friction, which is also its stimulant. Note that this is not

[92] Examples of "electrified" crowds include the popular story of the Lumière (Auguste and Louis) Brothers' 1895 film *L'arrivée d'un train en gare de La Ciotat* depicting a train arriving at station, which allegedly frightened the audience members into a panic.

> simple set of oppositions but a hermeneutical apparatus in constant flux." (Lehmann, 9)

"Modernité," and in the same vein "mode," may be understood as trans-historical projects conjoining the future with past, within a present flow of ephemeral experiences, objects, technologies, and more, only ever momentarily crystallized. Fashion, perhaps more than any other facet of early Modern society, carried the potential to embody this fleeting and ever-changing quality, at once bound by historical references, yet continuously renewed through the shifting of styles. As notes Lehmann, "Fashion is the supreme expression of that contemporary spirit. It changes constantly and remains necessarily incomplete; it is transitory, mobile, and fragmentary. This quality ties it in with the pace and rhythm of modern life" (Lehmann, xii). Hence, to be Modern is to be in a sustained condition of fleeting moments, where fashion "always appears as the most immediate present, affecting the future with its constant changes, yet it always quotes from the past" (Lehmann, xviii). Fashion, within this framework, becomes an important harbinger of the human condition, experiencing this rapid "fugitive" flow of change symbolically and concretely re-inventing the body.

Concrete and Conceptual

In their edited collection of essays *Fashion and Modernity*, Christopher Breward and Caroline Evans propose a further dissected etymology between "mode" and "modernité." They propose three terms to disentangle their meanings: "'Modernisation' refers to the process of scientific, technological, industrial, economic and political innovation that also become urban, social and artistic in their impact; ‘Modernity’ refers to the way that modernization infiltrates everyday life and permeates sensibilities; and ‘Modernism’ refers to a wave of avant-garde artistic movements that, from the early twentieth century onwards, in some way responded to, or represented, these changes in sensibility and experience” (Breward and Evans, 1). From this perspective, fashion is a multifaceted phenomenon, conceptual and material, which resolutely resonates across these same three terms linked to the “Modern.”

For example, one can consider how “Modernisation” in fashion is responsible for its materiality, from production enhancements (new sewing and fabrication machines, etc.) to textile innovation (the first plastics, a.k.a. “Bakelite,” and synthetic polyester cloths). Meanwhile “Modernity” can be associated with how fashion impacted on the everyday as a “mechanism for interrogating the subjective experience of modern life.” And finally, “Modernism” can be associated with the naming and situating of a stylistic shift occurring in art, design, and fashion. The complexity of fashion, and especially its link with the Modern, lies in its dual identity as both concrete and conceptual. Breward and Evans describe this concept at work: “Fashion is a process in two senses: it is a market-driven cycle of consumer desire and demand; and it is a modern mechanism for the fabrication of the self. It is in this respect that fashion operates as a fulcrum for negotiating the meeting of internal and external worlds” (Breward and Evans, 3). Hence, the material and tangible effects of the Modern necessarily funnel into and concinnate back to the material, technical, social, and aesthetic, all at once. This Ouroboros system of “progress” set out by the Modern—wherein ideas, materials, technologies, and styles shift forward and back again—

should be kept in mind as we think through the not-so-linear evolution of wearable technologies and that process's links to progress, the body, and meaning.

In the next section, we will further explore, through four historical case studies of fashion-performance-art, how Modernism seeded the idea and practice of non-computational wearables. Through these examples, we will continue to explore the links between technology and garments-fashion-costumes, as well as their performative potentials in a Modern context. Ranging widely in modes of expression and materiality—dance, fashion, performance art, and theatre—these examples shore up the conceptual, concrete argument that techno-artistic garments-fashion-costumes came into play at the dawn of the Modern age.

Figure 4. *Loïe Fuller dansant avec son voile* (1897). Photo: Taber Isaiah West.

Figure 5. *Loïe Fuller dansant, vue de profil droit* (1900–28). Photo: Harry C. Ellis.

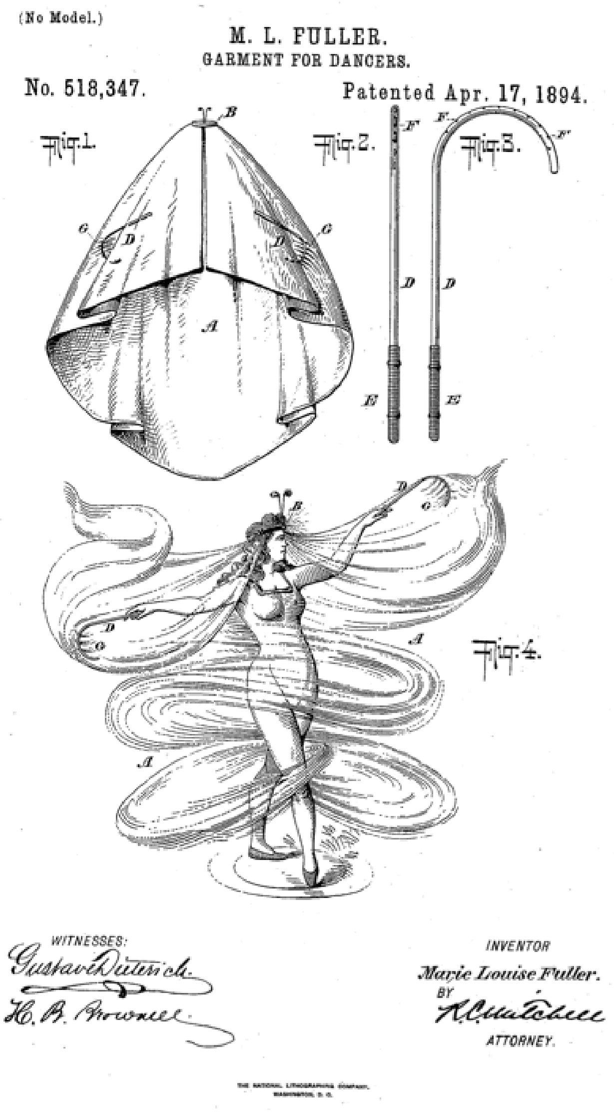

Figure 6. *Patent 518347 Garment for Dancers* (1894).

4.1 Loïe Fuller: *Serpentine Dance* (1891)

Loïe Fuller (1862–1928), also called "La Loïe," was an American avant-garde dancing sensation of the turn-of-the-century Parisian stage, famous for performances such as the *Serpentine Dance* (1891), the *Butterfly Dance* (1892), and the *Fire Dance* (1895). She expanded on and created a signature style, already exploited in the "skirt dance" craze of London's Gaiety Theatre of the same era, which uniquely brought together elements of dance, costume, light, staging, and music (Hindson, *Female Performance Practice*). Born Marie Louise Fuller in Chicago in 1862, Fuller began as an actor and sometime burlesque performer, to emerge only later as a key innovator in the field of contemporary dance. Fuller is responsible for the implementation of Modern avant-garde dance techniques freed from classical ballet, combining bodily expression with "performative" costumes and props. Her emblematic stylistic methods were a visible influence upon later canonical interpretations of Modern dance by luminaries such as Isadora Duncan and Martha Graham, direct descendants of Fuller's costume-body innovations and experimentation (Coffman, 84; Current and Current, *Loïe Fuller*). Not only pioneering the use of expressive fabric as an intrinsic dance element, Fuller also designed technological mechanisms to enhance her costume-based performances (Garelick, *Electric Salome*). These patented mechanisms ranged from hand props for the manipulation of her custom-designed garments, to hand-tinted glass for creating light projections to achieve ambient stage effects (Fuller, *Fifteen Years*; Harris, *Loïe Fuller*; McCarren, *Dancing Machines*; Brannigan, "'La Loïe'"). As technical inventions, these apparatuses designed by Fuller made her performances stylistically unique and prescient in imagining a new wave of technological inventions adapted for dance within the twentieth century (Coffman, "Women in Motion"). An acknowledged artist, researcher, and performance pioneer responsible for technical dance innovations, Fuller combined artistic *and* scientific bravura in equal measure.

What is important, here, is that Fuller's performances—which were not dependent on body mechanics or dance virtuosity in the traditional sense—were built specifically to capitalize on the body's ability to be enhanced by technical apparatuses. From its genesis, Fuller's technical experimentations—the use of colored electric lights, the moving potential of meters of flowing fabric—reshaped the articulation of body-enhancing technologies, placing them firmly in physical consort with her stage objectives, thus creating a new kind of performance genre that placed objects in consort with humans. I would argue that Fuller's art belongs to the wearables project of reshaping the body's form, and meaning, by way of technological transformation. Though Fuller's technology remains within the analog—unlike the computational and engineering-driven artistic wearables of today—they share the same exploitation of electro-mechanical and material technologies, foregrounding explicit performative interaction between the body and technologized garments-fashion-costumes seen today.

The Creation of "La Loïe"

According to her biographers, there are several—and at times contradictory—genesis stories of how the idea for the *Serpentine Dance* came about, many of which arose from Fuller's own, inconsistent tellings during various interviews. However, if we begin with Fuller's 1913 autobiography, *Fifteen Years of a Dancer's Life, With Some Account of Her*

Distinguished Friends, her "eureka moment" happened at a 1891 rehearsal for *Quack M.D.*, a play in New York City. At that time, known principally as an actress and sometime burlesque dancer, Fuller is said to have experimented with the first version of what would become the *Serpentine Dance*, in the role of a hypnotized young woman.

Allegedly lacking time or budget, Fuller tells how she explored her own wardrobe in the hope of finding a suitable costume to wear for this evocative scene, and found in her travel trunks an oversized garment made of soft, silky material that had previously been sent to her as a gift from two young English officers stationed in India. This career-transforming dress, exotic in material and overwhelming in size, was supposedly a traditional Hindu dress, which Fuller proceeded to convert for her character's dance.[93]

Clearly, these early experimentations succeeded in creating a reputation for the young Fuller, particularly when staged in the context of *Uncle Celestin*, showcased at the New York's Casino Theater in 1891, in which she performed what was for the first time named the *Serpentine Dance*. Reviews of the day, such as this one from the *New York Spirit of the Times*, attest to Fuller's seduction of her public via her stagecraft and effects:

> Suddenly the stage is darkened, and Loïe Fuller appears in a white light which makes her radiant and a white robe which surrounds her like a cloud. She floats around the stage, her figure now revealed, now concealed by the exquisite drapery which takes forms of its own and seems instinct with her life. The surprised and delighted spectators do not know what to call her performance. It is not a skirt dance, although she dances and waves a skirt. It is unique ethereal, delicious. As she vanishes, leaving only a flutter of her robe upon the stage, the theatre resounds with

[93] In other interviews, Fuller had also alluded to the origin of the garment being a muslin "old Hindoo costume," a silk Calcutta "Nautch" girl's dress, or yards of cheesecloth material. Hence, it is difficult to ascertain the exact origin of the material or contextual inspiration for the garment that came to be Fuller's performance signature.

> thunders of applause. Again she emerges from the darkness, her airy evolutions now tinted blue and crimson, and again the audience rise at her and insist upon seeing her pretty, piquant face before they can believe that the apparition is really a woman. Let us have the Serpentine Dance at the Casino and it will be the talk of the town.

Fuller's dance, it has been argued, was one particular "act" in a culture saturated with dances (including other "skirt" dances) and other vaudeville acts taking place in various locals from London to New York (Current and Current, 58). The *Serpentine Dance*, it may even be suggested, was hardly a dance but more of a multimedia spectacle, which played well with other vaudeville curiosities of the day, and which included "the warblings of a bird imitator" and "the antics of a comedian with an 'automatic piano'" (Current and Current, 33). Hence, the popularity of Fuller's dances must be set within a landscape of exhilarating performers and performance from magicians, circuses, and other vaudeville acts showcasing the virtuosity of machines, animals, and humans. Marie Layton, an ardent competitor of Fuller, argued that the inspiration for the *Serpentine Dance* stemmed from a similar costume designed for the burlesque performance of *Carmen up to Data*, also staged at London's Gaiety Theatre in 1890–91.[94]

It was not until she arrived on the Folies Bergère stage in 1892, however, that Fuller came into her full fame. Having tested her craft and audiences in London and New York, it was Paris that would make "La Loïe" an artist and star, as opposed to a mere entertainer

[94] It has been suggested that Fuller was, in fact, understudy for this performance during her UK stay, and it is quite plausible that she had been exposed to the costumes that later served as inspiration for her; Catherine Hindson, *Female Performance Practice on the Fin-de-siècle Popular Stages of London and Paris* (Manchester: Manchester University Press, 2007). During the height of Fuller's career, there were numerous imitators, parallel performances, and copycat dances capitalizing on the popularity of her skirt dance (Hindson, *Female Performance Practice*; and Richard Nelson Current and Marci Ewing Current, *Loïe Fuller: Goddess of Light* (Vancouver: University of British Columbia Press, 1997).

(Hindson, Female Performance Practice, 62). Whether Fuller's dance was the first, the best, or even her invention at all, is an argument that cannot be answered here; she did, however, become the symbol of that style. As *The Times* argued in 1898, "[w]hether Miss Fuller was the originator or not of this elegant dance, she is undoubtedly its ablest exponent"; and thus, Fuller came to represent the aesthetics of the *Serpentine Dance*, both for her own lifetime and throughout history (Hindson, *Performance*, 1997, 82). Hence, what distinguished Fuller from other dancers may have had more to do with persistent mastery of tools than some moment of genius or timing.

"La Loïe's" Invention

If we consider Fuller's performances as techno-artistic productions—straddling the worlds of technological inventions and art—then we can see how these fit well together with the world of contemporary wearables. As expressed in her biography, Fuller always intended her performances, first developed in New York but later popularized in Paris, to be considered nothing less than art, and not merely "entertainment," like others working in the burlesque and cabaret culture from which she came. In a similar vein, she positioned the use and creation of her tools—lights, garments, dance—to be an "invention," and proceeded to apply for patents to protect her performance technologies. The proliferation of performance venues in the Modern era—wherein theater, opera, and vaudeville intermixed—presented a variety of entertainment that included music, dance, opera, feats of bravery, erotic "entertainment," and conjuring and magic tricks. The ubiquity of these popular forms of entertainment in Europe and America created a climate for experimental forms of performance, which seamlessly included the showcasing of new "technological" inventions.[95]

In her biography, Fuller repeatedly describes herself as both an "artist" and a "researcher," while her performance techniques are described by authors as "experiments" and "inventions" (Fuller, *Fifteen Years*, 260, 286). In this way, Fuller strategically aligned herself with other arts-science inventors of her era, a category that included photographers, cinematographers, and other technological innovators intersecting with the creative arts. In fact, Fuller was to later become a member of the French scientific community, confirming her legacy as an "inventor" (Sommer, "Loïe Fuller." 53). It was in this spirit of art/science inventiveness that Fuller's avant-garde performances came to be recognized at once as art *and* as science.

Patenting Art

Keeping in mind that many of these never-before-seen art/technology developments were often "inventions" that often blurred the line between science and art, it is no surprise that Fuller's own hybrid performances became the subject of technical patents. The Modernist era of Paris, in particular, was awash with speculative art/science inventions and technical

[95] These inventions include: as Étienne Jules Marey's *Chronophotograph* (1888); Emile Reynaud's *Praxinoscope* (1892); the Lumière Brothers' *Cinématograph* (1895); and Léon Gaumont's *Chronographe* (1897). For more about such turn-of-the-century inventions, see: Margaret Haile Harris, *Loïe Fuller, Magician of Light: A Loan Exhibition at the Virginia Museum*, 12 March–22 April 1979; and Dayna Oscherwitz and MaryEllen Higgins, *The A to Z of French Cinema* (Lanham, MD: Rowman and Littlefield, 2009).

competition in photographic technologies and various audio-recording and film/image-recording devices, which became the subjects of international patent races and protections.

Aiming to own and protect her "brand" of dance, Fuller registered patents to protect her "research," which was focused on the articulation and design of her garments and the creation of dynamic light environments. Among the many patents she registered may be found: Patent No. 21,458 *Dancing Dress* (12 April 1892), a dress design ornamented with a series of serpents; Patent No. 518,347 *Garment for Dancers* (17 April 1894), a flowing gauze-like dress to be manipulated with specially designed props; Patent No. 533, 167 *Theatrical Stage Mechanism* (29 January 1895), designed to expand the stage; and Patent 513,102 *Mechanism for the Production of Stage Effects*, which proposed the embedding of lights in the stage.

What these patents ensured for Fuller was control over her innovations *through* the apparatuses that facilitated her signature cloth movements and light effects. Fuller had previously attempted to copyright her dances to put a stop to her many imitators; however, unfortunately for her, previous patents had been denied on the grounds that, "the merely mechanical movements by which the effects are produced on the stage are not subjects of copyright" (Harris, 16). Fuller must have quickly understood that while artistic styles could not easily be protected, the tools she used to create her style could be.

The issue of copyright of dance, incidentally, continues to generate controversy, as in the accusation against pop star Beyoncé that she copied moves from the legendary Anne Teresa De Keersmaeker's *Rosas Dances Rosas* dance in her 2011 music video

Countdown.[96] What the patents afforded Fuller was a way to own her craft. The consequence of this, the emphasis on the technical aspects of her dance, propelled her to conduct further research into artistic expression through technical innovation, a happy coincidence.

Let us consider her patents in closer detail. Patent No. 518,347 *Garment for Dancers* features a combination of a skirt "formed of several triangular pieces preferably made from a suitable light fluffy material," and two designs for wands, with and without a hook/handle that should "be made of any suitable light material, by preference aluminum or bamboo" (United States Patent Office, 17 April 1894). The claim to invention, in Fuller's words, is as follows: "My invention relates to certain new and useful improvements in garments particularly adapted to that class of dancing known as 'the serpentine dance.'" Through the use of her inventions, Fuller states, "many poses and movements may be executed which it is impossible to execute with a garment of any other construction." Hence, for Fuller, the apparatuses—not the mastery of the dancer—guaranteed the results. This was also a way to lay claim to authorship of the *Serpentine Dance*, which had become a dance style in itself.[97]

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[96] See "Beyoncé v De Keersmaeker: can you copyright a dance move?", *Guardian*, 10 October 2011, https://www.theguardian.com/stage/theatreblog/2011/oct/11/beyonce-de-keersmaeker-dance-move (accessed 28 July 2016).

[97] Stage lighting apparatuses comprise the second set of Fuller's inventions and patents. Her use of lights on stage appeared at a time where electricity was transforming performance venues. Her Patent No. 533, 167 *Theatrical Stage Mechanism* is described as "constructing a new and useful theatrical stage mechanism to be used in the production of a dance, said mechanism having the effect of multiplying the reflections of one or more dancers performing in front of the said mechanism, thereby producing to the eye of the spectator an illusionary effect" (United States Patent Office, 29 January 1895).

Loïe and the Expanded Costumes

It becomes clear through the exploration of her craft, and, more notably, its tools—as seen in the descriptions of her patents—that Fuller's conception of the body performance is highly embedded within the mechanical apparatuses in which she enveloped herself. It could be argued that the specially cut and designed cloth, the wands that controlled and propelled their movements, the lights, color gels, mirrors, etc.—all of these apparatuses, for Fuller, constructed the performing body. To be sure, these technologies were conceived as devices for altering the body's potential for movement, as well as the audience's perception of it.

Where other inventors were developing technologies to record and capture the body, Fuller's technologies were focused on transforming the *actual* body. Her technologies succeeded in giving to the body new avenues of expression—and to the audience, a new perspective on the dancing body. However, it should be noted that the ultimate goal, for Fuller, was to create art. And her understanding of her contributions to the international vaudeville stages of London, Paris, and New York, is not that of a technologist or inventor, but of an artist working in tandem with technology and the body to create artistic expression.

Fuller's oeuvre is a man-machine amalgam. Both the mechanics and body of the dancer are needed to create its effects. There is no *Serpentine Dance* without its body-complementary mechanism. Hence, the vitality of Fuller's *Serpentine Dance* effects lies in the admixture of technological tools conducted in consort with bodily action. Through Fuller's art, we discover new dimensions of the body, its presence, and its magic-trick-like effects—which help guide us toward a means to situate and analyze the wearables technologies of today.

Figure 7. Paul Poiret, *Faun* (1919-1920).

Figure 8. Paul Poiret, *Thousand and Second Night* (1911).

Figure 9. Paul Poiret, *Rosine Perfume Laboratory* (1920s).

4.2 Paul Poiret: *Couture as Performance* (1903–26)

Paul Poiret (1879–1944) defined modern fashion enterprises as we know them today. Of the many stylistic innovations he is responsible for—such as the liberation of women from corsets via his harem pants, to the creation of the cult of the fashion designer—Poiret is equally remembered for his performative strategies, which blended public-relations events such as parties, fashion shows, and public stunts, along with entrepreneurial adventures in the creation of fashion research, and, via his textile and craft ateliers, the creation of the first "designer" perfume. Within the context of these ambitious endeavors—from promotional events to tangible product research—Poiret's focus always remained on capitalizing on the power of artists, engineers, makers, and artisans to create eventful fashions.

During his eventful career, Poiret solicited the collaboration of many artists, illustrators, photographers, chemists, and engineers, demonstrating his spirit for creative hybrid innovation. The nature of these cross-disciplinary collaborations—between art, commerce, and science—can be witnessed today in contemporary artistic partnerships in fashion-tech and wearables, such as Hussein Chalayan's robotic dresses; Suzanne Lee's bio-couture; and Anouk Wipprecht's science-engineering Faraday dresses.

Thus, the example of Poiret, with his iconoclastic approach to fashion, propels us to reconsider the art/fashion/science paradigm. In his lifetime, Poiret distinguished himself from other contemporary fashion houses in Paris—such as Charles Worth (1825–95) and Jacques Doucet (1853–1929)—by re-defining two key elements of fashion: hybrid production platforms that blended art with science; and performance contexts that gave new meaning to fashion's role and the experience of the wearer. Hence it was these material innovations, combined with performative presentation platforms, which came to speak for his contribution to the history of fashion—and, for the purpose of this research, the performative roots of fashion and the future of wearables.

The Poiret Effect

The fashion archives conserved at the Musée de la Mode et du Textile in Paris contain numerous documents charting Poiret's entry into Modern fashion history. These artifacts include photographic and print materials from magazine advertisements, event flyers, photo documentation of parties and stage presentations, which offer unparalleled insight into both this era of effervescent couture fashion and Poiret's unique approach. What is more, Poiret—otherwise known as *Le Magnifique* because of his majestic presence and reputation—in the later part of his life (like Fuller) published an autobiography, *En Habillant l'Époque*, chronicling his life and career, as well as his dramatic and unfortunate financial and social decline, and providing many personal and career insights.

Poiret was born in 1879 in what would today be considered a middle-class family. He began his career at a young age, in 1889, apprenticing with the couturier Jacques Doucet, where he developed a clientele among the theatrical stars of the day, a critical economic and cultural link. During the burgeoning sartorial trade at the turn of the century, it was not unusual for major stage actresses to be associated with a garment designer both on and off the stage, much in the same way that today's Hollywood actresses become the muses of fashion designers both on and off the silver screen.

When Poiret opened his own atelier in 1903, his first client/muse of note was the immensely popular stage actress Réjane.[98] From 1906, with the opening of the Maison Paul Poiret, to its abrupt closure in 1926, Poiret would come to develop numerous markets (in stage, cinema, designer patterns, craft ateliers, signature perfumes, theme parties, and more) that re-defined the scope and role of the fashion designer, both in society and in relation to the fine arts, commerce, marketing, and materials research. Ultimately it is these two axes of excellence of Poiret's—materials exploration and performance showmanship—that I will explore in this case study.

R&D Atelier

One of the most telling and important aspects of Poiret's position in the Parisian and international fashion worlds—he was a larger-than-life figure—was defined through his dizzying and multiple enterprises. Poiret's foray into the public eye and social notoriety included shameless self-promotion, aggressive and multiple commercial endeavors, festive events, and political stances on women's fashion, alongside serious artistic collaboration and groundbreaking materials and science research for fashion. Most particularly, he was one of the first fashion designers to engage in hands-on development of materials and innovations that combined arts and science.

[98] Réjane, born Gabrielle Réjane (1856–1920), was a popular French stage actress whom Poiret had dressed when he apprenticed at Worth. She subsequently followed Poiret when he opened his couture house and became a spokesperson for his design label both off and on stage.

During its years of ascent and popularity, the Poiret house collaborated and aligned itself with numerous fine artists and celebrated illustrators—as well as scientists—for the creation of fashion pieces, textiles, and decorative fabrics, as well as catalogues, posters, promotional materials, and signature scents. Of the many notable collaborations, we can include collaborations with celebrated illustrator and designer Erté, with whom Poiret created a collection. Poiret and Erté also created theatrical costumes for Jacques Richepin's production of *Le minaret*, and partnered with artists like George Lepape and Paul Iribe to create costumes, promotional albums, and stationery, and even commissioned the house's label design (Troy, *Couture Culture*).[99]

However, Poiret's most famous association was with the young artist Raoul Dufy, from whom he commissioned decorative stationery and invitation cards for theme parties like *Thousand and Second Night*, woodcut prints for textiles, and interior decoration projects. Poiret was one of the first designers to align himself with artists and foster (as well as finance) collaborations that transgressed the art-craft divide for purposes of fashion design. This hybrid approach to fashion is a mainstay in the development processes of today's couture houses—and notably, too, in the works of wearable designers, who often solicit the participation of other talents (in industrial design, textiles, robotics, etc.) to enhance and further their practices.

[99] Romain de Tirtoff (1892–1990) was a Russian-born French artist and designer known by the pseudonym Erté, who worked in many disciplines including fashion, jewellery, graphic arts, and costume and set design for film, theater, opera, and interior decor.

As well, Poiret was a precursor of the hands-on atelier practice of experimenting with new materials and processes, as demonstrated by his Atelier Martine. Although the craft/art school associated with the Atelier—École Martine—was intended to teach impoverished girls skills in interior and textile design (including printing, embroidery, haberdashery, furniture construction, lighting, and clothing and accessories), it also promoted a vibrant atmosphere of experimentation and knowledge-sharing around textiles and art, as well as the development of numerous commercial design products.[100]

The Atelier Martine later developed into a store, Maison Martine, which promoted and sold the Atelier's household and craft designs, such as: "exclusive carpets, textiles, lamps and light fixings, vases, wallpaper, furniture and assorted ornaments" (Baudot, 11). This multi-channel approach to design by a fashion designer was in part inspired by visits to Austrian and Belgian counterparts, such as the Wiener Werkstätte in Vienna and Palais Stoclet in Brussels, which would later also influence the development of design schools like the German Bauhaus.[101] Again, this hybrid approach to collaboration, studio culture, and art/design practices could describe many of the wearable ateliers operating today, at the crossroads of science, art, and design.

Poiret can also be credited for inventing the "designer" perfume through his "Les Parfums de Rosine" brand of signature scents, developed in-house with his school-friend

[100] Poiret would name all of the various segments of his couture house after his daughters: *École Martine*, *Atelier Martine* and *La Maison Martine* were named after his second daughter, while *Les Parfums de Rosine* was named after his first.

[101] In this era, architects and interior decorators such as Frank Loyd Wright, Henry van de Velde, and Peter Behrens also created garment designs inspired by their settings. Of note, Behrens taught prominent future Bauhaus members Ludwig Mies van der Rohe, Adolf Meyer, and Walter Gropius. Nancy J. Troy, *Couture Culture: A Study in Modern Art and Fashion* (Cambridge, MA: MIT Press, 2003).

chemist, Dr. Midy. Each perfume edition was linked to a dress, and was designed to be a work of art through its creation of a bespoke bottle designed in collaboration with glassworks factories for production, and with limited-edition packaging produced in collaboration with graphic designers, writers, and typographers (Baudot, *Paul Poiret*).[102]

This innovative foray into branded beauty products was a first for the fashion industry, which today seems like a natural extension of couture houses, not to mention a very lucrative form of financing fashion labels. In this way, perhaps it would not be impossible to imagine that technology can become the perfume of the twenty-first century in creating new, body-specific experiences. For example, with the aid of chemists, designer and body architect Lucy McRae has been developing a "Swallowable Perfume" to transform how perfume is experienced and distributed via the body. These kinds of hybrid approaches, not only to perfume but also to other kinds of technologies that intersect with the body, can be seen in the work of beauty technologist Katia Vega, who has been developing electronic interfaces via makeup and other beauty platforms, such as nails and hair.[103] Both these designers have been embraced by the fashion-tech and wearables community for re-thinking the kinds of materials and interfaces we are (and will be) seeking for our bodies.

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[102] Some of the evocative names that Poiret used to name his perfumes included: *Toute la Forêt*, *Le Matin au Bois*, *Chez Poiret*, *La Rose de Rosine*, *Le Mouchoir de Rosine*, *Maharadjah*, *Nuit de Chine*, *Bosquet d'Apollon*, *Le Fruit Défendu*, *Aladin*, and *Minaret.* See: François Baudot, *Paul Poiret* (London and New York: Thames and Hudson, 1997); and Kenneth E. Silver, "Forbidden Fruits: The Perfumes of Rosine," in *Poiret*, ed. Andrew Bolton, Harold Koda, and Nancy J. Troy (New York: Metropolitan Museum of Art, 2007).

[103] For more on the work of Lucy McRae and Katia Vega, see, respectively: http://www.lucymcrae.net/ and http://katiavega.com/.

However, Poiret did more than commission work. He created functional laboratories to develop his vision, in consort with experts, artisans, and scientists. In this way, Poiret was not simply involved in an aesthetic re-styling of his era, but was also active in innovating practices and processes to propel new aesthetics, tools, and practices that ultimately contributed to new experiences of fashion, via art and design. This hands-on, scientific approach to innovation in fashion—both in style and material—echoes many of the labs involved in wearables and fashion-tech today, which are having to invent new materials, technologies, and applications for fashion.

Networks, Patterns and Copyrights

Poiret traveled extensively in America and Europe, and he was often accompanied by his muse/wife Denise, or by a group of girls, for staging curated interviews and media appearances in hotels and department stores, for press and fans alike (Troy, *Couture Culture*). As a consequence of his extensive travels and promotional efforts, Poiret's designs became increasingly popular, and hence were often illegally copied in foreign territories where the demand (or cost) exceeded the availability.

For this reason, Poiret developed various commercial strategies, including the distribution of "Original Poiret" patterns that retailers could recreate, via specific instructions, in order to fabricate an "original" Poiret design. This furthered Poiret's international presence as a fashion designer, all the while protecting his intellectual property and making a profit. To this purpose, Poiret named each of his designs individually (as opposed to that era's more popular, numerical form of indexing), which permitted him copyright the designs.[104]

Naming the designs also imparted a dramatic dimension to Poiret's fashion presentations, suggesting that, "each gown was a unique and highly aestheticized creation, an evocative works of art" (Troy, "The Theatre of Fashion," 12). In this way, Poiret was concerned that anytime one encountered one of his designs, one would be aware of its provenance and enter into the sartorial fantasy that was his label, brand, and reputation. Clothes no longer operated as utilitarian objects, but were seen as extensions of the designer's aura, as is the case today. However, the proliferation of the design patterns, via which anyone could create an "original" Poiret, feeds into the DIY and maker movements in e-textiles production and dissemination today.[105]

Performative Fashions

Beyond his hybrid atelier practice and international dissemination of patterns, Poiret was also known for expanding various performance-based strategies—from department-store fashion shows, traveling trunk shows, and theme parties to films and "art" photos—to build up his reputation, network, and growing presence in the fashion world. Poiret's designs often blurred the line between costume and fashion, from making creations for film stars—such as the celebrated actress Musidora, working with turn-of-the-century filmmaker Louis

[104] The reason for using names instead of numbers is because numbers cannot be copyrighted.
[105] For more on the link between Poiret and the maker movement, see my paper "Open Wearables: Crafting Fashion-Tech," *Nordes 2013 Proceedings* (2013): 211–17.

Feuillade—to throwing Arabian-themed parties, where the various attendees (artists, actresses, and *nouveaux riches*) were required to attend in thematic dress or be refused entry. Poiret never missed an occasion to have the wearers of his garment play a role (Lacassin, 208; Troy, *Couture Culture*).

The close ties between theater and fashion houses from London to Paris led to numerous presentations of couture costumes on stage, as well as sets, themes, and even scripts developed exclusively to promote the presentation of the garments. As notes fashion and art historian Nancy J. Troy: "The theatre provided an ideal venue for fashion display both on the stage and in the audience, and it therefore afforded a significant opportunity for elite couturiers, who were increasingly involved in costume design during this period, to position their work before an audience of interested spectators composed in significant measure of the upper-middle class women who formed their clientele" (Troy, "Theatre," 4).

Hence, the theater was a natural extension of the couture house, and served as a site of promotion and participatory fashion display and performance, both for the actors and the attending audience. As Troy notes, tensions between the traditional and the avant-garde, together with competition between designers for fashionability and relevance, was dramatic enough to be itself the subject of a play, *Rue de la Paix*, which showcased the rivalry that played out between an Orientalist designer (a Poiret-esque character) and a "classical couture house" (Troy, "Theatre," 25)

No other couturier of this era exemplified this blurring of fashion and theater more than Poiret. Not only was Poiret himself a theatrical character (and, literally, a character in a play), who created his persona through the development of exotic styles heavily influenced by popular enchantment with the Orient in the arts, he also seized on every opportunity to have his garments deployed "in action" in performance settings. Two examples include: sending models dressed in his latest styles to the Longchamps races on Sunday afternoons, to promote his couture house; and orchestrating a photo shoot of the actress Spinelly dressed in his garments and photographed in her home, which was designed by Atelier Martine on the theme of a Poiret perfume, *Le Fruit défendu* (Troy, "Theatre," 4).

Hence, Poiret understood that in order for fashion to resonate with the public, it had to be seen as relevant, of the times, and in action upon bodies. This tactic is still used today, as many fashion-tech innovation pieces are designed for actresses or performers to promote the designers. This was the case with Wipprecht's custom-made costumes, designed for and worn by Fergie of the Black Eyed Peas at the 2011 Super Bowl half-time show, or Diffus' *Solar Bag*, worn by Crown Princess Mary of Denmark at the opening of the *Health Environment Climate* exhibition in 2012.

Staging Fashion

The interplay between actress and mannequin, keenly explored by Poiret and other designers of his era, featured actresses and theater settings to promote the latest designs. In this context, performances were also staged for the intimate circle of Poiret's clientele. Here, mannequins were trained to perform like actresses, displaying the garments to interested clients and patrons. In 1909, Poiret commissioned architect Louis Süe to build a small stage in his couture house for the purpose of staging the presentation of his new collections. During these private shows, potential customers would be treated to a theatrical presentation of the collection, while seated much like a theater audience.

As costume historian James Laver remarked, the theatricalization of fashion became prominent in the early twentieth century, when "mannequin parades of the fashionable dressmakers became themselves fashionable occasions, which had certainly never happened before in the whole history of dress. People went to a fashion parade as their fathers had gone to a play or to a private view of pictures. They expected a luxurious décor, soft lights, music, a procession of beautiful mannequins, and, what is even more important, they expected something startling new and original presented before their eyes" (Laver, 91).

Poiret's fashion presentations (and those of other couture houses) were mostly performed by working girls trained to act like bourgeois women and dressed in Poiret's newest designs. They performed to bourgeois women (or their husbands) with the aim of enticing them to make a purchase. When describing the new profession of fashion models, turn-of-the-century fashion critic Arsène Alexandre noted that, "Everything about them and their profession recalls the theatre" (Alexandre, 105). In fact, the acting required on the part of the model had to be at a level sufficiently high to convince the potential customer that she (or the woman intended to wear the garment) would be imbued with the same elegance and beauty as the model presenting it. In this way, the audience/customer projected herself, or his loved one, into the role embodied by the model.

In order to expand opportunities to present his designs to larger audiences, Poiret capitalized on the emergent venue of the department store to further explore new fashion audiences (Troy, "Paul Poiret's Minaret Style"; Wollen, 10). Here, live presentations were staged in popular American department stores, such as Gimbel Brothers, R. H. Macy's, and John Wanamaker, in order to convey the full effect of the garments. The Wanamaker and Gimbel stores even went so far as to stage Oriental-themed sets and live presentations by models dressed in Poiret's fashions inspired by *Le Minaret* costumes, blurring the line between theater, fashion, and marketing. For this occasion, the thematic setting of the "East" was distributed throughout the store areas, as in the case of Macy's creation of a "Moorish Palace" on its eighth floor, which enveloped most of the floor's restaurant in masses of gold, red, and green (Troy, *Couture Culture*, 223).

The American department store played into the theatricality of commerce, offering a stage on which people could present themselves, much like the arcades described by Baudelaire and Benjamin. William Leach describes this theatrical dimension, wherein "merchants started to build their own auditoriums, [and] department stores literally became theaters, putting on plays, musicals, concerts, and, in some instances, spectacular extravaganzas…. Display managers used theatrical strategies inside and outside the stores. Windows not only were conceived as stage sets but also often depicted scenes from the latest theatrical productions…. Immersed in those theatrical, surreal settings, commodities themselves acquired new life, new meanings" (Troy, *Couture Culture*, 231).

Thus, the department store became a theater of sorts, both for Poiret's presentations, in the literal sense, but also for the potential buyers, who entered into the fabricated splendor of the "East," staged in the shopping environment, and projected themselves into Poiret's exotic, French-Oriental universe. One could argue that today's commercial and design fairs, such as CES and Augmented World Expo, Smart Fabrics (now WEAR conference), and SIGGRAPH, where many wearables or fashion-tech designs are first launched or promoted, likewise serve as theaters and showcase spaces for their products. Often, outside of rare museum exhibitions or online/print magazines, these are some of the only physical spaces where consumers will encounter new wearables. Again, many of these sales-focused events, when promoting wearables, choose to stage a fashion show or live demonstration in order to present the design and the technology in the most alluring and attention-grabbing fashion.[106]

Media and the Fashion Party

Beyond the stage and runway events, Poiret was equally known for his themed "fêtes," at which the guests had to arrive dressed in the designer's garments or be refused entry. His most famous *Arabian Nights*-themed party was the *Thousand and Second Night* (24 June 1911), where guests had to dress in "Oriental" costumes (Troy, "Theatre," 13).[107] With the emergence of photography and film, Poiret was quick to explore the possibility of promoting his fashions (much like in today's advertisements) via artistic collaborations and

[106] For more on these "walking" presentations, see interview with Anouk Wipprecht in Appendix A.
[107] Other parties included the *Fêtes des Rois*, inspired by the Sun King; *Les Festes the Bacchus*; the outdoor nightclub *The Oasis*; and the commissioning of three decorated barges—*Amours*, *Délices*, and *Orgues*—on the occasion of the 1925 Exposition internationale des Arts décoratifs et industriels modernes. See: Nancy J. Troy, *Couture Culture: A Study in Modern Art and Fashion* (Cambridge, MA: MIT Press, 2003).

films. As the films of his era required natural light, Poiret seized on the outdoor settings of his atelier, where his fêtes took place, as an opportunity to create films of his mannequins in motion. These films permitted Poiret to take his fashion show on the road, so to speak.

Furthermore, Poiret actively sought out artistic talent for the photography of his designs, which yielded collaborations with French surrealist Man Ray and American artist Edward Steichen. In an interesting parallel, films on wearables have lately come to dominate how we understand fashion-tech, since we are thus able to see the medium and design in action, and transform before our eyes. Also, because of the often ephemeral, one-off nature of fashion-tech designs, films are sometimes the only way an audience can encounter the work and understand it. Similarly, many of the works developed at the intersection of fashion and technology only ever exist via film documentation—because, that is, of the limited number of works, because of the design's or technology's short lifespan, or simply because it was an experiment, which, much like a performance, was meant for the moment, and not to be a permanent object. This applies to many high-fashion works, such as those of Diffus, Wipprecht, XS Labs, and 3lectromode.

Overall, Poiret's contribution is important because it demonstrates the interconnection of fashion with art, science, and performance. In Poiret's oeuvre and career, we see fashion expanding into society and being "performed" by sellers, buyers, and fans (or copycats) alike. In all cases, fashion is more than an object; it is an expression of social standing, of personal style, of the display of new mores surrounding the body. Fashion is an event and a performance. This blurring of acting/performing/presenting fashion is important for fashion-tech, because it is often argued that wearables are not “real” fashion. I would like to argue that not only were the roots of fashion intertwined with those of theater, artifice, and spectacle, but that an important element of fashion is performance: fashion shows, events, photo shoots, films, etc. In this way, fashion-tech provides an added layer of thematic performance effects (which, fantastical though they may be, do not run contrary to fashion’s roots) as well as multiple effects at transforming the body and our perceptions of it. From this perspective, the designs of wearables creatives must be taken more seriously, together with their makers’ efforts to shape new stylistic and material forms for fashion, experiences, and the body.

Figure 10. Giacommo Balla, *Futurist Suits* (1914).

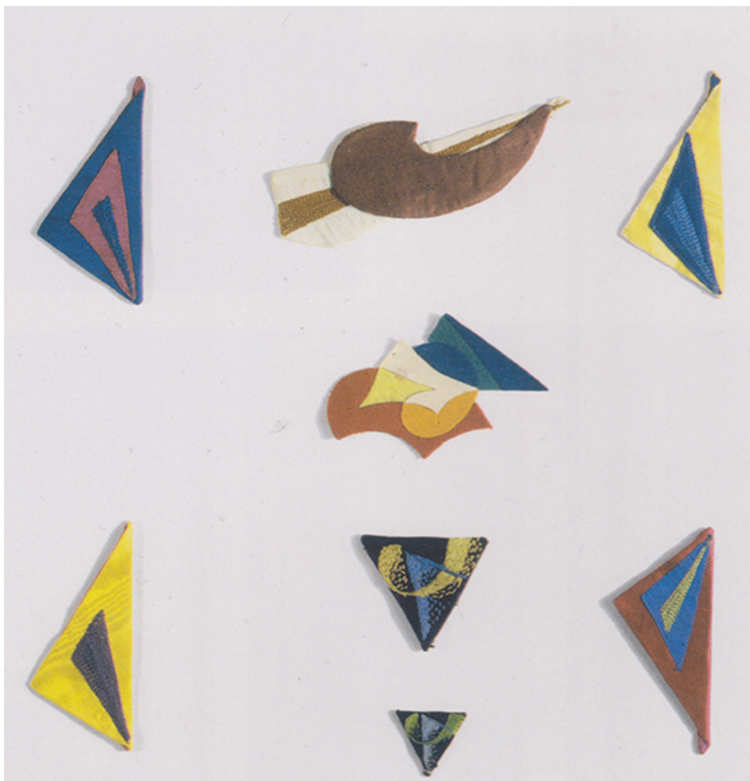
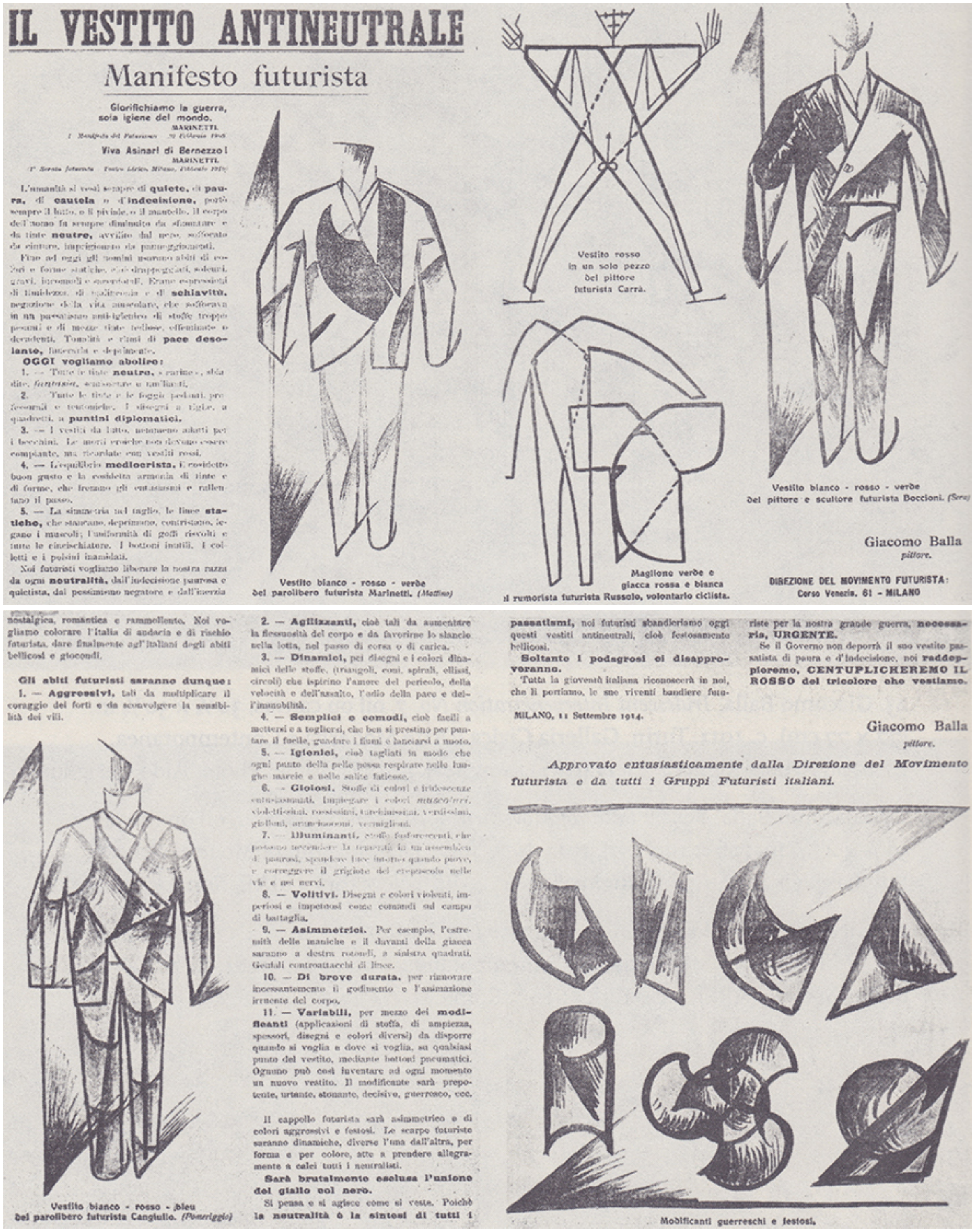


Figure 11. Giacommo Balla, *Modificanti* (1914).



IL VESTITO ANTINEUTRALE

Manifesto futurista

Glorifichiamo la guerra, sola igiene del mondo.
MARINETTI.
1° Manifesto del Futurismo 20 Febbraio 1909.

Viva Asinari di Bernezzo!
MARINETTI.
1ª Serata futurista Teatro Lirico, Milano, Febbraio 1910.

L'umanità si vesti sempre di **quiete**, di **paura**, di **cautela** o d'**indecisione**, portò sempre il lutto, o il piviale, o il mantello. Il corpo dell'uomo fu sempre diminuito da sfumature e da tinte **neutre**, avvilito dal nero, soffocato da cinture, imprigionato da panneggiamenti.

Fino ad oggi gli uomini usarono abiti di colori e forme statiche, cioè drappeggiati, solenni, gravi, incomodi e sacerdotali. Erano espressioni di timidezza, di malinconia e di **schiavitù**, negazione della vita muscolare, che soffocava in un passatismo anti-igienico di stoffe troppo pesanti e di mezze tinte tediose, effeminate o decadenti. Tonalità e ritmi di **pace desolante**, funeraria e deprimente.

OGGI vogliamo abolire:

1\. — Tutte le tinte **neutre**, «carine», sbiadite, *fantasia*, semioscure e umilianti.

2\. — Tutte le tinte e le foggie pedanti, professorali e teutoniche. I disegni a righe, a quadretti, a **puntini diplomatici**.

3\. — I vestiti da lutto, nemmeno adatti per i becchini. Le morti eroiche non devono essere compiante, ma ricordate con vestiti rossi.

4\. — L'equilibrio **mediocrista**, il cosidetto buon gusto e la cosidetta armonia di tinte e di forme, che frenano gli entusiasmi e rallentano il passo.

5\. — La simmetria nel taglio, le linee **statiche**, che stancano, deprimono, contristano, legano i muscoli; l'uniformità di goffi risvolti e tutte le cincischiature. I bottoni inutili. I colletti e i polsini inamidati.

Noi futuristi vogliamo liberare la nostra razza da ogni **neutralità**, dall'indecisione paurosa e quietista, dal pessimismo negatore e dall'inerzia nostalgica, romantica e rammollente. Noi vogliamo colorare l'Italia di audacia e di rischio futurista, dare finalmente agl'italiani degli abiti bellicosi e giocondi.

Gli abiti futuristi saranno dunque:

1\. — **Aggressivi**, tali da moltiplicare il coraggio dei forti e da sconvolgere la sensibilità dei vili.

2\. — **Agilizzanti**, cioè tali da aumentare la flessuosità del corpo e da favorirne lo slancio nella lotta, nel passo di corsa o di carica.

3\. — **Dinamici**, pei disegni e i colori dinamici delle stoffe, (triangoli, coni, spirali, ellissi, circoli) che ispirino l'amore del pericolo, della velocità e dell'assalto, l'odio della pace e dell'immobilità.

4\. — **Semplici e comodi**, cioè facili a mettersi e a togliersi, che ben si prestino per puntare il fucile, guadare i fiumi e lanciarsi a nuoto.

5\. — **Igienici**, cioè tagliati in modo che ogni punto della pelle possa respirare nelle lunghe marcie e nelle salite faticose.

6\. — **Gioiosi.** Stoffe di colori e iridescenze entusiasmanti. Impiegare i colori *muscolari*, violettissimi, rossissimi, turchinissimi, verdissimi, gialloni, aranciooooni, vermiglioni.

7\. — **Illuminanti.** Stoffe fosforescenti, che possono accendere la temerità in un'assemblea di paurosi, spandere luce intorno quando piove, e correggere il grigiore del crepuscolo nelle vie e nei nervi.

8\. — **Volitivi.** Disegni e colori violenti, imperiosi e impetuosi come comandi sul campo di battaglia.

9\. — **Asimmetrici.** Per esempio, l'estremità delle maniche e il davanti della giacca saranno a destra rotondi, a sinistra quadrati. Geniali controattacchi di linee.

10\. — **Di breve durata**, per rinnovare incessantemente il godimento e l'animazione irruente del corpo.

11\. — **Variabili**, per mezzo dei **modificanti** (applicazioni di stoffa, di ampiezza, spessori, disegni e colori diversi) da disporre quando si voglia e dove si voglia, su qualsiasi punto del vestito, mediante bottoni pneumatici. Ognuno può così inventare ad ogni momento un nuovo vestito. Il modificante sarà prepotente, urtante, stonante, decisivo, guerresco, ecc.

Il cappello futurista sarà asimmetrico e di colori aggressivi e festosi. Le scarpe futuriste saranno dinamiche, diverse l'una dall'altra, per forma e per colore, atte a prendere allegramente a calci tutti i neutralisti.

Sarà brutalmente esclusa l'unione del giallo col nero.

Si pensa e si agisce come si veste. Poichè **la neutralità è la sintesi di tutti i passatismi**, noi futuristi sbandieriamo oggi questi vestiti antineutrali, cioè festosamente bellicosi.

Soltanto i podagrosi ci disapproveranno.

Tutta la gioventù italiana riconoscerà in noi, che li portiamo, le sue viventi bandiere futuriste per la nostra grande guerra, **necessaria, URGENTE.**

Se il Governo non deporrà il suo vestito passatista di paura e d'indecisione, noi **raddoppieremo, CENTUPLICHEREMO IL ROSSO del tricolore che vestiamo.**

MILANO, 11 Settembre 1914.

Giacomo Balla
pittore.

Approvato entusiasticamente dalla Direzione del Movimento futurista e da tutti i Gruppi Futuristi italiani.

Vestito bianco - rosso - verde del parolibero futurista Marinetti. *(Mattino)*

Vestito rosso in un solo pezzo del pittore futurista Carrà.

Maglione verde e giacca rossa e bianca del rumorista futurista Russolo, volontario ciclista.

Vestito bianco - rosso - verde del pittore e scultore futurista Boccioni. *(Sera)*

Giacomo Balla
pittore.

DIREZIONE DEL MOVIMENTO FUTURISTA: Corso Venezia, 61 - MILANO

Vestito bianco - rosso - bleu del parolibero futurista Cangiullo. *(Pomeriggio)*

Modificanti guerreschi e festosi.

Figure 12. Giacommo Balla, *Il Vestito Antineutrale* (1914).

4.3 Giacomo Balla: *Antineutral Suit* (1914)

The Italian Futurists emerged in the flurry of the First World War, where speed, action, and politics influenced art. Manifestos and performance-art scripts of this era include instructions, declarations, images, scenarios, and first-person accounts of various groups' technology-inspired activism and art. Heavily invested in spectacle, controversy, and debate, the Futurists were active publishers, performers, and provocateurs, in tune with the changing technological landscape following the First World War. As the Futurists' figurehead and the movement's primary financial backer, Filippo Tommaso Marinetti wrote multiple essays and manifestos promoting his vision for an art of revolution, including *The Founding and Manifesto of Futurism* (1909), *The Birth of Futurist Aesthetics* (1911–15), and *War, the Only Hygiene of the World* (1915). These texts, along with many more that he and other authors would publish throughout the furor of Futurism, point to technology, revolution, and even war to liberate humanity from Romantic and Symbolist notions of society and art (Flint, 90).

It is in large part through these manifestos that we are able to access the Futurist mindset and motivations. Inspired by automata, machines, war, modularity, rapid change, and the impermanence and interchangeability of the body, city, and state, Futurism viewed clothing, set design, and *in situ* installations and performance as fertile ground for social critique.[108] The Futurist artist "wanted to act on all elements of daily life, from architecture

[108] Berghaus, *Italian Futurist Theatre*; *Avant-Garde Performance*; *Futurism and the Technological Imagination*, *International Yearbook of Futurism Studies*; Perloff, *The Futurist Moment*.

to furniture to carpets, from toys to food and music, and dress was no exception” (Stern, 29).

Born in Turin, Italy, Giacomo Balla (1871–1958) was principally known as a painter. Motifs of light and movement figured prominently in his work. Later, while living in Rome, he would become the painting teacher of Gino Severini and Umberto Boccioni, two painters renowned for their representation of movement and action. Balla, during his career, also collaborated on designing sets and costumes for related Futurist and avant-garde events, like the sets for Russian-French composer Igor Stravinsky’s *Feu d’artifice*, in 1917. An active Futurist, Balla signed his name to multiple manifestos written in collaboration with Marinetti and others, such as *Manifesto of the Futurist Painters* (1910), *Futurist Painting: Technical Manifesto* (1910), *The Exhibitors to the Public* (1912), and, in collaboration with Fortunato Depero, *Futurist Reconstruction of the Universe* (1915).

It was Balla, however, who delved into themes directly relevant to our research, namely the possibility for garments—especially men’s clothing—to be dynamic, electric, and generally artistically expressive, as well as structurally modular and materially non-traditional, thus breaking with the prevailing dress decorum of his era. Balla’s designs converge with other machine-body actions, inventions, and manifestos of his era, in art and culture, as discussed earlier in this chapter (Kirby and Kirby, *Futurist Performance*; Rainey, Poggi, and Wittman, *Futurism: An Anthology*). It is Balla’s modular, interactive, and artistically performative approach to dress and the body that I wish to explore, as a precursor to interactive garments of today as seen in wearables.

Futurist Men's Clothing, or The Antineutral Suit

Balla solo-authored *Futurist Men's Clothing: A Manifesto* (1914), which would soon afterward be edited and re-published by Marinetti under the title *The Antineutral Suit* (1914). This manifesto echoes the collective Futurist cry for change and antiestablishment acts of disruption, most particularly through sartorial shifts. The manifesto reads in two parts: what not to wear; and what to wear. Abolished were: morning clothes; neutral clothes; patterned clothes (stripped, checkered, and dotted); good taste and color harmony; symmetrical cuts; useless buttons; and starched collars. The proposition for Futurist clothes, or "what to wear," promoted designs that were dynamic; asymmetrical; agile; simple; comfortable; hygienic; joyful; illuminating; strong-willed; floating; short-lived (or ephemeral); and changeable. Of the many playful traits in this proposition, we can also identify tangible inspirations and developments that are presently occurring in the fields of wearables, fashion-tech, and smart fabrics: notably, for instance, the desire for clothes that transform in tandem with the wearer's rhythms, moods, and needs.

Balla's Futurist clothes were made variable, or transformable, by small add-on pieces that he called "modifiers." He describes these modifiers as "appliqué fabrics (of different size, thickness, or color) that you can dispose of when—and wherever—you want, from whatever part of the suit, by means of pneumatic buttons. That way anyone can, not just modify, but at any moment invent a new suit that corresponds to his/her current mood."[109] Presciently, Balla anticipated the wave of responsive technologies, including wearables, designed to adapt and indicate (to the wearer or to others) the various changing states—emotion and physical—through which the body passes. For example, emotion-based garments, such as Sensoree's *Mood Sweater*, can visualize "moods" using galvanic skin-response sensors, with the activation of colored LED lights.[110]

In the field of technical textiles, we are now also seeing materials programmed to respond to the wearer's physiological state, such as the *bioLogic* textile, developed by the MIT Media Lab's Tangible Media Group, which responds to the wearer's temperature states, opening up and letting the skin breathe.[111] When considering this cutting-edge research, one cannot but refer back to Balla's call for "hygienic" clothing that would be "cut in such a way that the pore of the skin can breathe easily." Finally, Balla's call for "illuminating" garments made of "phosphorescent fabrics that can spread light around when it rains" is perhaps the most popular form of e-textiles and wearables design expression, seen in countless design garments (from Wipprecht's Fergie costume for the Super Bowl, to Hussein Chalayan's dress, to Diffus' *Climate Dress*, and my own DIY designs with 3lectromode).

Transforming from the Outside-In

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[109] Balla's first modifiers were made of cloth, with subsequent ones made from coloured paper. Balla even considered creating "perfumed" and textured modifiers, thus experimenting with more than one sense. See: Radu Stern, *Against Fashion: Clothing as Art, 1850–1930*. (Cambridge, MA: MIT Press, 2004).
[110] See: http://sensoree.com/
[111] See: http://tangible.media.mit.edu/project/biologic/

For Balla, garments are neither frivolous commercial goods of vanity and display, nor are they purely functional items made to protect our bodies and decorum. Garments, for Balla, act as conduits for many of the physical and conceptual changes that inspired and drove this group of artists and activists. Furthermore, from a political standpoint, the garments imagined by Balla opened up the idea of fashion and costume expression for the individual. As notes Stern: “Within the limits fixed by the artist, the wearers of [Balla’s] clothing could express their own creativity, and in this way attire became an ‘open’ work of art” (Stern, 32). As previously mentioned, the movement for DIY (seen already with Poiret, and ever-present in e-textiles and the popularization of technology and craft) is also present in the ethos of Balla’s garments, where the wearers/participants can modulate their expressions via *in situ* and time-specific changes in their garments’ structures.

Balla was not only an essayist, but also produced significant bodies of art that tested his concepts of fashion and transformation, and which would later be put into action whilst wearing them. Most of the design concepts were developed as one-offs that Balla wore himself, or for various members of his family, such as his wife Eliza and daughters Luce and Elica (Stern, *Against Fashion*). Additionally, Balla was often solicited to participate in Futurist events, at which he arrived in “costume,” a spectacle that provoked either anger, ridicule, or contempt, depending on the context or public.

Clearly, Balla was interested in testing the aesthetic and social limits of his designs. He even went so far as to create an illuminated tie, which “consisted of a transparent celluloid box in which he put a battery and an electric bulb that lit up to emphasize electrifying passages of his speeches” (Crispolti, 100). Balla’s emphasis was on creating platforms through which one's ability to "speak"—and perform—would extend to one's clothing on a personal or collective scale—a completely novel and unconventional concept for the time.

Dance Technology

As Balla's manifestos were being disseminated, Marinetti was writing pieces on dance technology, influenced by his time on the WWI combat lines. His *Manifesto of the Futurist Dance* (1917), interestingly, refers to Loïe Fuller as inspiring machinelike movements for performance art/dance (Flint, 138). Some of Marinetti's other dance compositions, such as *Dance of the Shrapnel*, *Dance of the Machine Gun*, and *Dance of the Aviatrix*, invite the body to perform as a mechanical war machine (Azari, *Futurist Aerial Theatre*; Rainey, Poggi, and Wittman, *Futurism*).

Various other Futurists used performance to create a greater symbiosis between man and machine. Performance such as that described in Fedele Azari's manifesto, *Futurist Aerial Theatre* (1919), which advocated for the plane to "become(s) an extension of his [the human] body" in the grandiose performance of flight acrobatics; or Luigi Russolo's *Intonarumori* (1910), which featured machines, instead of humans, to create musical virtuosity. Even Balla experimented with performance, as in his work *Printing Press (Macchina Tipographica)* (1914), which linked the performer with (mechanical) representations of the typewriter.

Balla's script for *Macchina Tipografica* showcased performances for twelve voices emulating staccato word fragments from the typewriter, creating a cacophony of human-made machine sounds, emphasized a synergy between machine and man (Kirby and Kirby, *Futurist Performance*; Rainey, Poggi, and Wittman, *Futurism*). Kirby describes Balla's performance schema as follows:

> A sketch by Balla shows six performers, represented by simple stick figures, and indicates something of the movement. Standing one behind the other with their arms extended rigidly in front, two performers rock forward and back, making what could be a piston or a drive shaft. There are two such pairs of performers, and each "piston" seems to drive a "wheel," created by another performer who sweeps his arm or arms in a full circle. The two "wheels" face each other, the overlapping of their arcs and the indication that their hands are held at right angles to their arms suggests that they are "cog wheels" whose movements work together. (Kirby and Kirby, 95)

Futurist art critic Umbro Apollonio foresaw cybernetics and the future role of "machines" in "substituting mechanical devices in the performance of functions which were then still held to be the sole prerogative of human beings" (Apollonio, 9). Manifestos, such as Bruno Corradini and Emilio Settimelli's *Weights, Measures and Prices of Artistic Genius* (1914), declared that: "there is no essential difference between a human brain and a machine. It is mechanically more complicated, that is all…. For a typewriter to have its E pressed and to write an X would be nonsensical." (Appolonio, 8)

In this way, Futurists already foresaw, albeit in an artistic fashion, the cybernetic future of "thinking machines" as theoretically and mechanically conceived by Turing and Wiener, only a few decades later. In fact, the Futurists embraced the notion of the artist as scientist, and sought a mechanization of the human hand and mind, which would put the human being on par with the machine, no more or less.

For example, Corradini and Settimelli's manifesto calls for abolition of genius "subjectivity" with the objectivity of tools, by replacing "critic" and "criticism" with "measurer" and "measurement." Thus, we encounter a relativization of subjectivity and action that mirrors concepts of human and nonhuman performance in which agency in intermix and are relativized. Furthermore, Futurists embraced the abstract logic of numbers over taste, as in the case of the painter Severini, who advocated for an "aesthetic of numbers" that would herald the end of painting. In his essay, "The Statistical Sublime," Jeffrey T. Schnapp further notes the role of mathematics in shaping Futurist logic and artistic creations, as, for example, the numerically inspired manifestos, like Marinetti's *Geometrical and Mechanical Splendour* (1914), which called for the implementation of mathematical language into written text.

In his 1913 manifesto *The Plastic Analogies of Dynamism*, Severini championed an all-encompassing dynamism of form, merging pictorial, sculptural, and architectural dimensions, all the while living in "the open air." This ambitious, non-static, mutable, multiform art, of which Severini speaks, to our twenty-first-century imaginations evokes programmable, computationally driven interactive art in all its forms. This prescient embrace of mechanical and mathematical aesthetics and concepts—in an era that barely possessed a thinking machine more powerful than a manual typewriter—is telling of art's desire, or instinct, to align with mechanical modes of expression—and this before the birth of engineering proper. In this way, Balla's ideas and experiments confirm a pre-computational-era drive to play with interaction through clothes, in a way presently being explored and instantiated in wearables and fashion-tech.

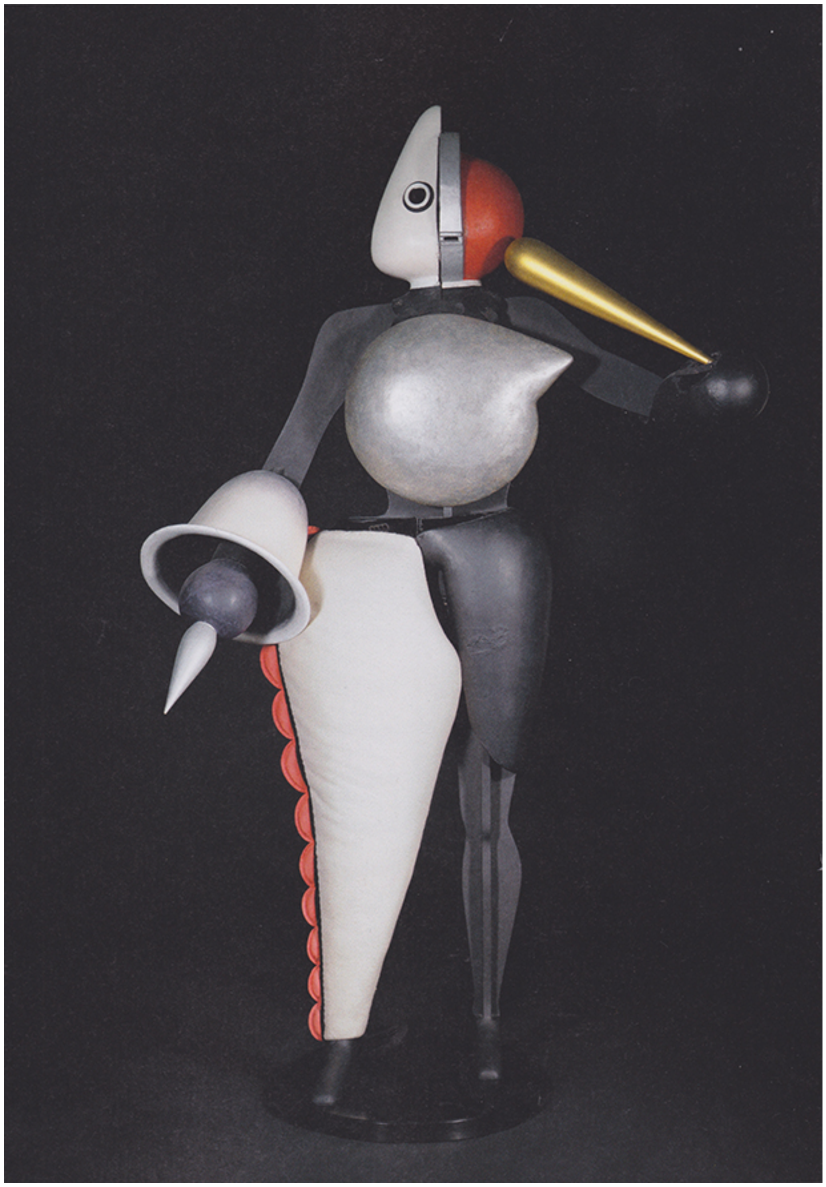

Figure 13. Oskar Schlemmer, *The Abstract* One (1922).

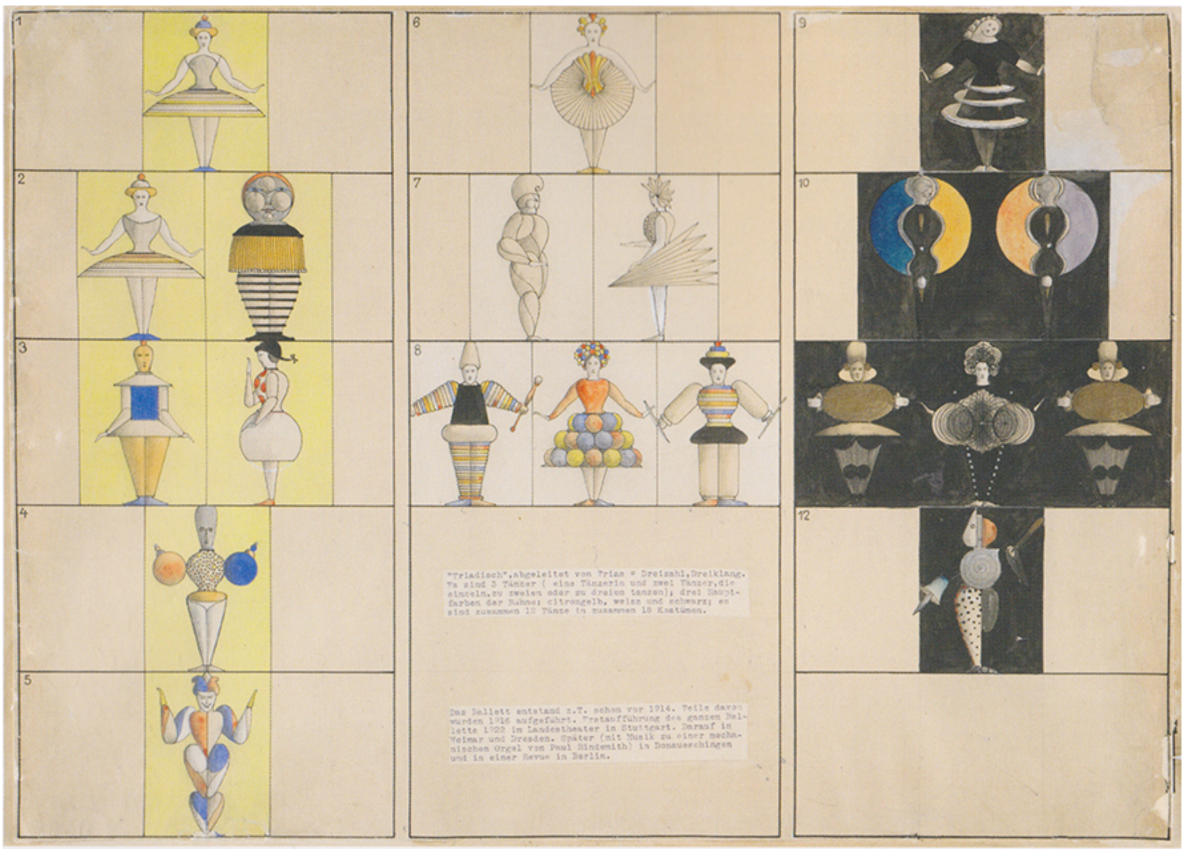

Figure 14. Oskar Schlemmer, *Triadic Ballet Costume Designs* (1926).

Figure 15. Oskar Schlemmer, *Triadic Ballet Group Photo* (1927).

4.4 Oskar Schlemmer: *Triadic Ballet* (1922)

The avant-garde across Europe had ignited a new passion for performance and the stage. Through the works not only of the Futurists but also of their many conspirators in performance, from the Dadaists to the Russian Constructivists, the stage had increasingly become a site for innovation. The archives of Oskar Schlemmer (1888-1943), which contain theatrical scripts, costume illustrations, and performance photographs of his *Triadic Ballet* (1922), are housed at the Bauhaus Archives in Berlin, Dessau/Weimar, and Italy. These richly descriptive documents (photographs, journals, and notes) offer a road map for his conceptualization of a technologized body expressed through stylized costumes. As we will see, Schlemmer's designs of the costumes (and scenography) for the *Triadic Ballet* were conceived as both a retooling of bodily kinesthetics and a representation of technological mechanisms.

As the "original modernist art school," the Bauhaus contributed exceptional conceptual and material designs centered on the emerging technologies of the day. These designs addressed the expansive fields of architecture, planning, painting, sculpture, industrial design, textile, and theater, and were created with the aim of "seeking a new synthesis of art and modern technology" (Gropius, 7; Siebenbrodt and Schöbe, 7). Rooted in Weimar, Dessau, and Berlin (1919–33), the Bauhaus movement and school redefined the role of the artist through the material practices of industrial production and tools. The movement sought an "effective connection between commerce, craftsmanship and industry, and the designing artist" (Siebenbrodt and Schöbe, 9). These artistic technological advancements are central to the Bauhaus ethos; and in the work of Schlemmer, they are related to the body and expression.

Marionette Man

Artist/designer Oskar Schlemmer cultivated many technical and artistic skills, including mural painting, stone sculpture, metalworking, woodcarving, life drawing, and, finally, theater theory and practice. After working in the sculpture department, in 1923 Schlemmer was appointed head of the Bauhaus stage workshop. However, it was the body as it relates to movement and skeletal-muscular articulations on stage for which Schlemmer became best known. Exploring man's holistic image in classes focused on the general theme of "Man," Schlemmer engaged in a number of investigations of topics including kinetics, the relationships between man and dwelling and man and science (biology), socio-hygienic issues, and the concept of "fluidum," as well as the aura of the human body in space (Blume, "Figured in Artificial Space"; Siebenbrodt and Schöbe, 57–58).

Schlemmer's experiments on the "synthesis of man and marionette," in performances such as *Space Dance* (1926), *Gesture Dance III* (1927), *Hoop Dance* (1928), and *Rod Dance* (1928/29), or the *Metal Dance* (1929), further explored abstraction and the reshaping of body mechanics through the effects of costumes and stage representations (Lahusen, 65; Siebenbrodt and Schöbe, 177; Valdiviesco, "Tell me how you celebrate").[112]

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[112] Schlemmer, along with many avant-garde artists of his era, was influenced by Heinrich von Kleist's 1810 essay "On the Marionette Theatre," in which he discusses the power of the marionette to cause man to

Triadic Ballet

This interest in reshaping the human body is most visibly invested in his ten-year (1922–32) experiment, the production of his *Triadic Ballet*. Therein, Schlemmer was interested in expanding two key elements: abstraction and mechanization. In his essay, "The Mathematics of Dance," Schlemmer states: "When the artists of today appreciate the machine, technology, and organization, when they want precision instead of vagueness, then this is nothing but an escape from chaos and a longing for form…. As for myself, I am for the body-mechanical dance, the mathematical dance" (Schlemmer, 118).

For Schlemmer, the mechanical body is not antithetic to the natural body, but rather sets free an inherent mathematical dimension already present in the body and its movements. As Schlemmer states, "The body itself can demonstrate its mathematics by setting free his bodily mechanics" (Schlemmer, "Mathematics," 118). What Schlemmer intended with the *Triadic Ballet* was to explore these theories in action—much like a performative laboratory—and elucidate this inherent mathematical dimension. As dance theorist Susanne Lahusen argues, although technology arrives through a desire for order, man remains very much at the center of Schlemmer's philosophy of man-machine (Lahusen, 67). Schlemmer's expression of abstraction mechanization can be seen in his use of spatialization and costume. Here is how he describes these two poles of dance:

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become self-aware and thus lose his innocence. See: Heinrich von Kleist and Thomas G. Neumiller, "On the Marionette Theatre," *The Drama Review: TDR* 16, no. 3 (1972): 22–26.

> One of the emblems of our time is abstraction. It functions, on the one hand, to disconnect components from an existing and persisting whole, either to lead them individually ad absurdum or to elevate them to their greatest potential. On the other hand, abstraction can result in generalization and summation, in the construction in bold outline of new totality.
>
> A further emblem of our time is mechanization, the inexorable process which now lays claim to every sphere of life and art. Everything which can be mechanized is mechanized. The result: the recognition of that which cannot be mechanized. (Schlemmer, "Mathematics")

In his drawings and writings, Schlemmer maps out a trajectory for the spatial expression of the body. As he describes, "out of plane geometry, out of the pursuit of the straight line, the diagonal, the circle and the curve, a stereometry of space evolves, almost itself, by the moving vertical line of the dance figure" (Schlemmer, "Mathematics," 118). In this way, space is a player in the choreography of the body. The design and deployment of stage costumes further shaped this sensation and the expression of space as a form of abstraction.

Schlemmer believed that the transformation of the human figure could be achieved by four methods of abstraction, as he states in his 1925 essay "Man and Art Figure." The first method looks at the "laws of the surrounding cubical space," transferred to the body in the form of cubic costumes, so that the body becomes "ambulant architecture." The second was derived from typified bodily forms: "the egg shape of the head, the vase shape of the torso, the club shape of the arms and legs, the ball shape of the joints," resulting in a marionette motif (Schlemmer, Moholy-Nagy, and Molnár, *The Theatre of the Bauhaus*, 26). The third explores "the laws of motion of the human body in space," with emphasis on rotation, direction, and intersection of space, resulting in a costume that forms "*a technical* *organism*" with the body. The fourth, and most important to Schlemmer, is the "metaphysical forms of expression, symbolizing various members of the human body: the star shape of the human hand, the infinite sign of the folded arms, the cross shape of the backbone and shoulders, the double head, multiple limbs, division and suppression of forms" resulting in "dematerialization." These, Schlemmer wrote, "are the possibilities of *Man as Dancer*, transformed by costume and moving in space" (Schlemmer, Moholy-Nagy, and Molnár, *Theatre*, 27).

As Bauhaus historian Thorsten Blume notes, "the space-shaping mechanisms of bodily movements, developing costumes that were simultaneously sculptural models of movement traces as well as media for programming movement," created a novel effect that is still resonating today (Blume, 134; Wesemann, "The Bauhaus Theatre Group"). Schlemmer's re-thinking of body mechanics can be interpreted as a reflection, through costume, of the early Modern era's fascination with automata and the boundaries between man and machine. For Schlemmer, it is through the costume designs that this exploration of space could be arrived at on stage (Lahusen, 72).

Schlemmer describes his *Triadic Ballet* as follows:

> [T]he "Triadic Ballet" was developed … "triadic" (from triad—three) because of the three dancers and of the three parts of its symphonic, architectonic composition and the fusion of the dance, the costumes, and the music. The special characteristics of the ballet are the costumes which are of a coloured, three dimensional design, the human figure which is in an environment of basic mathematical shapes, and the corresponding movements of that figure in space. (Schlemmer, "Mathematics," 119)

The *Triadic Ballet*, thus, was based on the principle of the trinity; consisting of three acts, each act was framed around a different-colored backdrop curtain. The colors corresponded to different moods, also expressed though music and gesture. In the first act, the color yellow evokes the comical; while in the second, rose conjures a solemn ceremony; and the final act, in black, creates an aura of monumentality. The dance first premiered in Stuttgart, Germany, on 30 September 1922, and featured Schlemmer as one of the dancers, accompanied by the couple/dancers Albert Burger and Eva Hötzel.

The performance unfolded through a total of three acts, or twelve scenes, with eighteen costumes in total. The costumes were the main drivers of the dramaturgical arc. Made of unconventional materials stemming from Schlemmer's involvement at the Bauhaus workshop, they were fabricated of wood, cardboard, glass, metal, and papier mâché. Forming geometrical shapes—spheres, hemispheres, cylinders, disks, spirals, and ellipses—the costumes visually and spatially connected the human figure to its active space, and directed its movements. As the dancers' movements were limited through the costumes, the body's expression was rendered abstract and mechanized.

Schlemmer describes these aspects of the *Triadic Ballet* as "the first consequential demonstration of spatially-plastic costumery. Spatially plastic, for they are so to speak cooler and metallic sculptures which, worn by the dancers, move in space, whereby physical sensation in significantly influenced, in such a manner that the more the apparently violated body fuses with the costume, the more it attains new forms of dance expression manifestations."[113]

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[113] Oskar Schlemmer, in "Stage Elements," a 1931 lecture quoted in Karin von Maur, *Oskar Schlemmer: Sculpture*, trans. Anne Engel (New York: Abrams, 1972), 43.

Nancy Troy, who has studied Schlemmer as well as Poiret, describes best what Schlemmer had in mind when developing this costume-influencing choreography. In the final scene of the last act of *The Abstract (Der Abstrate)*, which played on monumentality, a character performed by Schlemmer himself sported an asymmetrical costume:

> [B]ased on the principle of disequilibrium: the white right leg was very thickly padded and accented with red, while the left leg, in black tights, was hardly visible against the black backdrop. The arms were given similarly unbalanced emphases, and the mask that covered the entire head divide the face into two unequally weighted halves. The costumes asymmetrical features were echoed in the movements of "the abstract," for example by the dominant right leg, which took huge, lunging steps in directions that were diagonal to the front of the stage. Thus a lack of balance in the choreography was intended to express the specific character of the costume. (Troy, "The Art of Reconciliation," 133)

Other costumes also sought to constrict or limit the mobility of the dancers, which gave their movements a geometric tone. A costume for *Copper Sphere [= Gold Spheres]*, forced the wearer's arms to cross, shifting the performer's center of balance inward to the shoulders and legs. Here, "the costume became a whole body-mask, a space-sculptural housing which is animated, inhabited, and moved by the dancer" (von Maur, 196). Hence, each costume was designed to alter the performer's movements, in this way coloring their stage presence visually, somatically, and spatially.

In spite of the mechanical and automata references in the forms of the costumes, and the resulting constricting effects on the movements of the dancers, Schlemmer maintained that it was "Not machine, not abstract—always man!" that remained at the center of his work (Schlemmer, "The Letters and Diaries of Oskar Schlemmer," 115). As argues sociologist Eric Michaud, Schlemmer neither aimed to create robots out of men nor to reduce the performers to automata, but instead sought a dialogue at the confrontation of technology and man, wherein "[t]he precision of the machine is not to be mimicked in a more or less efficacious fashion, it is the very structure of the costume that requires 'precision'" (Michaud, 76). Hence, the geometry, spatialization, and mechanization in Schlemmer's work comprise a negotiation between human performers and nonhuman costumes, props, and gestural flow, a concept familiar from our discussions of performative laboratories.

It remains that marionettes, as previously mentioned, influenced Schlemmer and the concept of a man/automaton hybrid for the stage. Schlemmer's diaries give us a further glimpse into the ethos of his man-machine performances, wherein he states that "[b]oth these modes of consciousness—the sense of man as machine, and insight into the deepest wells of creativity—are symptoms of one and the same yearning," which he defined as the "yearning of synthesis." Schlemmer continues in describing the *Triadic Ballet*: "thus the dance, which is Dionysian and wholly emotional in origin, becomes strict and Apollonian in its final form, a symbol of the balancing of opposites" (Schlemmer, "Letters and Diaries," 127, 128).

As represented in the *Triadic Ballet*, Schlemmer's work can thus be seen as an exploration both of the expression of form, and a staged reconciliation/encounter of man and machine. Never advocating for the replacement of man by machine, he nonetheless opened a discourse where abstraction, body mapping, and the modification of gesture and movement through garments transformed both the experience and meaning of the body.

Each of the eighteen costumes featured in the *Triadic Ballet* maps a new body-garment hybrid that shifts both the experience of the wearer/performer and the public's perception and understanding of the body. Without recourse to electronics, sensors, data mapping, or visualization, Schlemmer envisioned a way for the body to be changed, augmented, and remapped through the added second skin of the costume. Furthermore, this mapping and somatic transformation foreshadow the ways in which the technologies to come will be embedded on the body, and will provide new experiences of the body for the wearer and new expressions for those encountering the active garment. Explorations such as those in the works of Diffus, with their *Climate Dress*, and XS Labs, with their kinetic garments such as those seen in the *Scorpions* series, are foreshadowed by Schlemmer's experiments in body-technology-movement-environment.

4.5 Conclusion: Wearables as Pre-Computational Performance

These four historical case studies demonstrate pre-computational examples of body, mechanism, and costume as forms of expression in various fields of performance, from dance, to fashion, performance art, and avant-garde theater. My aim, here, is to solidify the idea that wearables are part of a larger (older, artistic) legacy of sartorial body-mechanism transformations.

As we saw in the work of La Loïe, her *Serpent Dance* was at once a science apparatus, an invention, and a performance; while Poiret's hybrid experiments in making and staging fashion created a road map for how we understand and even consume fashion today. Meanwhile Balla and the Futurists playfully rewrote our relationship to clothing in artful interventions and provocations. Finally, the stage costumes of Schlemmer, in his

Triadic Ballet, coalesced emergent concepts of man-machine through costumes that contained and shaped their movements and meanings.

As we saw in these historical case studies, artists and designers alike worked conceptually and materially on these body-garment interfaces. Their designs sought to speak to the changing Modern times by presenting new, embodied relationships to technology and garments, which resonate with our ongoing fascination and exploration of wearable technologies today. These garments also sought to create further links or symbioses between the worlds of technology, abstraction, and art—and that of the body in motion. Interestingly, a strong personal desire to embody (literally) the activated garments runs through all of our historical examples (as it does in the computational genesis examples). Undoubtedly, the desire to extend the body, to have it connect with new forms, and create new expressions through these forms, is a recurring theme and inspiration. Furthermore, these examples cement the following key ideas: a) that the origins and concepts around body technology are fundamentally pre-computational in intent and form; b) that wearables, fashion-tech, and body technologies first emerged from within the artistic domain; and, finally, c) that wearables are inextricably linked to performance via their couplings of human and nonhuman agencies.

5 CONTEMPORARY CASE STUDIES: PERFORMATIVE WEARABLES

5.0 Introduction

The Wearable Performs

Thus far we have looked at the multiple disciplines that come together to make the wearable, from the various production and material cultures that produce them within the fields of electronics and engineering, e-textiles, smart and intelligent fabrics, and fashion-tech. Next, we (re-)visited the genesis of wearables within the fields of electronics and engineering and discovered that not only was the body present, but all kinds of social, personal, and electronic performances unfolded through the deployment of these designs. Further, we surveyed the rich landscape of theoretical frameworks that converge within the field of performance-related research, from sociology, media arts, and fashion theory to laboratory studies. Within these, we highlighted certain concepts, methods, and perspectives that will serve to better analyze and situate wearables within the field of performance. To support the argument that wearables are concerned with the coupling of the arts, the body, and performance, we next reviewed how pre-computational concepts of performance and technology fed into early Modern ideas of dance, couture, performance art, and avant-garde theater via four historical case studies.

Through this process, we have continuously discovered both performance's malleability, as well as precision as a tool of analysis for wearables. Presently, we will explore four contemporary case studies (all of whom have been mentioned briefly in the course of this thesis), which are presently shaping and inventing the wearables landscape. These are: the internationally known, Dutch-born, San Francisco-based fashion-tech designer Anouk Wipprecht; the Danish design studio Diffus, based in Copenhagen and run by Hanne-Louise Johannesen and Michel Guglielmi; my own DIY atelier, 3lectomode, located in Montreal; and Concordia University's XS Labs, directed by Joanna Berzowska, also in Montréal.[114]

The four sites were chosen both for their excellence in the field (all have won prestigious awards, commissions, and grants, and are internationally reputed thinkers and makers), as well as for their uniqueness and diversity of approach. Such a comparative analysis is necessary to articulate the argument that artistic wearables stem from a hybrid, multifarious, and expanding set of practices, overlapping with fields that include computer science, interactive design, architecture, fashion, media arts, and DIY. Each case study's particular epistemic culture shapes their material outcomes via their studio/atelier/laboratory's intermingling of tools and experts. This diversity of approaches aids further in cementing the argument that the performative layer enveloping artistic wearables is not limited to only one method, practice, technology, or material, but that it is transversally modular and exportable to expansive arrays of methods and approaches—each containing its own formula for "performativity."

My relationships with some of these laboratories and their members span years and comprise many meetings, interviews, encounters at conferences, and expert workshops, as

[114] Much of the content of this chapter derives from a series of audio interviews conducted in early 2016 with each of the contemporary case-study subjects. The interview transcripts can be found in the Appendix.

well as repeated visits to familiarize myself with the sites, designers, and methods found at each studio/atelier. In each case, the individuals involved have become allies, even friends; we have collaborated through the process of this research in elevating and sustaining the field of wearables within the design, tech, education, fashion, and art milieux. The process of conducting this extensive and often intimate research has meant that the study participants have also contributed significantly to the direction and depth of this dissertation, for which I am grateful and indebted.

Using some of the tools we have come by thus far—from the various material forms that encompass wearables, to the historical context of computational and pre-computational wearables, and finally the performative-theory perspectives from sociology, media arts, fashion, and STS—we will presently investigate contemporary wearables and their links to performance. Specifically, we will consider how the laboratory in itself is a research-social-materials space where humans and nonhumans and their "dance of agency" (Pickering) converge and create the wearable designs of today. Next, we will analyze the wearable in relationship to its technologies as a path to a better understanding of its effects on the body, as well as its role in shaping aesthetics and performativity. Further, we will examine how concepts of fashion and style influence wearables' various expressions. Finally, we will consider wearables in their body/interaction dimension, and how the totality of their parts (technology, design, interactivity with the body and other bodies) performs. Hence, we will work our way from the outside in—that is to say, from the laboratory, via technology and fashion, to the performatively social—as a way of situating the places, moments, and contexts wherein performance is visibly tuning the wearable.

Figure 16. Anouk Wipprecht, *Spider Dress* (2014). Photo: Jason Perry.

5.1 Anouk Wipprecht: *Spider Dress* (2014)

Context

The first case study begins in 2011 at V2_ Lab for the Unstable Media in Rotterdam, where I met Anouk Wipprecht, fashion-tech designer-in-residence at the time. While at V2_ for a three-month PhD residency stay, I participated in the E-Textile Workspace research cluster, which conducted monthly meetings on the themes of craft, DIY, and wearables. I also organized a Test_Lab event (single-evening events dedicated to showcasing new works) entitled "Clothing without Cloth," which featured members of the European wearables community (Italy, Holland, England, France) involved in active material experimentation that pushes the limits of "clothing" and textiles.[115] Since this research stay, Wipprecht and I worked on organizing the *TechnoSensual* exhibition, which took place at the MuseumsQuartier in Vienna (2013), and for which I curated the symposium. We have also sat on panels together, including a recent one on "Embracing Fashion + Technology" at the Atelier Néerlandais in Paris (2016), and we have collaborated on an upcoming fashion-tech festival to be held in Montreal in 2017.

Background

[115] Participants in "Clothing without Cloth" included: Emily Crane, a recent MA graduate from Kingston University, London, working with edible textiles (UK); Christien Meindertsma, a materials designer from Rotterdam (Netherlands); Carole Collet, then director of the Textile Futures MA program at Central Saint Martins, London (France/UK); Giada Dammacco, lead designer at Grado Zero Espace, a technology and design company in Florence (Italy); Pauline van Dongen, an independent fashion-tech designer (Netherlands); and Brian Garret, a 3D designer at Freedom of Creation (Netherlands).

Wipprecht, trained as a fashion designer and later in engineering for design, is one of the few mavericks in the field of wearables to straddle skill sets in aesthetics and engineering with equal virtuosity. With the mindset of an inventor and the ambition of a fashion star, she has built an impressive collection of works, collaborators, and followers, influencing the field of fashion-tech. Capitalizing on the growing maker movement, multimedia entertainment events, and opportunities for fashion-tech to tell its story and be at center-stage, she has developed a style that combines robotics and techno-aesthetics. As a researcher, she is keenly invested in wearables' interactive and inter-relational dimensions, and in the potential for wearables to offer the body new capacities for expression that traditional fashion cannot. In short, Wipprecht has crafted a fine creative balance, in which her designs—combining fashion, technology, and the body—permit us to visualize, experience, and dream how we may wish to perform with the fashion-tech of the future.

Laboratory Culture

To begin with the laboratory, or studio context in which Wipprecht works, one should first mention her nomadic and collaborative praxis approach to fashion-tech design. Unlike other designers, who may have set places and spaces of production, Wipprecht prefers to embed herself within R&D work settings such as Intel, Autodesk, or Microsoft. Once on site, she builds partnerships with internal teams to develop new designs that respond to technical needs, embark on explorations, or undertake media showcasing of new fashion-tech technologies. The majority of Wipprecht's work of the last four years has been the result of client-based commissions and sponsorships from some of the biggest tech industries in America, allowing her unheralded access to new technologies, materials, and processes, not to mention high-profile platforms for the presentation of her completed designs. As an epistemic culture, it is one that is often times predicated on a client's need to create better aesthetics and/or stories around emergent technologies in the form of desirable fashion-tech displays. In this way, one of the biggest challenges is balancing the need to showcase a clients' technology while maintaining a consistent signature design. Keeping this goal in mind, Wipprecht's fashion-tech has been structured around a techno-futurist aesthetic that (to date) consistently features 3D printing, robotics, sensors, exoskeletons, and leather.

Wipprecht's works often result from opportunities to forge into new materials and technical or expressive explorations with both clients and collaborators, in what she calls a "collision of practices." As notes Wipprecht: "The best context for collaborating is when someone wants to get into fashion" (Wipprecht interview). For example, the *Smoke Dress*, developed for a 2013 Volkswagen car show, resulted in a collaboration with Italian architect Niccolo Casas. Harnessing the opportunity to fund a new series of works, Wipprecht invited Casas to participate in developing the new pieces for VW. Their collaboration provided an opportunity for Casas to experiment in the field of fashion (he has since become one of Iris Van Herpen's main collaborators in the fabrication of her 3D-printed fashions), while Wipprecht benefited from the hands-on tutelage of Casas to master the 3D software Maya for fashion-design use. In this way, both designers could benefit by expanding their skill sets while creating new work, a common strategy for Wipprecht.

Technology

In fact, the *Smoke Dress* had an earlier iteration, presented at the *TechnoSensual* exhibition (prototyped with Dutch fashion technologist Aduen Darriba), prior to its VW redesign. In explaining the initial prototyping process for the *Smoke Dress*, Wipprecht describes how she (and Darriba) first experimented with the use of smoke machines to visualize the effects on the body. Wipprecht often begins with ideas, images, or concepts that later spur and feed technical experimentation. Examples of this process include: the visual effect of ink floating in water, as s starting point for the *Pseudomorphs* dress (developed at V2_ in 2009); the idea of a "disappearing" garment, which informed the *Intimacy 2* dress (also developed at V2_ in 2009); and finally the notion of social invisibility, propelling the idea of the *Smoke Dress*. Once the concept is established, Wipprecht engages in a process of visualization—both through tangible mock-ups and collage/moodboards—in order to map the placement of technologies, as well as the interactive system's architecture, on the body, thus defining the garment's shape. As Wipprecht cautions, "You can visualize through photos or drawing, but with interaction you need to physically see it in action" (Wipprecht interview).

Early in the design process, accommodation for technical needs and limitations is at the forefront of the design parameters. For example, questions around battery and wire placement can dictate the shape and style of the garment, as in the case of Fergie (of the Black Eyed Peas, performers at the Super Bowl 2011 halftime show), where the batteries were located on the shoulders as epaulettes, instead of around the waist, in order to preserve the pop star's silhouette. In the case of the *Smoke Dress*, the overall shape of the garment was structured in an hourglass shape as a consequence of accommodating the smoke machine in the lower-torso section; while the *Spider Dress* features black spheres (that look like eyes) integrated into the design in order to conceal the proximity sensors. Notes Wipprecht, "my style is created out of the spaces that I create around the body in order to place the electronics." Hence, as a design process, it is one that is predicated on action and tacit experiments that oscillate between the concepts and technical possibilities. This performative model of discovery—which engages in a process of virtual-to-tangible modeling—dictates the final garment's shape, style, and materiality.

The idea for *Spider Dress* stemmed from a short, experimental stop-motion video featuring an analog puppet mechanism placed on the body, which was produced in collaboration with Viennese programmer/technologist Daniel Schatzmayr. After posting the video online and receiving an enthusiastic number of "likes" literally overnight, the duo proceeded to create the piece in earnest. In this way, the Internet could even be considered as a collaborator/performer, as it instigated the development of the piece.

Spider Dress is based on the idea of creating personal space for its wearer. Conceived as an "aggressive" and perhaps even anti-social wearable, it features animatronic arachnid limbs that are activated by the presence and approach of others. Protecting its human "prey," this exoskeleton can enact twelve different behavioural states, depending on the type of approach (fast/slow, back/front, etc.), featuring different speeds and combinations of activations for the spider legs. *Spider Dress* was developed in two iterative processes (Wipprecht often reworks previous designs): the first version was created with Schatzmayr; the second, in collaboration with Intel. The principal difference, other than the showcasing and embedding—and the Intel Edison chip in the second design—is the color. In our interview, Wipprecht emphasizes the importance of aesthetic choices in choreographing wearables' interactions, and notes how the first version, fabricated in black, was too menacing, and thus antithetical to interaction (Wipprecht interview).

Fashion-Tech

Spider Dress was manufactured using PA-12 material via 3D printing using SLS (selective laser sintering) techniques at Materialise in Belgium. Meanwhile, the upper dress bodice was developed in collaboration with Studio Palermo in Austria. Wipprecht describes the inner workings of the *Spider Dress* as follows:

> The Edison module runs embedded Linux, the design is programmed in Python. The dress interactions are defined in "twelve states of behavior" through two Mini Maestro twelve-channel USB servo controllers from Pololu, and uses inverse kinematics. I am working with twenty small 939MG metal gear servos (0.14sec.60o / 0.13sec.60o—stall torque 2.5kg.cm/2.7kg.cm). All servos run back to the system. I am also working with Dynamixels (XL-320 series) of Robotics, which are super-nice to work with, as they are smart, strong, and very accurate. (MakeZine, 19 December 2014)[116]

Spider Dress works via a series of embedded sensors that react intelligently to the ambient interactions it encounters. The 3D-printed robotic shell is enabled with proximity and breath sensors that trigger the carapace's movements. Wipprecht explains: "Using wireless biometric signals, the system makes inferences based on the stress level in your

[116] See: http://makezine.com/2014/12/19/anouks-new-creation-the-spider-dress/ (accessed 12 July 2016).

body. It can differentiate between twelve states of behavior."[117] The behavior of the legs modulates depending on the speed at which one approaches the devices, as well the wearer's physiological reaction as measured by her breath. The technology powering these effects are a combination of an Intel Edison bluetooth controller and a Maxbotix proximity sensor encased in the dark globe at the front of the wearable. Wipprecht's arachnid wearable thus operates as a collaborative visualization of events both within the wearer (breath and proximity) and through the actions and reactions of those surrounding the wearer (speed of approach, distance to fashion-tech garment, length of stay, and sequence of movements). Hence, the movements of the legs are an amalgam of the performance of fashion, body, and technology as encountered both on the wearer's body and through the public's interactions. In this way, the *Spider Dress* is a co-created performance involving wearer, device, and public.

Collaboration

While Wipprecht is hired by companies and sponsors to create fashion-tech designs that promote and showcase their technologies (software, hardware, automobiles), the element of social interaction, relatability, or "readability" is paramount in her design choices, both from an aesthetic and an interaction standpoint. For the designer, a wearable piece has several layers of interaction, of which approachability is the first. The white, Intel version

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[117] Interview with Anouk Wipprecht, "Robotic Spider Dress Powered by Intel Smart Wearable Technology," *iQ by Intel*, 6 January 2015, https://iq.intel.com/smart-spider-dress-by-dutch-designer-anouk-wipprecht/ (accessed 23 December 2016). Interview conducted by *iQ by Intel* executive editor Ken Kaplan.

(or albino, as she calls it) of the *Spider Dress* was altered in order to enhance this first layer of interaction. Wipprecht had felt that the first (black) design was too ominous, and hence did not invite the public/user to approach it. Second, the shape of the design itself, explains Wipprecht, should reveal, or announce, its nature/character from afar (Wipprecht interview). Thus, the 3D-printed, spider-like legs and overall dress structure announce early on that the garment will feature animalistic qualities. Furthermore, for the designer, fashion-tech should speak to all audiences, including (perhaps most of all) those uninitiated to wearables, fashion-tech, or this type of technology. With the *Spider Dress*, because of the strong visual spider theme, the behavioral dimension of the design is easily relatable to almost anyone, as a spider is both recognizable and behaviorally predictable. This known, or "readable," motif makes the garment that much more successful, according to Wipprecht, because it can be immediately accepted and understood, and does not require initiation or special knowledge. Like fashion, which at all ends of the design spectrum must be socially recognizable (e.g., what is the value of a luxury item that cannot be recognized as such?), the wearable, too, must fit into an ecology of fashion.

Considering Wipprecht's design process, we may surmise that her epistemic culture is one of demand, availability, and co-design: the *demand* of the client/market to create something for a specific context (a spectacular Super Bowl halftime-show garment; an Audi/VW brigade of tech-dressed car presenters; or an Intel/Edison intelligent dress); *availability* because through tech-industry partnerships like Intel, Autodesk, and Materialise, Wipprecht secures access to special resources, which she engineers toward fashion-tech outcomes. And, finally, *co-design*, as the internal workings of this nomadic studio practice is primarily choreographed around friendships, the sharing of skills, and the collective pursuit of developing new technologies for the body. Thus, Wipprecht's pieces are rarely a solo process—or a solo vision, for that matter—and the public is often invited to witness, provide aid (crowdsourcing via social media for help and tips), and weigh in on the evolution of the designs as she posts process images online and via social media platforms (Instagram, Facebook).

Bodies/Interaction

When planning the body's actions and the "attitude" of the wearable, Wipprecht works through a number of different scenarios. The piece's attitude comes together in the final stages, often in the context of the photo-shoot, which is also often the first time all the parts are seen together and on a body. The styling and choice of model further influences the feeling of the piece, together with choices over how to perform for the camera, all the while emphasizing certain parts of the wearable above others. Wipprecht describes the process:

> For example, in the Spider Dress photo the model is looking down, the system gets more attention this way. It depends what you want to highlight. Do you want to take away a little bit of the face and the information through that? And, what kind of attitude do you want to create with it. That is what you mostly do with the photo shoot. This is the place where you figure out the piece's identity and the DNA. (Wipprecht interview)

The performance and presentation contexts of the *Spider Dress* were guided by Intel's need to promote a new product—the Intel Edison chip. Hence, presentations of this iteration of the *Spider Dress* took place principally at tech events, such as the Consumer Electronics Show (CES), held in Las Vegas every January. As trade fairs are focused on “demo-ing” new technologies to industry and media audiences, the *Spider Dress* was presented in a format Wipprecht calls a “walking act,” wherein the model walks amongst the attendees and demonstrates the work. In the case of CES, the *Spider Dress* was additionally accompanied by a small flock of 3D-printed robotic spiders, mirroring the wearable via an ambulatory cluster of similarly designed creatures.

Beyond the need to promote industrial clients is Wipprecht’s overarching aim to craft new forms of intimacy via wearables. Inspired by the social challenges faced by many in their efforts to connect, assimilate, and build appropriate social “fronts” (as theorized by Goffman), Wipprecht’s designs speak for the socially awkward, resistive, and ambivalent. For Wipprecht, social malaise is a universal concern, which is perhaps most directly tackled in her recent project *Agent Unicorn*. Developed in collaboration with the Ars Electronica Center in Linz, Austria, *Agent Unicorn* is a wearable adapted for ADHD kids. Playfully designed to look like a unicorn horn, and fabricated via 3D printing, it monitors moments of concentration (when the wearer is still and focused) and communicates this information back to the child/wearer. In this way, affected children can better identify and understand their own patterns of attention/inattention, and thus act on them in a more deliberate fashion.

However, Wipprecht is adamant that the interactions and experiences offered by wearables go well beyond the panacea of health, fitness, and happiness too often marketed via consumer wearables (Wipprecht interview). Rather, Wipprecht pushes her wearables into uncomfortable emotional terrains of anger, shyness, indecency, or misfire.[118] As Wipprecht notes, she is interested in how "these systems around our bodies intuitively might both behave and misbehave … wearables should not behave, because we are misbehaving most of the time, or at least I do. Wearables should provoke the idea of making us better, by calling us out." Hence, in the choreography of her fashion-tech wearables, Wipprecht aims at the co-structuring of experience *with* the garment. She is chiefly interested in how we perform with the wearable, as well as the potential for it to perform for us, and even solicit better, or more authentic performances from us. As notes the designer, "If 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."[119]

This symbiotic performance proposes new ways of thinking about how wearables can extend performatively around and with our bodies, as well as through our mental and emotional states. In a way, one could argue that Wipprecht is interested in breaking the artificiality of the "front" and other social constructions proposed by sociologists like Austin and Goffman more than half a century ago (Austin, *How to Do Things*; Goffman, *Presentation of Self*). Her work expresses a dimension of social breakage and re-invention that both resembles König's concept of sartorial deviance and elucidates the states of non-closure and transition as described in Turner's theory of "liminoid" states (König, *A la*

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[118] For more on emotional wearables, see: Lisa Stead, Peter Goulev, Caroline Evans, and Ebrahim Mandani, "The Emotional Wardrobe," *Personal and Ubiquitous Computing* 8, no. 304 (July 2004): 282–90.
[119] See: http://makezine.com/2014/12/19/anouks-new-creation-the-spider-dress/ (accessed 12 July 2016).

Mode; Turner, "Betwixt and Between"; "Liminal to Liminoid"). Given this line of thought, is it possible to imagine a future in which it will be acceptable for our garments to push people away, or obliterate us in a cloud of smoke when we grow tired of someone or are uncomfortable speaking to them? To be sure, these scenarios, in being more complex and contradictory, are also richer than many of the socially interactive platforms that we engage with today.[120]

Historical Link

We capture glimpses of the work of Loïe Fuller in Wipprecht's fashion. Apart from the obvious comparisons in lifestyle—international art-star nomadism, the scientific muse of invention, reinvention of the body's shape, engineering for emotional effect and drama—at the core of their designs is the dynamism of an exoskeleton overlaid onto the body, amplifying and transforming its expressions. Both artists construct a second skeletal system that comes to stand with, defend, and expand the presence of the person inside it. There is an interesting anecdote about one of La Loïe's fans meeting her backstage and being rather disappointed at the performer's plump, short stature in comparison to the exuberant grace just witnessed on stage (Fuller, "Fifteen Years"). I think of Wipprecht as also creating a second shell (as opposed to skin) that forms and informs these bold effects, expanding the body both physically and communicatively. These armatures of expression, while rewriting

[120] In the interview conducted for this thesis, Wipprecht repeatedly brings up the malaise of social media. She makes it clear that she is interested in creating more "authentic" interactions than the veneer of happiness and sociability afforded by likes and brags, as seen in many social media exchanges. See interview with Wipprecht in Appendix A.

the body's expressivity and emotional amplitude, create a performative symbiosis between body and artifice. And yet, the body is never lost, either in the performances of La Loïe or the fashion-tech designs of Wipprecht. Not merely objects of artifice or decoration, their technological inventions transform the body through performance. Far from posthuman/cyborg dystopias featuring active exoskeletons on "dead" bodies, La Loïe and Wipprecht rather reanimate the body using their second shells, complexifying its expressions though technology. There is a touchingly poetic and beautiful (maybe even intuitive) parallel in these works, which seek to reposition the body in a world of machines and mechanisms by inviting their wearables to perform in tandem with their bodies.

Figure 17. Diffus, *Climate Dress* (2009). Photo: Anni Lauesen.
Model: Anne Sophie Fioritto Thomsen.

5.2 Diffus Studio: *Climate Dress* (2009)

Context

The second case study considers the work of Danish design studio Diffus. In the fall of 2011, invited by Diffus, I participated in the Copenhagen Artist in Residency program (CPH AIR), and, later that fall, in the Danish International Visiting Artist (DIVA) program via an invitation from Aarhus University. The CPH AIR provided me with an atelier space at the Fabrikken: Factory of Art and Design, where artists have access to traditional fine-arts workshops for wood, metal, and painting. During this residency, I worked with Diffus' co-directors, Hanne-Louise Johannesen and Michel Guglielmi, at their research office/atelier. While at Diffus, I familiarized myself with their various wearables and interactive textile designs, as well as their material libraries, and collaborated on brainstorming sessions with local and international partners: Alexandra Instituttet (Denmark), Forster Rohner (Switzerland), and Cetemmsa (Spain).

Background

Diffus design is a multidisciplinary, materials-focused studio working at the intersection of theory and application in art, industrial design, architecture, smart fabrics, and wearables. In existence since 2004, they have developed a number of client-based works and projects that highlight material innovation with design excellence. Wearables have comprised a part of their research focus, though not exclusively. Johannesen has a master's degree in art history and has worked as assistant professor in visual culture at the University of

Copenhagen, and now teaches at the IT University of Copenhagen, while Guglielmi is an architect working with tangible media and interaction design, who teaches at the Royal Danish Academy of Fine Art in the schools of architecture and design.

Laboratory Culture

Diffus describes its approach as both practical and theoretical, wherein which art, culture, aesthetics, and technology all play equal parts in informing design decisions. Particularly, they are interested in experimenting at the intersection of traditional know-how (and craft) combined with new materials in order to create both "soft" and complex technologies. Recognized for their attention to detail in design, Diffus is increasingly sought out by international companies and universities to contribute to the conceptualization of new "smart" designs. Their added value, they assert, is in creating aesthetic objects from technological and innovative materials from various textile and research industries (Diffus interview). In their quest to create designs (and meaning) out of brute materiality, Guglielmi and Johannesen often approach their task from a philosophical point of view, wherein feelings and concepts about materials, bodies, and interaction guide the decision process and feed into the final design. In this way, the firm seeks to innovate designs that "appeal to our emotional self and open up to the sensibility of a large public."[121]

The Diffus studio is a small, intimate space located in Copenhagen's central Vesterbrø neighbourhood and situated in a former residential building with other creative

[121] See: http://www.diffus.dk (accessed 6 July 2012). The website has since been updated and the statement removed.

studios. The Diffus workspace, however, also extends to remoter spaces, including: their personal and teaching settings, and the laboratories of collaborators and service industries—all depending on material needs or convenience of work flow. Many collaborators intersect in their design development process, including seamstresses, engineers, 3D printers, and other textile/material professionals. Because of Diffus' location in the EU, many of their clients, partners, and collaborators come from government-funded research grants (such as Horizon 20/20), putting them in direct contact with small and medium enterprises, notably in the field of industrial design—Pilotfish (Germany), VanBerlo (Netherlands), Fuelfor (Spain), and Zaha Hadid Architects and Base Structures (UK)—as well as research universities—Delft University (Netherlands), Southampton University (UK), Polytechnic Milano (Italy)—and graduate students. In this way, Diffus is able to benefit from a large network of materials and research resources that both inspire and feed the direction of their projects. As Johannesen mentions in the course of our interview, these collaborations open up the studio to new and not-yet-distributed (or published) processes and materials, which guides the design concept phases and tangible possibilities. Furthermore, says Guglielmi, the EU grants also offer precious time for reflection and discussion—key to developing aesthetic and material concepts and ideas.

Technology

Materials are the essence, or core, of Diffus. As explains Guglielmi, "We always try to remember where we come from, which is, exploring the possibilities of creating reactive materials from a design standpoint. Sometimes we try to go back to those roots, as a way of remembering" (Diffus interview). A key way in which this materiality is concretized, from a research point of view, is through an ever expanding "sample book." Functioning much like a materials library, this sample book permits Diffus to archive and collect materials (which they may have encountered or tested during research), as well as to communicate their skill set to potential clients or collaborators. Explains Johannesen, "the sample library acts as a very active communicator" (Diffus interview). In these sample books are contained various kinds of conductive materials (yarns, textiles, metal components) and processes (inks, embroidery), through which they highlight their past projects, breakthroughs, and expertise. While these tests are often the result of contracts and requests on the part of collaborators, Guglielmi notes that the process is not always systematic, but consists more of "making associations from materials that you use in one field and looking at the possibilities of translating them through small adaptations that you find interesting as a designer" (Diffus interview). In either case, experimentation and research are "more or less equal" for the design process at Diffus (Diffus interview).

Through their EU and client networks, and via their extensive experience and expertise, much of the work at Diffus is client-oriented. In this way, the epistemic culture of the lab is driven by external needs and opportunities (both financial and materials-based). It is in part through such a process that the *Climate Dress* was developed in 2009.[122] The dress was conceived as a proof-of-concept collaboration with the Swiss textile company Forster Rohner, funded in part by the Alexandra Instituttet, a Danish technology

[122] The *Climate Dress* is also at times referred to as the *CO_2 Dress*; for purposes of this thesis, I will refer to it in the former manner.

think tank. Seeing a need to diversify their core business of *haute couture* embroidery and lace manufacturing, Forster Rohner has embarked upon engineering embroidery for smart fabrics. Led by Dr. Jan Zimmermann, head of textile innovations at Forster Rohner, the company has been developing smart fabrics for various textile and design uses (from fashion to architecture to auto industries) adapted to the integration of hardware, such as LEDs, sensors, and batteries. The partnership with Diffus emerged from mutual needs: that of Forster Rohner, to showcase their new expertise in smart embroidery fabrication; and of Diffus, to secure access to emergent processes and industry techniques for smart textiles. The *Climate Dress* features a combination of conductive embroidery parts, embroidered LEDs, a $C0_2$ sensor, and an Arduino to compute and manage the data inputs and outputs. The dress is designed to be wearable as a visible air-quality sensor, which can navigate various geolocated spaces and assess environmental air quality. The dress alerts the wearer and those near the dress to distressing levels of $C0_2$, both to warn the public over air quality and to sensitize them to the dangers of pollution.

Fashion

The partnership between Diffus and Forster Rohner was initiated through an invitation to showcase a design within the context of the COP15 Climate Summit in Copenhagen in 2009. Some of the parameters that the design duo took into consideration when developing this piece included: creating a garment using traditional craft; revealing information through aesthetics; and creating a new relationship with embroidery that featured technology. Hence, the *Climate Dress* was born from a desire to fuse craft and tech in such a manner that would aesthetically reveal its functionality. Inspired by the methods of turn-of-the-century French architect Gustav Eiffel and his decorative use of metal structures, Diffus set out to create a garment that could build on the concept via embroidery rather than steel. Created in under two months, the process saw meetings between students from the Danish Design School, technicians from the Alexandra Instituttet, and the technical team at Forster Rohner. Diffus describes their primary work as mediating between the various participants and collaborators in order to arrive at the results they aimed for. Along the way, considerations had to be made for the capacity of the conductive thread and LEDs to adequately illustrate $C0_2$ levels in a visually cohesive and pleasing manner. Guglielmi describes the process of negotiating needs with aesthetics:

> The interaction played a major role in the design of the embroidery and indirectly in the design of the garment on which the embroidery would be applied. More LEDs with more processing abilities could have been added but we needed to constrain ourselves to clear interaction rules between CO_2 levels and the LED patterns as pulse. Those clear rules influenced influenced the design of the circuit layout as well as the design of the required algorithm. (Genova and Moriwaki, 142)

Because the departure point for research at Diffus is materials exploration, it makes sense that the fashion (and aesthetic) frameworks are built around technical and interaction needs. Instead of seeing this as a limitation, the Diffus team is inspired to make "form follow function," as coined by American architect Louis Sullivan.[123] Interestingly, Johannesen refers to Adolf Loos, also a proponent of functional architecture, as an inspiration for their design ethos. She explains: "I think that because of someone like Loos,

[123] Similarly to Eiffel, Sullivan was interested in how steel, in this case in the construction of American skyscrapers, could create new architectural aesthetics.

I was scared to go into something to do with embroidery, because embroidery is just ornament. I think it is really interesting, then, to give this ornament a functionality. Trying to respect Loos, and at the same time subvert him, or being subversive towards him" (Diffus interview). Another concrete example of this philosophy in action is the *Solar Handbag*, created in collaboration with Forster Rohner, the Alexandra Instituttet, and the Hochschule für Technik Rapperswil, in Switzerland—and also the outcome of an EU-funded research grant.[124] The bag uses solar cells to power portable devices; instead of concealing the solar cells, Diffus approached the problem similarly to the *Climate Dress*, making the square cells an integral part of the exterior fabric and design.

In this way, the Diffus studio is closely guided by the quest to discover appropriate form and function through materiality. In describing his action- and time-based performative laboratory, Pickering outlines how human agency's intentionality must be mediated through the nonhuman agencies of matter, machines, and things. Because Pickering's "dance of agency" proceeds across this human-nonhuman negotiation, which unfolds via *temporal emergence*, outcomes can neither be forced nor predicted. Diffus' philosophical approach to integrating new technologies into design in a holistic and self-evident way is, in my opinion, indicative of a performative laboratory approach. Rather than force ideas about interaction, use, or aesthetics onto a material or a technology, the studio embraces the process of discovering these things, of seeing them revealed *through* the process. In this way, their studio often arrives at results that fittingly display and

[124] The *Solar Handbag* has since been re-branded as *Eclipse*, but for purposes of this thesis I will refer to it in the former manner.

propose a logic (and aesthetic) of use that may have not been readily apparent at the start, but which springs from the nature of the initial material. For these reasons, it is not unreasonable to see their process—focused primarily as it is on creating interaction and design out of technology—as inherently performative.

Body/Interaction

The designs of Diffus—wearables or otherwise—are always informed with the body in mind, in consideration both of how the body will react to the design and how it will interact with it. Concern over touch, texture, manipulation, and interaction feeds many of their form and material design decisions. In this way, the emphasis on materiality subscribes to the project of the re-embodiment and re-materialization of the technical object, as opposed to screen and data streams. Johannesen explains their position on materiality: "When you work with technology and you work with human beings using the technology, it has to somehow occur within an experience. I think that we are working with technology that wants to be noticed, and thereby, it enters the fashion area" (Diffus interview). For Diffus, interaction, aesthetics, and technology are inextricably intertwined.

One could also argue that Diffus' performative design matrix builds on new-media concepts of embodiment and experience. Foregrounding the body (touch, sight, movement, etc.), they bring a phenomenological dimension to the experience of their wearables. Diffus' work thus focuses on how design objects can, through good design and style, enter into the world of body-centric, sensuous, and interactively rewarding experiences, which reposition the body at the center of the technological question. Not surprisingly, as Diffus works for clients seeking new forms of expression for materials that have yet to find a use, meaning, or shape, their work often consists in unlocking (and scripting) the interactive and poetical dimensions of matter. More than orchestrating new functionalities for technologies and smart materials, the Diffus team believes their design objects should also offer a respite and meditation for the future user, opening a door to deeper experiences. However, as they are well aware, designing for technology, as Guglielmi notes, is “a polarity, really. On the one side, the need to do things simpler, and on the other side, exploring the complexity of structures, materials, and so on. It is about finding the balance between those things” (Diffus interview). As a performative platform, their designs invite the sensing, sensitive, living, touching body back into the technology, both through attention to detail and a sensibility toward form that follows function.

Historical Link

If we consider this focus on creating resolute beauty and contemplation, as well as a keen wish to make functional things for the elevation of the consumer experience, Diffus’ approach maps the future of designed technology. This approach recalls Poiret’s avant-garde innovations in fashion and design, focused as they were on developing new materials and objects through various artistic collaborations, as well as laboratory processes. Similarly, Diffus enriches the field of wearables through both their collaborations and unscripted/experimental approach, which highlights high-craft practices and the sensuality of the user experience. Much as Poiret surrounded himself with multiple experts and modes of production to accomplish his vision of a radical couture, Diffus builds on and capitalizes upon cutting-edge researchers and processes to realize their visions as designers. Garments like the *Climate Dress* poetically display a necessary connection between high craft and technology. As a fashion object, it also further enters into a conversation with questions of climate change, the environment, and humanity's position or role vis-à-vis these issues. The dress points both to the human interior and to others watching her, and asks, "Hey, what are you going to do about this problem?" in a way that is poetic, yet provocative. By situating themselves as a research studio, crafting tangible experiences through objects at once technological and aesthetic, Diffus is at the forefront of innovation, all the while pointing back to the performance of the sentient, sensing body, and the technologies and materials that inform their designs.

Figure 18. 3lectromode, *Strokes&Dots* (2013). Photo: Julia Marois.
Models: Mathilde & Yollie (Dulcedo).

5.3 3lectromode: *Strokes&Dots* (2013)

Context

The third case study concerns 3lectromode, my own DIY atelier for craft and e-textiles wearables. For several years, while researching this PhD, I have been active in creating accessible DIY wearable platforms that borrow equally from the culture of at-home garment sewing (i.e., *Vogue* and *McCall's* patterns) and hobbyist electronics. These platforms and communication devices have been produced at my label's atelier, as well as at various collaborative institutions—Hexagram Institute (Montreal), V2_ Lab for the Unstable Media (Rotterdam), Fabrikken for Kunst & Design (Copenhagen), Oboro (Montreal), and InterAccess (Toronto)—and been funded primarily through grants from the Canada Council for the Arts, the Conseil des arts et des lettres du Québec, and the Concordia University Part-Time Faculty Association. During this time, I have also participated in a number of residencies, conferences, and other events to trace the limits and potentials of this emerging field. Residencies have included the Danish International Visiting Artist program (DIVA), hosted by the Department of Information and Media (IMV) Studies at Aarhus University, where I delivered a conference presentation titled "Kitchen Table Wearables," together with a series of workshops with design students titled "How to Knit Your Own Computer." Other conferences on the subjects of DIY and performance include an "Open Wearables" panel and workshop, which I led at ISEA 2011 in Istanbul, Turkey; an "Open Hardware Summit," held at Eyebeam Art + Technology Center in New York City in 2012; MEDEA's "Prototyping Futures" conference in Malmö, Sweden, also in 2012, which examined emergent DIY technologies; and the MODE@MOTI symposium in Breda, Netherlands, in 2013, as part of a master class in fashion and technology where I tested my ideas on the link between fashion-tech and Modern-era innovation.

Background

In short, I have been active in researching and testing the limits of e-textiles and DIY culture (and various other themes in this dissertation, such as performance, materiality, and the history of wearables) to inform wearable aesthetics and production methods. As discussed in Chapter 1, the field of e-textiles, while lacking the finesse and resources of more industrial or academic research projects, offers a rich platform of collaborative and self-directed explorations for embedding electronics in garments. In this sense, my atelier is more like an artist studio than a design company or service-oriented studio. Due to the nature of the funding—arts exploration grants—the projects are, for the most part, self-directed and independently developed. That said, the techno-arts atelier of today relies on a number of external industries and resources that directly impact onto the design. As I argued in my talk "Open Design Practices + Wearables + 3lectromode" (ISEA 2011), there is a growing body of research describing the shift in production paradigms taking place as a result of the proliferation of new technologies, machines, and shared expertise, as seen in the "Maker" movement. Examples of this increased access range from the multiplication of shared physical spaces offering access to rapid-prototyping technologies (fab labs and hacker spaces) to the expanding networked possibilities of "print-on-demand" services for remote 3D printing, as well as textile and circuit printing. Increasingly, the arts and design "laboratory" has much in common with the cottage industries that existed before the Industrial Revolution, with small artist/artisan spaces playing critical roles in fabrication processes and choices, all the while retaining control over the end-product or design—an element that Modern production chains had all but erased (Anderson, *Makers*; Gershenfeld, *FAB: The Coming Revolution*; Openshaw, *Postdigital Artisan*s). Hence, for a field such as wearables design, access to machines, technicians, and materials can make all the difference. This dimension of DIY wearables has been explored in a number of how-to and instructional publications (Buechley, Peppler, Eisenberg, and Kafai, *Textile Messages: Dispatches from the World of E-Textiles and Education*; Genova, Aneta and Katherine Moriwaki, *Fashion and Technology: A Guide to Materials and Applications*; Hartman, *Wearable Electronics: Design, Prototype and Make Your Own Interactive Garments*; Pakhchyan, *Fashioning Technology: A DIY Intro to Smart Crafting*). Much like fashion designers who began their careers with a collection of accessible equipment, like home sewing machines and sergers housed in basement studios, the wearables designer and techno-crafter of today has access to a fast-growing palette of technologies and tools—from LilyPad Arduinos, conductive threads, and inks, to remote technical resources like laser cutters, textiles, and 3D printers—to create her/his creations.

Laboratory Culture

3lectromode is a small design atelier run by myself as designer/owner, together with a variety of other experts from textiles, fashion, and engineering and media arts who work on an ad-hoc basis on various aspects of designing, developing, making, and disseminating or marketing fashion-tech designs. Our designs range from material explorations, fashion-tech design, and workshops that straddle the communities of high-tech, craft, arts, product design, and speculative design. Key to 3lectromode's design ethos is the desire to create a library of executable open-source fashion designs that may be assembled as kits by anyone with an interest in wearables, electronics, or fashion.

Performativity in the 3lectromode laboratory occurs among the individuals on-site in the atelier, together with the extended community of users and collaborators, from pattern makers to textile specialists, graphic designers, and engineers. The team works towards a functional wearable aimed at satisfying a number of parameters, from the aesthetic to the technical, while one central concern is to create a wearable template that could be built by anyone. For this reason, all steps for producing (and reproducing) 3lectromode wearables are integrated and communicated via the design itself. This is done by means of graphically illustrating the placement of all necessary parts—from electronics, batteries, sensors, circuit layout, to buttons and garment sewing—needed to assemble a functional wearable. Hence, many of the design parameters depend on the construction of a product that can be translated into a functioning wearable design. In this way, DIY culture expands the possibilities for anyone and everyone wishing to participate in it. By making the design and electronics open-source and accessible, 3lectromode, like many electronics companies that publish instructional videos, blogs, and schematics, including Arduino and Adafruit, allows the general public access to various toolkits for the construction of wearables, thus contributing to the collective effervescence and activity in the field.

Technology

As a case in point, *Strokes&Dots* was designed with the intention of communicating the fabrication process of wearables to a general audience. Part of a micro-collection of sixteen garments, *Strokes&Dots* was inspired by early Modernist representations of speed, graphic design, abstract art, and technology—as well as the print work of Russian/French textile visionary Sonia Delaunay. We began the design process by looking at early Modernist textile pattern and fabrication processes, which flourished during the early twentieth century. To begin with, a series of watercolor graphics inspired by Delaunay were created as design explorations. Next, we created four different garment patterns around which to build the collection: a top, a shirt, a skirt, and a dress. Then we digitized the watercolor graphics and made them into textile patterns that could later be integrated into the (also) digitized garment patterns, created on a 1:1 scale in large Adobe Illustrator files. Finally, we integrated the layout guidelines for the placement of the electronics, which could later be machine- or hand-sewn with conductive threads onto the wearable. The digital document, now containing schematics of the transformed watercolor graphics, the garment pattern layout for sewing, and the electronics placement guides, was printed on Japanese Hobotai silk with a Mimaki digital textile printer at the Hexagram Institute at Concordia University. While the electronics guides were printed on a "bottom" layer along with the textile graphics, the "top" layer, a slightly thinner fabric, acted as light diffuser for the integrated LEDs. From a material standpoint, the *Strokes&Dots* kit contains: a textile printout featuring the outline of the garment pattern and the layout placement for the electronics, which include: a LilyPad Arduino, an accelerometer or light sensor, and five to twelve (depending on the design) embroidered, responsive LEDs. The garments are reactive depending on the types of movements made by the individual wearing them. Three states of LED light displays were embedded into the design to communicate with the wearer and those nearby. The first state is when the wearer is at rest, and the lights cycle through lighting each LED to display its presence. When the wearer moves more dynamically, the LEDs respond by lighting up more actively and randomly, as though they had be "woken up" or charged. Inversely, when the wearer stops moving for a long period of time, the LEDs display a warning sequence, in which all the lights light up at once and flash, indicating that the person should perhaps move. This playful communication between the wearer and the garment expresses the interactions taking place, and having taken place, for all to see. In this way, they become a second layer of communication for all to "read."

As kits, which can be sold, constructed at home or in DIY wearables ateliers, or sewed in workshops or educational contexts, they are design objects that reveal their fabrication process and thus transform the user into a maker (or at the very least, a "learner"). This method takes some of the initial guesswork out of electronics assembly, while allowing the user to create a customized and fashionable design. As each piece is uniquely designed and comes with customizable options for different print patterns, colors, and sizes, the designs aim to give the user/designer agency in fabricating his/her own iteration.[125] Computational variations are also included to modify the LilyPad Arduino program, with the aim of simplifying the programming one step further. So far, 3lectromode designs have focused on integration of LEDs with various sensors, using the LilyPad Arduino platform for electronic components and programming. However, this is but a starting point for later iterations, which may integrate other emerging DIY technologies, as well as customizable options, thus adding to the landscape of maker-directed wearables. The 3lectromode label's next goal is to develop a maker/meeting space to foster community exchange and building around DIY wearables, as seen internationally in events such as Fashion Hack Day (Berlin) and the E-Textiles Summer Camp (Loire Valley, France).

Fashion

Beyond the mission to create a kit that can visually communicate how they can be built, a second important driver in the *Strokes&Dots* project is the creation of a collection of interactive objects that can stand on their own in the world of fashion. Being as many fashion-tech projects are one-off designs, this element of reproducibility in the studio was ever important to create a large collection, as opposed to a singular prototype. In this way, the sixteen stylistically connected garments could be deployed as a micro-collection on the runway, or in other live events. Furthermore, the wearability—the ability for the garments

[125] A future project for 3lectromode's kits will be to integrate a Web-based customizable interface that will permit the consumer/maker to edit the garment's style and functionality via the document, and thus print-on-demand and assemble. This method has proven popular with custom kitting designers, such as Unmade. See: https://www.unmade.com/ (accessed 6 April 2016).

to be worn in the everyday, on a variety of bodies, of varied ages, and for a prolonged period of time, like at a cocktail party, art opening, or fashion show—further reaffirmed their viability as fashion objects. Aesthetically, the *Strokes&Dots* garments had to "pass" as fashion first and electronics second in order to make headway into the universe of fashion. With this goal in mind, the wearables were fabricated with silk and followed the shape of prêt-à-porter fashion; in other words, the garments are meant for "everyone" and for "anytime" contexts. These stylistic and functional factors meant that the studio was able to mount traditional fashion shows (*D-Moment*, 2014; *Academos*, 2015) with the interactive garments, as well as participate in a number of public events (Augmented World Expo 2014; Boston Consulting Group 2014; CES Las Vegas and New York 2012, 2013, 2014, 2015). Having the garments stylistically echo fashion trends was important, enhancing visibility and in this way providing ample testing grounds to engage in live presentations, as well as encounters with a diverse public.

Body/Interaction

Finally, as a performative object, what does the wearable communicate? In the case of *Strokes&Dots*, a few elements can be identified. First, as they are disseminated as kits, the garments are often worn by their makers, and hence are tangible testimony of their maker's process and skill, as expressed in the wearing. A close collaboration with the technology is enacted, as the wearable's "performance" runs parallel to that of the lived—and creative—body that wears it. As the technology (the accelerometer or light sensors that give information on the body's movements or environment) is set into motion, the effects

(LEDs, in the case of the DIY Social Skin) have an expressive dimension not fully controllable by the actual and situated body. At times, one might have the impression that the technology speaks with, for, or even on top of the body. This duplicitous relationship between a self-unfolding technology, a garment as fashion expression (what says "technophile" more than embedded technologies in your clothing?), and a body in action reflects the complex, negotiated performativity that is the wearable.

Two strong messages arise out of the culture of DIY wearables, as exemplified in 3lectromode's design strategy. The first concerns the individual's participation in the construction of technology, or otherwise getting dirty, beyond the smooth surfaces of the Web 2.0 culture of input apps and content interface screens.[126] The second touches on the political act of wearing your technology as a craft movement. As a performative object, the DIY wearable is not a consumer item, but rather an object of technological affirmation for the masses. More than putting on a wearable gadget, DIY electronics and interfaces are about the storytelling and the individual's David-versus-Goliath struggle to have a voice in an increasingly technologized environment. One could even argue that it is a creative form of performative resistance to popular consumer tech culture, which forces the wearer and others to position themselves vis-à-vis the greater landscape and politics of an increasingly technocratic society.

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[126] I take this opportunity to thank Hanne-Louise Johannesen for mentioning Katherine N. Hayles' book, *How We Think*, during our interview. As notes Johannesen, referencing Hayles, it is important that, "all of us do hands-on stuff, because digital media and technology is such an integrated part of our society, it is so important that we all contribute to it." See "Diffus Interview" in the Appendix; and Katherine N. Hayles, *How We Think: Digital Media and Contemporary Technogenesis* (London and Chicago: University of Chicago Press, 2012).

Historical Link

When Giacommo Balla created his interactive garments, he was looking for a path to express revolution and social change on an intimate scale. The power of clothes to announce, and thus communicate social groups, standing, and political allegiance as outlined by Simmel, Lipovetsky, Barnard, and Entwistle, offer clues to better understanding the work of Balla and 3lectromode's DIY wearables. For the Futurists—and other art movements, from Wiener Werkstatte to the Bauhaus—small-scale, artisanal, and considered design and garments go beyond pleasing the eye, and tangibly advocating for values grounded in respect for the maker and collective experience. Furthermore, for Balla, clothing proposed a liberation from "neutrality," as in the case of the *Antineutral Suit*. As notes Stern:

> When Balla imagined variable shapes and colors for his clothes, he did much more than "invent the kinetic work of art in the Futurist sense: a work, which could be manually transformed through the manual intervention of its user." The modifiers fundamentally changed the relationship between the dress and the person who wore it. Dress was no longer a given object to which its owner had to submit. "Thus, anyone can not only modify but also invent a new dress for a new mode at any instant." … The responsibility for controlling changes in dress was given instead to its wearer, who had to enter the aesthetic realm and collaborate with the designer. (Stern, 32)[127]

At the forefront of this argument is the agency and performative dimension that garment transformation (analog to digital) can provide for the wearer. As Balla sought to disrupt art openings and manifestations with provocative garments that, for the most part, were

[127] The quotation is from Gioacommo Balla's *Il Vestito Antineutrale*.

constructed along the lines of conventional fashion, yet featured extra abilities and surprises, my garments, too, embody ideas of invention and whimsy in the everyday. Both Balla's and 3lectromode's designs subscribe to an ethos of self-transformation and invention as seen in social constructions as proposed as per the performative turn (Goffman, *Presentation of Self*; Turner, *Ritual Process*; *Dramas, Fields and Metaphors*). Furthermore, the performative dimension of garments is also expressed in the modes by which they are produced. In 1931, Sonia Delaunay imagined a revolution in fashion fabrication that resonates with many of today's DIY fashion platforms, as well as the maker movement:

> I imagine the future of fashion in these terms: there will be design centres, research laboratories that will deal with practical applications, constantly adapting to the changing conditions of life. Research into the materials used and a simplification of aesthetic notions will become increasingly important. On such carefully considered and up-to-date foundations, vision and sensuality will find a wide field opening up before them. (quoted in Stern, 186)

Modular, self-made, dynamic, democratic, and expressively transformative garments such as those encountered in Balla's "modifiers" and electric clothes, as well as those proposed in 3lectromode's atelier, invite the public at large to perform in the making and wearing of wearables.

Figure 19. XS Labs, *Captain Electric and Battery Boy* (2010). Photo: Guillaume Pelletier. Models: Émilie Grenier (*Sticky*), Marjorie Labrèque (*Stiff*), and Lisa Small (*Itchy*).

5.4 XS Labs: *Captain Electric and Battery Boy* (2010)

Context

The last case study explores XS Labs, situated within the Milieux Institute (formerly Hexagram Institute) at Concordia University and directed by Joanna Berzowska, associate professor of design and computation arts. Joanna and I have been colleagues in the same department for over a decade, and by virtue of intersecting interests, I have had the privilege of witnessing the evolution of her studio, and even curating some of its works in international exhibitions, such as *Sartorial Flux* (A+D Gallery, Columbia College, Chicago, 2006) and *Electromode* (2010 Vancouver Olympics). With XS Labs nearby in the same institution where I teach, I have benefited from its proximity by intersecting with and learning from the research conducted in its laboratory, and in sharing resources and information. Furthermore, in being embedded at Concordia, XS Labs has provided a research focus on wearables engineering and crafting, thus attracting researchers and collaborators both locally and internationally, to the benefit of the local academic milieux, as well as the wider professional wearables community.

Background

Berzowska's background combines degrees in design and mathematics in an era before computation arts, interaction design, or digital-arts education. As an academic researcher, her lab is focused on innovation, knowledge building, education, publishing, and lecturing in the field of e-textiles, new materials for wearables, and interaction design. Important research grants from the Fonds de Recherche du Québec—Société et culture (FRQSC) and the Social Sciences and Humanities Research Council of Canada (SSHRC) have guided the lab's focus toward a combination of fundamental research, design concerns, and the training of what Berzowska calls "highly qualified people" (HQP). XS Labs seeks to innovate in design via new technologies, while responding to such designs' impact and poetic resonance on the body's actions. In this way, how interactive garments script the body is a central question for the lab. Having studied at MIT's Tangible Media Lab, the founding institution for wearables technologies, Berzowska is well versed in the challenges and aims of creating meaningful designs that can inspire both industry and art.

Laboratory Culture

XS Labs, a design research studio founded in 2002, focuses on innovating in electronic textiles and responsive garments. Says Berzowska, "A core component involves the development of enabling methods, materials, and technologies—in the form of soft electronic circuits and composite fibres—as well as the exploration of the expressive potential of soft reactive structures" (Berzowska, "Programming Materiality"). XS Labs works at the intersection of two communities: researchers and students. In this way, the laboratory's epistemic culture combines material and design innovation via the continuing education of her student researchers. Berzowska describes her lab as a playful and experimental space where students are encouraged to try new ideas and materials, thus creating a collaborative, collegial approach to research-creation.

Technology

Core research at XS Labs is focused around the creation of design platforms for emergent technologies. The studio approaches new technologies with a concern and sensibility to make design "softer," and hence more wearable. Motivated by the lack of e-textiles and poor wearability in traditional HCI applications, XS Labs has cultivated a palette of techniques and materials better suited to embodied and worn-interaction platforms. Berzowska explains that XS Labs is:

> particularly concerned with the exploration of interactive forms that emphasize the natural expressive qualities of transitive materials. We focus on the aesthetics of interaction, which compels us to interrogate and to re-contextualize the materials themselves. The interaction narratives function as entry points to question some of the fundamental assumptions we make about the technologies and the materials that drive our designs. (Berzowska, *XS Labs*)

From a technical standpoint, the studio works with materials including conductive fibers, reactive inks, photoelectrics, shape-memory alloys, conductive inks, LEDs, thermochromic inks, motors, and more. While cutting-edge material inventions propel the studio's designs forward, the cultural history of textile fabrication processes (weaving, stitching, embroidery, knitting, beading, quilting) also inform how this innovation will take shape. These experiments allow the construction of "complex textile-based surfaces, substrates, and structures with transitive properties" (Berzowska, *XS Labs*). Examples of this high-tech craft approach include the *Karma Chameleon* research project, carried out in collaboration with Dr. Maksim Skorobogatiy, Canada Research Chair in Photonics at the École Polytechnique de Montréal, which involved a mixture of nanotechnology and traditional weaving.

Body/Interaction

XS Labs' designs reconsider how interaction through soft and textile networks can foster novel, and at times ludic or even dark-humored forms of physical and body-based interaction. As Berzowska notes, new materialities "promise to shape new design forms and new experiences that will redefine our relationship with colour, texture, silhouette, materiality, and with digital technology in general" (Genova and Moriwaki, 24). This body-material-focused design approach has influenced many of the studio's early designs, like the *Memory Rich Clothing* series, featuring dresses that invited strangers to touch the wearer in order to activate the material transformation of thermochromic inks (*Spotty Dress*, 2004); or garments that beckoned you to whisper into them so as to activate a series of lights and thus tangibly display the act of intimacy (*Intimate Memory Shirt & Skirt*, 2003). In this way, the technology arrives at its logical (or illogical, in the case of self-described absurdist or transgressive projects) placement and interaction, focused on creating meaning as opposed to efficiency, productivity, or other Wearable Tech strategies discussed previously.[128]

This visceral and whimsical approach to designing new modes of interaction with emergent materialities is succinctly illustrated in the *Captain Electric and Battery Boy* (CEBB) research project (2007–10). Initiated on the occasion of a class titled "Second Skin

[128] For more on speculative and confrontational design, see: Carl DiSalvo, *Adversarial Design* (Cambridge, MA: MIT Press, 2012); Anthony Dunne, *Hertzian Tales: Electronic Products, Aesthetics Experience, and Critical Design* (Cambridge, MA: MIT Press, 2005); Anthony Dunne and Fiona Raby, *Design Noir: The Secret Life of Electronic Objects* (Cambridge, MA: MIT Press, 2013); and Anthony Dunne and Fiona Raby, *Speculative Everything* (London: August Media; Basel: Birkhäuser, 2001).

and Softwear," which Berzowska taught at Concordia in the winter of 2008, the project took off with a student brief to create "Human Powered Illumination." The results propelled further investigations (and a 2008 summer workshop) into haptic platforms for power generation and storage via wearables. Exploring the potential for garments to harness the body for electricity, the project produced three designs, which playfully highlight our co-dependent relationship with electricity. Inspired by conceptual frameworks of co-dependence, parasitic systems, or even extreme power relations between users and their need for or use of electricity, the designs stage a series of physical interactions that both amplify and visualize this exchange, or power dynamic.

The results of CEBB showcase erratic, intransigent garments that provoke the user to pull, scratch, and wrestle comically with its materiality, in the aim of generating future available wattage. Fittingly named *Itchy*, *Sticky*, and *Stiff*, the garments stage body-generated energy systems, capitalizing on various strategic, gestural platforms of activation. Building on intuitive actions, such as pulling, pushing, and rubbing, the garments activate both the collection of energy, as well as its visualization through a variable output (sound or light). For example, *Itchy* invites the wearer (or others) to rub the concentric circles of its wool collar, thus creating static energy that powers a series of LEDs. *Stiff,* meanwhile, projects a parasitically passive platform for energy creation that necessitates the participation of an external player, who must push its attractive little back hump in order to activate a recording device only available to the wearable's wearer. Alternately, like a cat trying to scratch its own back, the wearer can also seek to collide with objects so as to activate the awkwardly placed bump. Finally, *Sticky* features a waist-activated lever system that both restricts and benefits from the wearer's natural arm/hand actions to feed its need for energy. Admittedly, these are at once awkward and provocatively thoughtful systems that force us to consider the human-energy relationship in a new light, as well as the concept of "natural" forms of wearable interaction scenarios.

These three CEBB wearables force the wearer to "work" in order to have access to energy. Each fashion-tech garment forces the wearer to negotiate not only awkward or uncomfortable textiles and sartorial shapes, but also to engage in unnatural movements in order to create electricity friction. In the case of *Itchy*, the wearer must rub the collars together, or invite others to do so in a way that is "normal," or socially condoned. We all know that static is the enemy of good fashion; yet here, fashion invites the creation of static friction through robust movement. In the case of *Stiff*, the garment is literally stiff—the antithesis of textile garment comfort. The hump-like protrusion embedded into the garment is not only anti-fashion in shape, but also rather inaccessible, as an interactive platform for the wearer. In this way, the garment becomes a parasitic system, in search of participants to activate it, or proposing unconventional ways of interacting with the environment, such as repeatedly bumping into walls or other objects in order to charge it. The final design, *Sticky*, is a bully system that requires the wearer to pull the device in order to be charged. However, the device also influences normative movements such as picking things up, because any movement using the hands must interact with the pulley. In this way, any movement of the hand has no choice but to participate in the kinetic ecosystem of energy gathering, whether the wearer wishes to do so or not. An inverse way of looking at the interaction is to think of the wearables as hosts who make use of the body to power themselves, thus inverting the power dynamic of wearable and wearer.

Furthermore, such projects exacerbate the limits of “smart” design by highlighting both the very real, as well as absurdist nature of our present-day technological demands. This work highlights current concerns over energy, environment, and climate issues, which are at once distant and day-to-day concerns. Perhaps it could even be argued that, as transitional objects of an absurdist nature, CEBB designs demonstrate a “liminoid” quality, as they neither fully adhere to the expectations of an HCI system, nor are they purely art. Not quite functional, and not quite purely playful, the CEBB designs reside at the limit of what we might expect or be willing to engage in when using a wearable. Berzowska reminds us that we “need wearable computing that is irrational, poetic, musical, and theatrical. We need wearable computing that stimulates magical and literary experiences in our everyday life rather than just trying to improve productivity or our efficiency” (Genova and Moriwaki, 24). In this way, XS Labs’ designs question the form and meaning of the wearable through their choreography of distinctly “off” interactions.

Historical Link

When Schlemmer conceived of the *Triadic Ballet*, he described his desire to illustrate the balancing of Apollonian and Dionysian forces in which “the dance, which is Dionysian and wholly emotional in origin, becomes strict and Apollonian in its final form, a symbol of the balancing of opposites” (Schelmmer, *Letters and Diaries*, 128). One goal of the *Triadic Ballet* was to visualize this push-and-pull between man and machine in a manner both rational and emotional. One could argue that Berzowska's works stage a similar dichotomy, residing as they do at the intersection of research and theatrics, or the practical and whimsical. Berzowska has described her work as performative, inasmuch as it unfolds through the wearables' active enunciations of situating the body in/with technology and design. Furthermore, there is a symmetry between Schlemmer's and Berzowska's schematic approaches to choreographing—and segmenting the different parts of the body—via garments/costumes that refer back reflexively to their technology and limit their movements. Where Schlemmer symbolically and tangibly structured the body (and hence the costume) via an abstraction of dynamic shapes that restricted movements, XS Labs' work similarly frames the body within designs that shape and limit its action and movements. Thus, both artists stage the body in its encounter of its own biomechanics and expressive force, as channeled through the constraints of technological costume.

5.5 Conclusion: Wearables as Performative

The above four contemporary case studies invite us to reflect on how performance informs wearables and fashion-tech's epistemic cultures of production and internal systems of performance occurring in the studio/atelier/laboratory. By following key works produced within each studio, we see how performative potentials are seeded though the course of their conceptualization and developmental processes. Furthermore, we can see how contemporary wearables are pushing the boundaries of performance through design, style, interaction, and use of technology by infusing their works with questions of social interaction, emotions, poetry, agency, bodies, and politics. In each case study we encounter the processes, agendas, tools, materials, dreams, and struggles at play within the theater of wearables creation. Furthermore, each case study proposes a new angle on the kind of performance unfolding in the studio, from those of collaborative industry research in fashion-tech (Wipprecht); to smart-fabrics innovation via fashion and design (Diffus); and from DIY e-textile production (3lectromode); to the rethinking of HCI scenarios via wearable design (XS Labs). Most importantly, however, we become aware of performance's role as central to the *raison d'être* of the wearable, as it is present its logic of use. In other words, wearables need bodies, fashion, and technology, and each of these facets contributes to how a wearable is experienced. The performance of robotics mixed with emotion, as seen in the world of Wipprecht, or the acrobatic interaction scenarios proposed by Berzowska through CEBB, both point to the body performing *with* technology. Furthermore, these examples confirm how the wearable would be devoid of meaning without a body to push up against it (sometimes literally), and without the shapes and materials that inform/comprise them. The same can be said of how matter performs over the course of its process toward becoming an "intelligent" design, as seen in the Diffus studio; or the proposition that DIY wearables can offer appreciation and knowledge through their hands-on production and deployment. In the contemporary wearables atelier, we encounter a positioning vis-à-vis wearables' capacity to offer new experiences for the body, as well as new relationships to fashion and technology.

6 FUTURE PERFORMATIVE WEARABLES

6.0 Introduction

Overview

The aim of this research has been to explore and solidify the argument that wearables are performative. Through the past five chapters, we have examined the links between performance and wearables through their uses on the body, the mechanical and technological apparatuses that shape them, and the aesthetics that communicate cultural concepts through their designs. Throughout this process, I have argued that wearables are performative at many stages and in many modalities, which include: laboratory practices and events taking place in the research, development, and design of the wearable; the social uses and somatic interactions that wearables solicit; and the expressive displays embodied in the materiality of wearables that unfolds through their use.

In Chapter 1, we considered the landscape of technologies, practices, and terminologies that surround the field of wearables. Here, we identified three important trends that have guided research in the field for the past fifty years, which include: the field of engineering and wearable technologies; the material research and practice of e-textiles and soft circuit making; the growing industry of smart fabrics and engineering for textiles; and, finally, the newly emerging field of fashion-tech, which combines a high level of design concerns with electronics and other wearables materials from robotics, 3D, and smart fabrics.

Next, in Chapter 2, we probed more deeply into the genesis story of engineering for the body. Here, we reviewed the processes by which Edward O. Thorp developed his in-shoe wearable devices to thwart casino roulettes; and how Steve Mann experimented with head-mounted networked cameras and information systems that challenged social norms around surveillance and the body. In these histories, we discovered the performative dimension of these researchers, in which the bodies, the shaping and design of the technologies, as well as the use contexts informed the meaning and events (and, at times, controversy) occasioned with the wearing of these devices. We learned two things significant for this research: wearables impact the actions of the wearer; and wearables impact the perceptions of and interactions with the wearer. Thus, we were able to conclude that wearing a wearable had performative repercussions on the inventors wearing their devices, as well as those encountering them. Furthermore, we noted that the design, aesthetics, and engineering of these pieces were fundamentally tied to the body uses, intended performances, and use contexts. One instance was guided by a desire to conceal the device (Thorp); while the other was driven by a conviction to display it and thus confront social norms (Mann). Hence, we were able to conclude that even the field of wearables electronics had roots and legacies in performative concerns as linked to the body, fashion, and technology.

In Chapter 3, we reviewed and analyzed different theoretical frames of performance and performativity that intersect with wearables from social, design, and material standpoints. We began with the works shaping the "performative turn," wherein we unpacked concepts of performance as linked to the social body in the works of philosopher of language J. L. Austin, sociologist Erving Goffman, and cultural anthropologist Victor Turner. We confirmed that social performances were contextual (Austin); constructed (Goffman); and transitional, or "liminoid" (Turner). In this way, performance of the social body is an ongoing process, invention, re-invention, and inter-personal/social project.

We then reviewed media-arts literature around technologies of the body. In particular, we analyzed how wearables had been written about from within this field and found two overarching methodologies: semiotics and phenomenology. In particular, we saw how semiotics and "cultural visibility" informed the field as described in the work of media-arts theorist Susan Elizabeth Ryan. Next, we reviewed media philosopher Susan Kozel's use of phenomenology to inform her wearables practice in projects such as "Whisper[s]" and how phenomenology re-situates the body within technology. However, I argued that these perspectives have limited our ability to understand the full impact of wearables, as they either reduced the wearable to a fixed and "readable" symbol (Ryan) or made it a conduit for body expression in technological frameworks without attention to the details of the design objects (Kozel). As media arts perspectives (thus far) fell short of a full understanding of the convergence of bodies, fashion, and technologies found in wearables, we concluded that a performative theory remained an apt route of investigation.

Next, we considered how performance informs fashion theory and discovered that socio-economic concerns and emulation informed many early sartorial theories as seen in the work of sociologist Georg Simmel. As well, sociologist René König argued that the psychological dimension of fashion feeds into many of its expressions, even those that seemingly deviate from the stylistic consensus. Next we explored how many theorists, such as cultural theorists Malcolm Barnard and Fred Davis, et al., have viewed and explained fashion as a coded system of communication, again inspired by a semiotic reading. Finally, we discovered a growing trend in analyzing the "now-ness" and transient nature of fashion in the work of cultural theorists Luca Marchetti and Emanuele Quinz, who argue that fashion is an "aesthetic of experience," and thus performative.

In the last theoretical section, we investigated how laboratory processes around material-based research have also been analyzed through a performative lens. In particular, we looked at how human and nonhuman elements produced what sociologist Karin Knorr Cetina calls "epistemic cultures," which feed into the modes, processes, materialities, and results of laboratory research. Next, we examined the interplay of human-nonhuman activity in the lab, or what STS scholar Karen Barad describes (building on philosopher, anthropologist, and sociologist of science Bruno Latour's research) as a discursive and inter-connected event. Last, historian of science Andrew Pickering's theories of the performative lab illustrated how performance unfolds in the laboratory. Notably, concerns over *temporal emergence* in research and research through action provided guidelines for situating the performative dimension of the studio/atelier/laboratory.

Within the course of this rich overview of the uses of performance concepts in society, media arts, fashion, and science, we elucidated its application through examples stemming from contemporary case studies (which we would investigate further in Chapter 5). The overall intention of Chapter 3 was to provide tools that we could refer back to when discussing, describing, and analyzing the wearables that are currently being produced.

Chapter 4 provided us with a view of the wider history of technologies of the body and their emergence within pre-computational contexts of performance. The focus, here, was to give ample evidence that wearables are informed by multiple factors—of which the body, fashion aesthetics, and technological invention are key—and which historically emerged in performance-related venues and disciplines that have included: dance, fashion, art, and theater. The three historical case studies considered different modes of producing performance with garments. The first case study investigated La Loïe's use of technical apparatuses in dance to create new expression. Furthermore, La Loïe positioned herself as a scientist and inventor in a manner very similar to wearables designers today. The second case study demonstrated how concepts of performance, from the runway to the street, have informed fashion since its beginnings, as seen through Paul Poiret's extravagant parties, events, and public fashion showcases. As well, Poiret was a material alchemist, mixing materials and different kinds of practices, and collaborating with experts, from artists to chemists, to create his vision. The next case study looked at the work of Futurist artist Giacommo Balla and his politically playful suits, which could be modified and electrified. Finally, we saw how Oskar Schlemmer's costume designs for his *Triadic Ballet* rewrote the way bodies were displayed and moved on stage. Schlemmer's costumes continue to inspire and influence ideas around bodies and technology today.

Chapter 5 addressed current production and investigation in wearables and fashion-tech. We began with the work of Dutch fashion-tech designer Anouk Wipprecht, who collaborates with international tech companies to create wearables that use robotics, 3D printing, and exoskeletons. We discovered that part of Wipprecht's project was to create new kinds of emotionally tuned wearables that could speak or stand in for the wearer. We also compared her work to that of Loïe Fuller, as both employed body armatures to expand and transform the body. The next contemporary case study touched on the work of Danish smart-material designers Hanne-Louise Johannesen and Michel Guglielmi, and their search for a new, poetic form of design and experience. In particular, we examined their philosophy of design, which contained important echoes of the performative laboratory as they sought to discover the uses and expressions of smart material through time and incremental inventions. Their approach to creating better consumer goods and experiences reminded us of Poiret's desire to innovate, with his couture house, in creating new fashion. The third case study considered my own studio and its efforts to explore how DIY approaches to fashion and technology could be performative in a distributed and collaborative manner. This reminded us of how Balla sought to change how fashion was constructed, by personalizing it and bringing in craft techniques. Finally, we explored the work of Concordia-based XS Labs, where for more than a decade Joanna Berzowska has sought to create new forms of soft human-computer interactions that provoke and question wearables. Her lab is reminiscent of Schlemmer's experiments with choreographing the body through costume.

During these journeys through materiality; engineering as performance; theories of performance and their links to bodies, fashion, and technology; historical examples of performative bodies of fashion; and contemporary testimonies on and examples of wearables and fashion-tech innovations that address and combine the concerns of this thesis, we looked for proof that performance is a guiding thread, practical as well as theoretical, for wearables.

6.1 Conclusion: Critical Avenues for Future Performative Wearables

Why Performance?

The reader may yet still wonder why performance is intrinsic to wearables. For a further argument, which builds on both engineering, pre-computational, and cultural histories and current case studies, is the proposition that wearables *need* theory. Other than in its (by now hopefully obvious) presence in the making, design, technologies, and uses of wearables, and the bodies that wear them, there is also the fact that performance is wide enough in scope to contain all these complex, moving parts. Furthermore, performance is disciplinarily agnostic and does not belong within one entrenched medium, discipline, philosophy, or theoretical approach. Thus, we can start within a new and as-yet-undefined category, which does not limit wearables to *just* technology, *just* fashion, *just* the body. By ambitiously bringing in so may theoretical frames to which wearables might refer—fashion, laboratories, technologies, bodies—I am also arguing that not only is the wearable an admixture of all these disciplines, it also operates in a flow of change and transformation, as we have seen emphasized in so many theories from the social (Turner), to the phenomenological (Kozel), in fashion (Marchetti and Quinz), and, finally, in the laboratory (Knorr Cetina and Pickering).

A final note: a performative theory and perspective on wearables gives import to its many contributing parts, all the while connecting them through their use, genesis, and social impact.

And for Whom?

In the first place, this thesis is for anyone interested in wearables. The knowledge obtained can be relevant to a number of individuals, from artists and designers to engineers and sociologists. Ultimately, the work aims to make a case not only for wearables being performative, but also more complex and diversified in their history than pure engineering, pointing also to art, design, and philosophy. In this multi-pronged approach, one can envision an engineer encountering new perspectives on wearable technologies situated within the humanities and the arts, while the artist or designer may better consider issues of research, laboratory cultures, and the power of materiality and their impact on form and meaning. I believe there are multiple potentially rewarding paths, here, and that the work of crisscrossing between concerns regarding bodies, aesthetics, laboratories, technologies, meaning, and action has only just begun. Furthermore, through the process of writing this thesis, I am increasingly aware that each of these avenues—bodies, fashion, technologies—could be analyzed further and more deeply than the scope of this work permits. The theoretical frames invoked in my arguments around performance, so diverse and each one quite intricate in nature, could themselves spawn multiple potential theories for the analysis of wearables. I believe, however, that this initial groundwork of tracing the lines around the various disciplines that wearables encounter—and bringing them together under one roof, so to say—was much needed, and was until now uncharted territory. From here, we can look forward to new scholarship, which, with this map in hand, may unearth new issues and attributes of wearables in relation to performance via fashion, technology, and the body.

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APPENDIX A: Anouk Wipprecht Interview

Designer: Anouk Wipprecht

URL: http://www.anoukwipprecht.nl/

Date: April 28, 2016

Location: Toronto, Canada

1. Describe your studio/atelier/laboratory.

AW: It is a collaborative praxis. I work at companies that hire me. They call me and they say that they want to have fashion-tech, and then I ask them: What kind of fashion-tech? And then they say: We don't know, you are the expert. I ask them if they have a desk for me, and then they pay for my ticket and I go there. Otherwise, if I am not there, it is hard for me make what they want because I need to know if it something that is more in my line—for example, like another *Spider Dress* or a *Smoke Dress*, or if it is research, such as hacking products or creating new kinds of textiles or sensory applications, or maybe if it is only in software. So, then I do that.

2. What kinds of equipment do you use and have access to in your studio/atelier/laboratory?

AW: The only things I need are a laptop, a soldering iron and a sewing machine. It depends if they have these for me, or if I need to find a maker space, or if I need to bring these with me. For the 3D stuff, I work with Materialise [http://www.materialise.com/] or Shapeways [http://www.shapeways.com/], and they ship to wherever I am. For example, for the *Black*

Cocktail Dress, I made the leather dress in the Netherlands, I 3D-printed the parts the day before I came to Canada, and then I went to a local maker space [SteamLabs, Toronto] to solder it up.

3. Whom (professionals/students/interns) do you collaborate with?

AW: *Synapse* was produced at Intel. With *Synapse*, I had never used EEG. I told them that I wanted to work with a girl team, so they proposed Carly. Carly worked on figuring out what signals we could get for the EEG system, while I worked on the design of the piece and the LEDs. At Autodesk Pier 9, there are a whole bunch of machines you can use, so I worked on the *Tesla Dress* on my own. At V2, Simon [de Bakker] developed the circuit boards for the pneumatic controller and taught how to use the Eagle program, while Piem [Wirtz] played more of a project manager role.

4. What functions/contributions do the collaborators bring to the research and designs?

AW: The best context for collaborating is when someone wants to get into fashion. If people reach out to me—for example, Niccolo [Casas] wanted to do something with fashion, so he dropped me a line, and he said: Hey, if you ever want to collaborate, let me know. I had just gotten the Volkswagen deal, so I told him: Volkswagen wants to do stuff and I have a budget, so we can freak out on something. Then we thought of what this could be, and Niccolo said that he liked the *Smoke Dress*, so we began thinking of how the identity of Volkswagen could come into the design. I proposed the grill of the Volkswagen car, and we began brainstorming in Maya. At that time I was just getting into Maya, so he was mentoring me in Maya, and then I was mentoring him about the body or the materials to use, because he had never 3D-printed for the body. Both of us just went on this quest as we figured things out, a kind of flow.

At V2 there was less of that, because Simon just wanted to know what I needed and then he delivered it. So, that was less collaborative, where one person is doing something and the other person is doing something else, it is less a collision of practices. You know what I mean?

For Intel, I used the Edison, a Bluetooth controller that you can connect to the NeuroSky. We did make a board, but that never pulled through. The *Spider Dress* uses a Teensy that I programmed for the LEDs, because I could not run them with the Edison. It has little customized boards in the second version, but we are using the first version on the model and the one that is on display.

5. What kinds of materials do you work with?

AW: For 3D printing I use Polyamide PA12, the most lightweight polymer. For example, the front of the *Cocktail Dress* is PA12 and the back is PA16, which is a little bit more heavy. So it is all Polyamide-based. The front of the *Smoke Dress* is TPE, that is Thermoplastic Polyurethane 92A-1, and that is more flexible, but it is very gritty. So, for example, I wanted to use it with the Audi project, but they told me it was too gritty for them because they wanted the surfaces to be like the car, they wanted everything smooth. So, I also used PA12. If I am in America, I can only use nylon and TPE, so that is Thermoplastic Elastomer, because they have a patent and they are not able to sell the urethane that Materialise uses. If I need to have the Thermoplastic Polyurethane, then I have to have it shipped to an address in Europe, and then sent to America. For the paint, I use car paint and then lacquer over it to enclose it either in matte or glossy. For Audi, the front is glossy, and the back is matte. Then I use leather, because I think it has a good co-existence with the 3D print, and does not require stitching.

For input, I use Maxbotix environmental sensors. For body inputs, I use EEG, EMG, heart-rate variables, heart-rate volume, respiration, place in space (I did one thing with the galvanic skin response, but like it is more the PH and I could not get a lot out of it), temperature and proximity. The outputs are: fluids (ink or drink), smoke, mechanics (servos), nitinol/flexinol shape-memory alloys and lights (high power LEDs).

6. How do you research new materials and their uses for your practice?

AW: I research based on recommendation. That is why I like to work with Materialise, because you can always discover new materials through them. In San Francisco, I go to a lot of manufacturing events and places. In Los Angeles, I work with three studios, the ones that are making the Thor and Spiderman suits. They always get samples packages, because their manufacturers want to make them use it. Mostly these are epoxy, silicones and other materials that they make the natural suits from. I have work at Spectral Motion [http://www.spectralmotion.com/], where they do monster design, and they research silicones a lot. They do skins samples, and all that stuff. I have a desk there, where I make things, and they always let me have new materials. If I have new materials—for example, Materialise came up this COA material that changes colour with heat—I show them. So, you are always showing materials around, or making little videos and sending them to people. If you do that, then other people do that back. However, I worked in the shoe business, with Dutch shoe designer René van den Berg, who taught me how to make shoes. In his field, you cannot ask—that is not a thing. That is really an LA attitude. It is a community of nerds. You have your tools and you share them.

7. How do you implement new materials in your practice?

AW: Presently I am revising some of my older systems, because I am getting into machine learning and computer vision. This is more technical, such as programming intelligence. With machine learning, your system becomes sort of a measure for education. For the next version of *Synapse*, I am looking into embedding unreal sense so it has 3D data, so you can go a little bit more into computer vision with it. If I gave my older designs an update today, I would be programming them in Python.

8. What role does experimentation play in your (or your studio/atelier/laboratory's) research process?

AW: That is the problem. I always try to do a new process every time. So, the process will never be the same. For example, you can start from an emotion or a visual speculation. You can go from the idea of disappearing, like the *Smoke Dress*, then you have that feeling, and then you go through the process of figuring out how to make it: not inks—it is too drippy—so smoke, because it is floaty. Or, like with *Pseudomorphs*, the ink-dripping dress, you start with the visualization of ink in water, and first you go technical and then you go visual. Either way, you always need to have your visualization. Then I always try to draw it out. The *Spider Dress* was really about the mechanics, how big the mechanics should be, so that was what I drew first. But in the case of the Audi collection, I started from the car and tried to abstract the various things that I liked or did not like, and made a collage. Then I started to create the dresses. Every time I have a project, I look at it from another methodology. Of course, you always have the technical, the visual and the conceptual. But sometimes you mangle them up.

9. What is the balance between technical innovation and artistic/design innovation in your practice?

AW: How you can measure a successful project is if you can show it. That is why the *Smoke Dress* is successful, the *Spider Dress* is successful, and *Synapse* is not because it is introverted. When my grandmother, or a child, walks up to the *Spider Dress*, they immediately get a psychological thrill. They know that there is something going on, even if the legs do not move. If the person walks closer in, be it a boy or a grandmother, they do not need to know anything about sensors or technology, because they see it react and recognize it behaving like the animal. If the interaction responds to what you sense as you are walking up to it, then you know that this is a good design.

Niccolo is always getting mad at me because I always speak of design as more of a shell, because I give more importance to the interaction and the technology. Niccolo, on the other hand, argues that aesthetics are everything. However, I think intelligence is everything, or interaction. If you have a fight with an engineer, or a fight with an architect, or a fight with a designer, they are always on a very specific topic. For example, that design should inform you about the interaction about to come.

10. Describe the steps in creating a new design.

AW: The *Spider Dress* began because Daniel [Schatzmayr] and I made a short, stop-motion animation that became popular on the Internet. We decided to explore making the mechanics of the design by creating a little puppet to see the behaviour before building it. I mostly always make mockups first. For example, with the *Smoke Dress*, we used a smoke machine to make a visualization. Sometimes the photo shoot is also an opportunity to make a visualization, such as the recent photo shoot with Victoria [Modesta], where the technology was not informing anything, but we were visualizing how to use a medium around her in a way that would cover her. So, you can visualize through photos or drawing, but with interaction you need to physically see it in action. If the mockup is successful, you can go to the technical part. Then you need to ask questions like: How can I actually make this happen? How big is this going to be? Where can I place elements? Where are sensors placed? You do this to inform the design, which is the third step. That is when you start to shape the design.

For the *Smoke Dress*, I designed it like a pear, because I wanted to have down smoke here [lower torso]. the *Spider Dress* is V-shaped, because I wanted to have the mechanism up here [upper torso]. For the [Black Eyed Peas] Super Bowl 2011, they did not want the battery placed anywhere around Fergie's waist, because they wanted to show her hips, Fergie, so I placed them in the shoulders, and they became a little bit more bulky. So, questions like where to place the batteries and the micro-sensors—in the first *Smoke Dress* it was a problem, because I had not planned on having sensors in the beginning, and you really see them. I learned from that, and in the *Spider Dress* you have these big balls that are already black, to hide the Maxbotix in. You need to create these spaces, where these spaces inform my style, or rather my style is created out of the spaces that I create around the body in order to place the electronics. So, what are the physical limitations?

Sometimes I put a cardboard on the body and I start to move with it. I had one shoot with Audi where I forgot to do this, and the 3D pieces came back (and it was a lot of money), and this thing was pointing in my neck. So, you need to mock it up, then go one step back from the original idea, to mechanics or whatever you are busy with, and then you start to see how things can work. The mocking-up informs what steps you can take, and what kind of architecture you can make for the body. For example, Audi gave me the task of working with polygons and diamond shapes, so the challenge was how to mix my own style with the client.

11. How do you present your work—via runways, exhibitions, video documentation, conference presentations, or a combination?

AW: Mostly like a walking act, or an installation. Walking act would be used for the *Spider Dress* at CES, where she walked around and demoed the piece. At trade events, like CES, because people are already going to see some demos, it is good to show it on a model. What we did at the Digifest cocktail yesterday was also a kind of walking act, where she was serving shots but not necessarily interacting with the people, because that is the job of the system. The funny thing with the game version [Daredroid] is that the model is also not social because it is the game that is doing the interaction. With *Spider Dress*, the model does not talk and the dress does all the acting, like grabbing out and all that stuff. With Audi, it was not really a show, it more of a visualization—and later, with the models doing a walking act in the crowd.

I do photo shoots before I finish the interactions on the pieces. If the dress is finished, then this is the first time that you see everything come together. Then, with the styling of the model and the setting for the photo shoot, you work on the behaviour. For example, in the *Spider Dress* photo, the model is looking down; the system gets more attention this way. It depends what you want to highlight. Do you want to take away a little bit of the face and the information through that? And, what kind of attitude do you want to create with it? That is what you mostly do with the photo shoot. This is the place where you figure out the piece's identity and the DNA.

With that I can construct the show or the attitude of the work. But I like it most when the models just freestyle with it—because different people will behave different, and get different interactions. For example, the *Spider Dress* had one model that was walking up to people, and this is very different from letting people walk up to her. Sometimes you work on that together with the model: this it is mostly what you are doing at the photo shoot, trying to define this.

12. What is the role of the body in informing your designs, both from an aesthetic and a technological perspective?

AW: The body mostly does nothing. Actually, my first wearables project in school had a not necessarily comatose human being, but an overwhelmed being—somebody like the fainting goat? I had an idea of an entity that could not react for itself. So, she had systems on the body that were doing the communication for her. That is where the *Smoke Dress* comes from, where these systems in the beginning came from. So, being overwhelmed—we all have these moments where you are standing in traffic and everything becomes quiet, and you get a sense of disassociation because the city is so hectic, you know? So, this is where technology can give us a sense of protection or an awareness.

In the past, the body did not really have a main role in my work, and the systems were there to protect or defend, communicate, or to express. Now, for example, with these social designs, like the *Cocktail Dress*, she is reacting, and interacting. As I mentioned in regard to *Daredroid*, the model plays a game with you where you have co-control with the system.

The model is not relying on the system, but she is interfacing or interacting with people through the system. Here, the technology is the role giver or is the curator.

But for other ones, like the *Spider Dress*, anyone can wear it. You do not have to do anything with the *Spider Dress*, because it reacts to others no matter what. This is the same for the *ink dress* [*Pseudomorph*] and the *Smoke Dress.* With the *Audi Dress*, the models are still pretty passive looking.

13. How is your work informed by performance? Please consider how the bodies/fashion/technology perform in your work?

AW: With the *Spider Dress*, the body is passive. However, the *Spider Dress* is not true to nature, because on the one hand it says do not come closer, and, on the other hand, because it is an interesting design, so you want to come closer. So, you are always on the cusp there. If you have the *Smoke Dress*, the smoke is engaged wherever she is walking, so—but that is also being commanded by people coming up to her. The *Cocktail Dress* is more active, because she is going up to people, and also she needs to give a physical thing, she needs to do something [the game], or push the button, and then give the drink. The *Audi Dresses* are controlled by the stage manager because it is a different context and they need to be showcased. They work on two modes. When they are showcased, they work from the stage, and when they are in the audience, they are interactive. With *Unicorn Horn*, I don't know if it is passive, but it is measuring EEG. It is on your head, but you do not have to do anything with it, except for being cute. So, you need to be cute—you are playing an active role. You can see it from both sides. In *Unicorn Horn*, the design is the invitation, as with the *Spider Dress.* Through design, you are inviting people in. People come closer to any intriguing design.

14. Describe the "performance" that occurs in your studio/atelier/laboratory on a regular day involving bodies/fashion/technology. Who is there, what is happening, what equipment is involved?

AW: My everyday is where I have a closet full with hats, and then you put on another hat all the time. So, I put the hat on for the sewing lady; I put the hat on for the soldering person; I the put a hat on for the programming person. So, there are different roles that I have.

15. How do you imagine the research you are doing impacting the future of technology and of wearables?

AW: I think that through technology we can be pure to ourselves. So, if you have, for example, wearables that are correcting or that are representing your emotional state—if you are unhealthy or if you are unhappy—it will also show. This is one thing that I try to research, but also push a little bit and bring attention to it. So, I do things, instead of the happy stuff, I work with anxiety, like the *Spider Dress*. I do things with shyness, or the introvert, like the *Smoke Dress.* I try to play with these feelings and emotions because I think that this is important, and that psychology and wellness—mental health—are connected to these things. With the *Unicorn Horn*, I developed a wearable for kids that might not have that much social skills, and played with that in order to make a fashion accessory that is more compatible for therapy. This work is about intuition. A lot of our technology is based on rationality, and that is why I am always talking about animalistic behaviour, instead of robotics that are always represented as the rational beings created by rational minds. They are never really to be seen as intuitive or animalistic in behaviour, because they have not been programmed that way. But, for example, I love the Paro, because it is based the notion of a baby seal, and it does not have any robotic distinctions. People do not really know what a baby seal looks like, or how it acts, and these are made for people with dementia, who have their own notion of this animal and want to take care of it. Maybe real baby seals always bite, but they have no idea, because it is cuddly. So, that is a funny example of how roboticists are thinking—of, instead of making robots that are true to ratio, rather making robots that are true to mythological beings, or beings that might not exist. That is more intuitive, a way much closer to nature as to how we are creating or representing technology. This is something that I try to express in the area of wearables—by thinking of these systems around our bodies intuitively and how they might both behave and misbehave.

16. Are you inspired (or frustrated) by the hype around Wearable Tech? Describe how, or give an example.

AW: Well, now everything is VR. Halfway through 2014, I got a little bit annoyed because it was the year of wearables, and people put too much pressure on the fact that wearables should be pushed out at that time. I was afraid of the moment after the hype, where the whole world would say: Your year was the year of the wearables, where are the wearables? You failed as wearables people! But then everything became VR. I also tried the website: http://whatthefuckismywearablestrategy.com/ [no longer active].

17. Are there historical references, or artists/designers, that you are inspired by (or draw from) when you create your work?

AW: I do not like ornamentation, like Baroque, because I think it is more of an add-on. I like engineering as a more constructional style, like when Roman engineering created arches, and because of that they could create the windows, the lights came in and that was the time of enlightenment. I am a big fan of Ernst Haeckel, because he collected objects of architectural geometry that are appealing to our eyes. His curated selections were based on intuition—because it was not really measured—and on what we like and dislike. Also, he did a lot of research regarding "the perfect," why we like certain things. Then he curated all of these objects and put them into his books. His things were shells and bones, so they have a natural affinity with 3D prints. His work is a really good correlation for 3D printing.

18. Rank what is most important to you in a wearable: a) wearability (form-fitting on the body, comfort, etc.); b) aesthetics and design innovation (new styles, new expressions); and c) technological advancement (improvement or innovation in computation hardware and software or interaction).

AW: I would choose: 1) technological innovation/interaction; 2) b [aesthetics]; 3) a [wearability]. Otherwise I would not be doing 3D printing.

19. In your wildest dream (if all technology and fabrication processes were possible), what kind of wearable would you like to create and why?

AW: One thing that I would say is that we are not able to detect (reliably) emotions, because there are always different set factors. Also, in research, companies and specialists and universities and hospitals are not talking to each other. So, people working on EEG try very hard to get emotions from their brains; and people from heart [research] try very hard to get emotional data from the heart. But if together they could get reliable emotional readings, then you could really advance therapy. The dream wearable would have multiple ways of adapting and behaving in different situations—because the dress that you put on in the morning, for example, is not the dress that I want to wear now, because I am tired.

It is beyond a second skin, because it also needs to have the expressive. Talking about session skin is okay, but it does not really have the expressive notion—for example, creating a materiality that could transform both your body (such as warm, cold), as well as your expressive ability. We are able to communicate with the devices that we use today, but what if we are able to communicate through the things that we wear? By creating a wearable that is true to your emotions (which we are going to do), we would know when we are mad and sad and glad.

Medicine and health are always telling us that we need to better recognize our body, to know when we are stressed, or need to de-stress. But we are always lying to ourselves, because I am never stressed, you know? Or you have the people who always think that they are stressed, but are not. Every wearable design student wants to create a wearable that is behaving, you know? But wearables should not behave, because we are misbehaving most of the time—or at least I do. Wearables should provoke the idea of making us better by calling us out.

20. If you could create a wearable for one specific or particular body/person, who might they be and what would they be doing?

AW: I cannot really access kids with Autism of Asperger's—so, if I were able to create a wearable that can do their facial expression for them, or that can help them, that would be great. Because with Autism, people think that they cannot understand emotions, but they do, they just do not know how to react to them. That is a very interesting thing. So, if there could be a wearable that data-visualizes what they are sensing, things from the environment and their bodies, instead of a screen. If there is something, I would try to help kids with Asperger's around 7 to 12 years [old], the time when they realize that they are different, and other people also notice. For example, the *Unicorn Horn* would never be able to help them; that is for ADHD kids, because a person with Asperger's wearing a *Unicorn Horn*—that would work against them. So, there is this one boy [with Asperger's] and he only speaks through a therapist or through blankets—they put the food though the door, sort of. Hell no, that person is not going to put on a *Unicorn Horn*. But if he could have a device that he speaks to, and that device, and that recognizes emotions and situations, this system could become a buddy for him. In that sense, you can cater to somebody who has problems with expression with something that can help communication. You can have your little Tamagotchi that is actually smarter than you.

I showed the *Spider Dress* at Georgia Tech to an autistic group. During the lecture there, there was this boy and he said he did not understand the *Spider Dress*, and this girl could. She was explaining it to him, because she had this emotional attachment to the dress, and he did not. He was a little bit further on the autism spectrum, and he could not relate to the idea of anxiety and why you would have a system on the body that would react and protect. But the girl, who was also partially blind, could connect to it from an emotional point of view, because she has that mindset of wanting personal space. So, the *Spider Dress* functions in her head as an extra set of arms. So that was a funny thing. Meanwhile, the boy could not relate to it, because for him it was just a spider. I am interested in what it would take to explain this notion to that boy.

I have over thirty works, and every time I give a lecture some people relate to the *Smoke Dress*, some people relate to the *Spider Dress*, some people to the *Unicorn Horn*. Everybody always relates to something different. So, I think personalization in wearables is key. A person would never have that *Spider Dress* this way, they would want it smaller, bigger, orange, pink, you know. There would always be something that the person wants to have. I chose my leather jacket, and my leather jacket is a one of a kind, and I can never find that leather jacket again, something like that. The perfect wearable is like that leather jacket: one of a kind.

APPENDIX B: Diffus Interview

Designer: Diffus / Hanne-Louise Johannesen (HJ) and Michel Guglielmi (MG)

URL: http://www.diffus.dk/

Date: February 22, 2016

Location: Copenhagen, Denmark / Montreal, Canada (via Skype)

1. Describe your studio/atelier/laboratory.

HJ: It is a multifunctional space, because we need to do a lot of different things. So we shift between being a studio, an atelier and a laboratory, during a week. Actually, I think that it is also important to say that we have this physical location in Vesterbrø (where you have been), but then our laboratory is also expanded to our own places, because, for example, I cannot have a sewing machine here, because it is too noisy, so I do a lot of things at home, and Michel is also doing things from home.

MG: The people that we are working with are also doing things at different locations. But our space is based here—it is a hub—and we use it a lot of the time.

HJ: We have a lot of facilities here, and we will be, as of March 1, building up a small electronic table with soldering things, because we hired a technical guy who is going to be working with us. We also have different facilities for testing and prototyping, and we have a lot of materials on site. It is not an organized material library, but in a sense, it is almost like a material library, or sample collection. We use it quite often to describe what we are working with, because we are trying to bridge the design space with a more industrial space, or industry. As many of our collaborators are from industry, the sample library acts as a very active communicator.

MG: Our studio is always under construction and expansion, because we are slowly but surely growing. So, it is also a process.

HJ: We are under construction in a way that changes. I started by saying that it is a multifunctional space, but it is also a space that needs to be able to change to different things. It is a thirty-square-meter room in a flat with other creative people, and then we have this expansion of it, because our laboratory is also a little—but at the university—a little bit at home.

MJ: You know, do you have 7-11s in Canada? It is like that. It is small, it does not look like much, but you will find everything [you need].

2. What kinds of equipment do you use and have access to in your studio/atelier/laboratory?

MG: We start with the computer.

HJ: Then different kinds of sewing equipment, sewing machines. We have access to laser cutters and also 3D printers, [although] we have not used it really much. And then, close collaborators from the outside, such as concrete casting, soldering, and smart printing [companies]. We also use Arduino and other kinds of small electronics that are easy to program.

3. Whom (professionals/students/interns) do you collaborate with?

MG: It is a mix again. We have had a lot of students here doing their master's [studies]. Some of them are from Hanne-Louise's department, and because of the European projects we are involved in we are also connected through a series of educational institutes, such as Delft University, and some of those students have come to visit and work with us.

HJ: From students or interns, we have had a variety of design students and interns. From mid-March, we are going to have an intern who is from classical design and has been working with wearables. Last year, [we] had an intern from Italy who was educated as a costume designer. So, it is a mix of design, industrial design, [and] other kinds of creative people.

MG: We have also had people [collaborators/interns] who are more oriented toward communications. Those people help us in communicating our projects, getting us on Wikipedia, making applications, or taking care of our home page.

HJ: Then we have a range of universities that we collaborate with through EU projects, such as Delft University, Southhampton, Polytechnical of Milano, ITA (Institute of Textiles in Aachen), and several others. We are collaborating with a lot of companies, especially within the textile industry, and I think this bridge has been quite interesting as one of the bridges to go, maybe in [a] direction other than only wearables. For example, we are collaborating with a textile firm that is making acoustic ceilings, a company that is making textile for furniture, and a third one that is making textiles for automotive. So, in that sense, we are collaborating with quite a lot of textile industries, and through the EU project we also have more technical collaborators. For example, a company that is making piezosensing technologies, and another one that is making smart print technologies that can print smart fabrics. It is a mix of mainly textiles, but also other industries.

4. What functions/contributions do the collaborators bring to the research and designs?

MG: There is a whole range of inspiration, which should not be neglected. It is not necessarily just formal collaborations, but rather the fact that we are together for longer time periods—for example, through the European projects—and we have the opportunity to communicate in a deeper way with some of these collaborators.

HJ: I think that there are two things that I would like to say. One thing is, we totally forgot a very import aspect of the professional collaboration, because also again the European projects make us collaborate (which is really, really interesting) with several design companies. So, in that case, we are collaborating with industrial design companies like Pilotfish in Germany, VanBerlo in Holland, and Fuelfor in Barcelona, Zaha Hadid Architects in London, and Base Structures in the UK—again, a textile company, but much more on the structural side of architectural textiles. I just want to say another thing about the functions and contributions that the collaborators bring. I think an important thing is knowledge about other processes and materials. For instance, the universities that have scientific research, we have the opportunity to visit their laboratories working on very specific technological developments, and this gives us new inspiration for other ways of doing things, as well as knowledge into new technologies that are upcoming and not on the market.

MG: The function of collaborations is very much also about opening new doors and seeing opportunities for making crisscross relations. When we are working with an industry or universities, we look for the potential to create new kinds of constellations. We end up using some research time to see if, through this network of academics, industry, designers, and all kinds of collaborators, there is some kind of synergy.

5. What kinds of materials do you work with?

MG: We are, as a matter of fact, working a lot with textiles. We always try to remember where we come from, which is exploring the possibilities of creating reactive materials from a design standpoint. Sometimes we try to go back to those roots as a way of remembering. So, we work with textiles, but we are open to any kind of material, which allows us to play in a reactive way.

HJ: We are making a lot of very systematic tests on different kinds of materials that are conductive, and what kind of conductivity do they have. I know that a lot of other people are doing it, but we are trying to expand our sample book, and we now have a stack of different kind of samples: yarns, textiles, different metal parts, all sorts of elements. We are, in the research projects, combining these elements with a sewing technique, but also print. So, we are working a lot of different inks, smart inks—again on textile, but they could also be on other materials. We are reworking one of our EU projects right now with a combination of smart materials and natural materials. We are working with four different materials in a tableware set—that of rubber, wood, ceramic, and glass—and combining these with a reactive and interactive surface. We try to work on a lot of different materials. It could be a very, very long answer….

6. How do you research new materials and their uses for your practice?

MJ: One thing that we have been doing in expanding those sample books—so, we try to find specific ways of testing new materials to add to the collection. Another thing is by bring invited to lead workshops. Right now we are researching smart inks, and all these different kinds of pens that are out there, as well as gilding—do you say that when you put gold leaf onto things?—because we have been invited to develop something specific for some research. So, it is a combination of people asking us to do something that propels [us to] research something, or our interest in testing something new. Through our EU projects, we also investigate new materials and how to use them. In one of the projects, in the beginning, the project had two different materials that did not yet exist. All the designers in the project had to find ways of using this material that was [still] in the making. It was actually quite interesting to design with something that does not exist (yet).

MG: There are other [things] also, such as making associations from materials that you use in one field and looking at the possibilities of translating them through small adaptations that you find interesting as a designer. This is the most lazy way, because you do not need to start from scratch, you just need to just make small translations.

7. How do you implement new materials in your practice?

HJ: Sometimes it is through a more systematic way, where we say: How can you use this in different aspects without having an end goal? At other times, there is an end goal and then we have to find a solution to that. I think, depending on how much time we have and what kind of assignment is given to us, it can change. Sometimes it begins with a material and we discover the obvious way of using it, and it then becomes a project. This was the case when we worked with the optical fibers, where suddenly it was obvious that we needed to work with a lamp even though we had last used the fiber inside a bag. In that case, we had the material and no one had asked us to do a lamp, but then it just felt natural. The material itself pointed to the way it should be implemented into a product, or project. At other times, you have the idea of a product or project, and then you have to find the right materials.

8. What role does experimentation play in your (or your studio/atelier/laboratory's) research process?

HJ: A big role. For us, experimentation and research is more or less equal, it is the same.

9. What is the balance between technical innovation and artistic/design innovation in your practice?

MG: I do not think that what interests us as such is the technical innovation. We are open to whatever tools are needed to achieve a goal. For us, it is really about looking at existing crafts, and combining these with the tools that are at our disposition today. If it just happens, then, that there are new tools that appear at our hand, we use them. It is not because they are new that we use them, it is just because they are there. So, it is not an obsession about technology, it is just about trying to be contemporary.

HJ: If we should answer your question in one sentence, I would say that with open-minded and curious artistic and design practice, we create technical innovation.

MG: Basically, the technical innovation is just for technique, and the people who are using less tools than we do, it is just because they create limitations for themselves.

HJ: You could say that we make technical innovation, or innovation in a lot of different ways, but for us technology is just a material. You find a piece of cotton, and you find some thread, and you find some technology, and for us all of these elements are equal, material-wise. How you bring that together creates a new piece. So, it is never a goal to do technical innovation as such, it is much more a goal to use technology as a material within creation.

10. Describe the steps in creating a new design.

HJ: I don't think we ever start completely from scratch.

MG: We are very much opportunity-guided in the way that we work. Maybe we are a little bit lazy, or we require too much resources to start something from scratch. So, if an opportunity arises for some reason, and we see potential, then we create a new design. It is about potentials, and again it is about making associations with something else that we have in mind and combining things. In that way, it is a very traditional way of working as a designer, which is to make associations.

HJ: If we were to describe study, or a method, that we have used repeatedly, I think you could say that we often start with the material. As mentioned, for one of our EU projects we were given two materials, and then we had to come up with an idea of what to do with it. Another example, the *Space E-Motion* project, with the disks that create a wall, it started with the idea of using contact speaker and drum skins in order to create sound. So, that was the starting point, but then it evolved into a complete piece. We often ask ourselves: How can you take this idea and make something out of it? I think that often, in our projects, we do not start from a problem. We are not user-centered designers, in the sense that someone is having a problem out there and we come up with a solution to it. I think we are more material-oriented, saying: We have this material or this combination, and how can we build around it and make it into an idea?

MG: We work with an associative mind: First we ask: How can we be inspired from Lego? Can we make something that is so versatile, like their model system (which is known here in Denmark)? Can we do something which is like a Lego set? Then the other thing is about the craft—how to respect the quality of craft [in design].

HJ: But to be specific, I think that it starts with a material idea, and then we have a process of doing several prototypes, where we create small elements first, and test [them], and then take that further and learn as we make other ones. I think that, in that sense, it is not a very unusual way of working—to have an idea, make several steps of prototypes, and evaluate every time, in order to get a specific product. It is quite a normal process of developing an idea, but I think that the idea is often connected to material, a craft, a process, rather than a problem some user has.

11. How, and where, do you present your work: via runways, exhibitions, video documentation, conference presentations, or a combination?

MG: Since we took a little bit of distance from wearables, we have presented in a lot of exhibitions. For example, *Space E-Motion* has been exhibited in different settings. What happens more and more, because we are working more closely with industries, which requires some kind of discretion, it is often a private show. So, we often show things in those kinds of more private settings.

HJ: We have been doing all the kinds of presentations that you mentioned [runways, exhibitions, video documentation, conference presentations], as well as a combination of these. However, right now, we present our work much more through our samples and sample books. In the last year, we have not really participated in many exhibitions or other things, and have been presenting our work mostly to clients. When we do these presentations, we do oral presenting and show the samples to demonstrate what we can do, and what we have achieved.

MG: We are like the Loch Ness Monster. We plunge underwater for some time, and then when we come up again, hopefully we are able to show more things to the general public through documentation, videos, and so on. But right now, I think we have to be a little bit discreet.

AW: We are in a secrecy dive.

12. What is the role of the body in informing your designs, both from an aesthetic and a technological perspective?

HJ: I would say that the body fits in the center. I think that what we are trying to do is have this holistic approach toward the body, and the mind, and the experience. I think that whatever we do, it is very much about creating for the human being and how to use beauty, aesthetics, and poetry together with technology in order to create something that is interesting and not cold, plastic-like. How can you work with people's feeling of touch, sensibility, and all of these elements? So, the human senses, and thereby the body, is really at the center of everything that we do.

MG: I would add that, not just the senses but also the spirit and the soul, are also there. It is "holistic," in the real sense of the term. At its best, it opens up to contemplation and meditation, and so on. But of course, that is a kind of ambition, and what we do does not always have this level of….

HJ: We are challenged on that perception of things all the time, especially when we are meeting industrial partners that are asking for prices and pragmatic solutions. How can we reduce that price? So, it is really something that is always put into question and something that we are fighting to keep all the time. I think that we are trying to be different in the way that we take this artistic approach to the industry, and the fact that we have achieved designs that have a level of polish. The poetry and the level of finished-ness is something that is valued from our partners.

13. How is your work informed by performance? Please consider how bodies/fashion/technology perform in your work?

HJ: If you think of bodies, fashion and technology, and how you can work in a performative setting with that, experience is the key word. When you work with technology and you work with human beings using the technology, it has to somehow occur within an experience. Of course, there is a lot of technology that is just there, and we never notice. I think that we are working with technology that wants to be noticed, and, thereby, it enters the fashion area. For us, it is very important that technology become material again and part of the experience, not as a foreign element but as something that is attractive. In that sense, I think that a performative approach is very important. Another thing is to always question how we perform with technology. What happens, quite often, is that by making a textile version of technology—rather than putting it into a black box or telephone—the bodily experience is really, really strong. A lot of people are amazed that you can light up an LED through an embroidery, even though it is so low in praxis in terms of technology. Because you can have this ability to make a bodily understanding of technology [through smart textiles], I think this gives people a much more intimate relationship with technology.

14. Describe the "performance" that occurs in your studio/atelier/laboratory on a regular day involving bodies/fashion/technology. Who is there, what is happening, what equipment in involved?

MG: For example, when we had Arianna here—the Italian costume designer that we collaborated with—she stayed with us several months. We had to expand and add an extra room, because we realized that it would not be possible to have such an experience with the size of the studio that we have right now. We had the possibility to expand, and had a second room where Arianna worked on huge drawings all over the floor that were then folded onto the mannequins. There was a lot of back-and-forth between the two rooms, and a lot of testing, also. Hanne-Louise, she is very involved with Arianna, going from the computer, to the sewing machine, to the mannequin. So, it was a very physically dynamic process.

HJ: For eight months, that was an everyday life situation. Although she is no longer with us, I still think that we have a lot of these dynamic elements, because we often get new samples or new things, or have to discuss different projects in different ways and in different stages. For example, last weekend I made some assignment that our Chinese students next week, they [will] have to do. In order to create the assignment, I had to do the things that they will be doing. I showed it to Michel this morning, and we had a further discussion how to refine things. I think that is closer to the everyday life of the studio. Either we get something that we just ordered, or a design that we print out in full scale, and then we discuss the details before we send it to our collaborator or have them made professionally. In that sense, there is a lot of dynamic between the details that we create on the computer and then seeing the real things. There is also a lot of discussion around details, and now that we are going to collaborate with a technical guy, we will be emphasizing three different projects, because prototypes [will be] made around May–June. That means that from now on until June, we are going to be three people (again) working intensely on making these prototypes. There is going to be a lot of back-and-forth, and all the prototypes that we are making also involve other people (collaborators), as well as questions of how people perform with the designs. For instance, the table for the project that we talked about earlier, we made a lot of tests on the interactive properties. How can you make an interaction that is inviting? How can you make an interaction that is playful? How can you make an interaction that is rewarding, for instance? It is one thing to try to describe it, or code it. But how can you actually create that kind of interaction? That is something that we discussed a lot, and that we will really need to design, program, and test during the next months. Another project, such as the acoustic ceiling tiles, is about how to qualify space with light, what kinds of sensors do you need in order to control light in space, and things like that. I would say that the everyday, of course, is not everyday—but maybe once or twice a week, we are involved in this kind of dynamic. Then the other days, it is more like answering emails and this boring stuff.

15. How do you imagine the research you are doing impacting the future of technology and of wearables?

MG: We are a little bit modest. We just do our job. We of course think that what we do has some kind of importance for us, but I do not think we have the pretension to revolutionize something. Still, I think that some of the projects that we are working on could be quite groundbreaking, because they are things [that] are quite new. It is a mix between being proud of what we do, and also being modest, because we see a lot of people doing great things around us.

HJ: I find great inspiration in a book written by N. Katherine Hayles called *How We Think*, where she describes how important it is for non-technical people—not engineers, but people who have a more humanistic approach—to get their hands dirty in coding, in doing things, and not just doing the nice polishing [of] things with nice web pages, and things like that. If we do not get into the machine room—people like us—then the results will be dull. She is really arguing for how important it is that all of us do hands-on stuff, because digital media and technology is such an integrated part of our society, it is so important that we all contribute to it. In that sense, I believe that our contribution is as important as anyone else who is working in the technological field, and I think that what we do, by insisting on the poetry and aesthetic qualities, may not revolutionize—but we see that when we meet people that are very technical, they are quite amazed. Sometimes they understand what a sensor is doing, because we made the sensor in textile, for instance. Trying to understand what the techniques are doing and translate these into a textile material makes technical people, who know how they work, realize: wow, that is how it is built up [in design]! These bridges are quite interesting.

16. Are you inspired (or frustrated) by the hype around Wearable Tech? Describe how, or give an example.

HJ: I am so annoyed by the bracelet—everything is a bracelet. Because, in the beginning, there are so many visions about intelligent textiles and things like that, and then after a while, when it came time to make a product that can be sold, then it becomes a bracelet, or a watch, or a pair of shoes, and that is it.

MG: But also in the field of wearables, there are a lot of gimmicks. A lot of things are just superficial. I do not even feel concerned. It is just another force that is in motion, another topic.

HJ: Somehow wearables have been equaled to Nike, Apple Watches, and things like that, and are not so much about clothes anymore. When you tell people that you are working with wearables, people think that you are working with Google Glasses, or something like that. Of course, that is a little bit frustrating. Susan Ryan's book talks about wearables and the kind of aesthetics within this aspect of dress. That, to me, is much more connected to the wearable. That is lost in watches.

MG: I think that it is almost a Darwinian thing. Fifteen years ago, creative people started to do fantastic things on the screen, like web design. To be a web designer was something pioneer-like, where people would do amazing things with just three kilobytes. The first versions of Flash, people were really doing amazing, creative things. And then, at some point, this field vanished. Those gurus—who had, maybe fifteen years ago, been making creative animation on Internet pages—disappeared, and now they are just part of the mainstream web-design culture. Some of this may happen with wearables, it is just moving in other areas.

17. Are there historical references, or artists/designers, that you are inspired by (or draw from) when you create your work?

HJ: Yes, several—all those that you are using from a historical point of view [for your dissertation]. Oskar Schlemmer is a great inspiration that we have looked into quite often. Quite often goes back to what he has been working with—but there are several, such as Paco Rabanne, Gustave Eiffel.

MG: We reference Eiffel a lot, because he had that kind of mixed background, as an engineer and architect. Also, because he was the first architect to become aware of this technology [steel], which was already used in the nineteenth century, and give it its own legitimization as an aesthetic expression. Instead of hiding the structure of the building, as architects of the time were doing—imagine, for example, the railway stations in Paris from the nineteenth century, which were clouded with stones—he would just reveal the metal structure's aesthetic potential for a new century. That is why we think similar people should appear today with regard to the digital technology that is still within a black box, as steel structures were within the white boxes of marble.

HJ: Eiffel used technology, or structure, as a material, an aesthetic element. I think that is basically the big comparison. Staying within the architectural world, I have a hate-and-love relation with Adolf Loos, who wrote his *Ornament and Crime*, because we are doing ornament, but we are giving ornament a functionality. I think that because of someone like Loos, I was scared to go into something to do with embroidery, because embroidery is just ornament. I think it is really interesting, then, to give this ornament a functionality. Trying to respect Loos, and at the same time subvert him, or being subversive toward him.

MG: With my background as an architect, I have this love-and-hate relationship with Mies van der Rohe, who always makes [one] try to think: can we do it with less? It is a kind of mantra. Do we really need that? Because I think that in simplicity, also, you find a kind of meditative quality. But it is a polarity, really: on the one side, the need to do things simpler, and on the other side, exploring the complexity of structures, materials, and so on. It is about finding the balance between those things. I also have a love-and-hate relationship with Gaetano Pesce, whom I like as a designer and I dislike as an architect. He inspired me a lot when I was younger, and came out from the architecture school, because he was one of those people defining the work of an architect as a work of poetry, storytelling, and exploration.

HJ: From a more performative point of view, which is not historical because he is still alive, someone like William Forsythe is interesting because he uses a digital approach. He is creating this alphabet of movements, and then the alphabet of these movements is what creates this choreography. So, it is not so much about finding some bigger story, but really about going into the details of the materiality, of the movement, to try to use that and combine that to create a choreography.

18. Rank what is most important to you in a wearable: a) wearability (form-fitting on the body, comfortable, etc.); b) aesthetics and design innovation (new styles, new expressions); and c) technological advancement (improvement or innovation in computation hardware and software or interaction).

HJ: My comment would be aesthetic and design innovation first, wearability second, and then technological advancements—because, for me, the technological advancement becomes a by-product of the other ones.

MG: I think wearability would be number one, because we are designers, we have a client, so we have to fit the needs of the client. This is something which should be paramount and which should create the constraints for the other parameters.

HJ: I think, that expression is really important, and then the wearability comes second. I think that wearability is quite important, but I do not want to create something that might be nice to wear but looks ugly. If you look at our website, you will not find any mention where we say we want to make things comfortable. But you will find plenty of places where we are trying to work with aesthetic and design innovation.

MG: Some designs we do as a statement. Another thing is that when we meet a client, they need us to use our abilities to *résoudre la quadrature du cercle*. At the end of the day, when [we have] experimented and so on, we do so to come up with solution which makes sense for people.

HJ: Actually, Michel, I think that if we should be very crucial, we would say: 1) b [aesthetics]; 2) c [technology]; 3) a [wearability], in that order, because we are trying to be different from other design companies by focusing on aesthetics and poetry. Of course, it is also nice that it is wearable, but that is something where, for example, anyone who has had to design some kind of wearable device for an ill person, for instance, would look at. I think that our approach, in that context, would be: we do not want this wearable device to look like something that you get in a hospital. We like to make a wearable device that even people who are not ill would like to wear, because it is really cool. In that sense, I am quite convinced that wearability comes last.

MG: Diffus is disagreeing on the essence of what we are doing [laughing]. It is really a tricky question, because we also can say no, that we can cannot resolve the challenge, because we cannot satisfy all of these needs.

19. In your wildest dream (if all technology and fabrication processes were possible), what kind of wearable would you like to create and why?

MG: I think it is, of course, a chameleon garment, which adapts to your day, and changing with the evolution of the day. This is the kind of scenario that is very attractive, that it is changing its morphology. The fact that it can not only change colour but change shape, in an organic way, is something very appealing.

HJ: I was quite inspired with a visit in at the aerospace and fight research center at Delft University, where they talked about their obsession with self-healing material. I think that creating wearables that can heal themselves, or cannot break because they can heal themselves, is really interesting. But then again…

MG: It is nice to have wounds, because it tells you about the tragedy of life.

HJ: Yes, but you could also have some garments that are healing themselves but keeping the marks, the scarring. So, you can have this memory of what happened to the material—basically a second skin.

MG: By the way, I spoke about Pesce, and he made a book which slowly goes into decomposition the more you read it—the more you turn the pages, the more fragments of pages fall apart. So, you have physical traces of the use of the book. This is like a skin—something that is alive—which is storing stories and keeping traces, healing, changing slowly, morphing, getting older.

20. If you could create a wearable for one specific or particular body/person, who might they be and what would they be doing?

HJ: My view is a little bit colored by having two parents who are doing very badly, are ill, and therefore not really socializing very much, which is really sad. If it was possible to create something for people who are not socializing enough, doing something for the elderly and lonely. That is also a kind of standard question, is it not?

MG: I think that I would go back to this kind of spiritual dimension, which is exploring the sacred part. I think that this is also something that technology has potential to contribute. Although technology is not saying much [about spirituality] for the time being, I think we can move it towards it. Can technology help us to discover our inner self, or help us to have a sacred relation again? For example, you could imagine this existing in relation to a wedding, or a ceremonial situation. I think that it could also support this contemplative and sacred dimension that sometimes is missing in society.

HJ: A lot of people, ourselves included, are living with too much speed in our life, or too little speed in our life. I think that there is a huge gap between people who have too little time in order to contemplate, to think about things in life, and then another group of people that has too much time, and therefore they do not use it to contemplate, they just feel frustrated that they have nothing interesting to do, or to watch T.V. So, wearables to create a more fruitful inner life.

MG: A few years ago, we imagined a wedding where the couple at the ceremony ritual would slowly begin to exchange patterns—of thermochromic ink, for example. Also, the sacred ritual of baptism, where you have the tradition of the family giving the baptism clothes to the next generation. Imagine these clothes build up extended patterns from one generation to the next, which would only change every twenty years. So, it would be a slow process of building up patterns from one generation to the next, instead of always thinking of this hyper-fast morphing of patterns. You would think the other way around. So, this may be some of the answers.

HJ: So, no matter what, something that is doing something about time.

APPENDIX C: 3lectromode Interview

Designer: 3lectromode / Valérie Lamontagne

URL: http://www.3lectromode.com

Date: July 1, 2016

Location: Montreal, Canada

1. Describe your studio/atelier/laboratory.

VL: My atelier is situated in my home. I find it convenient and intimate to be able to work from home. Also, I appreciate the fact that everything is under the same roof: tools, books, food, and family.

2. What kinds of equipment do you use and have access to in your studio/atelier/laboratory?

VL: In my studio, I house a number of craft and DIY tools, from industrial sewing machines to prototyping tools for soldering, e-textiles, and small batches of textile printing. Mostly, the studio is used to develop and prototype ideas—both on the computer and tangibly, as mock-ups. Because many of the moving parts in my designs are produced off-site—such as printing textiles, printing and assembling circuits—there is a back-and-forth between these sites of production and the studio. I think of the studio as the central nervous system—where the thinking happens—and then the off-site places contribute to the realization of the ideas.

3. Whom (professionals/students/interns) do you collaborate with?

VL: I collaborate with seamstresses and pattern makers to develop the garment structures and forms. For textile, I have collaborated with graphic designers to create prints, as well textile printers, hand weavers, and embroidery professionals to create e-textiles and custom designs. For the electronics and programming, I hire different engineers or new-media artists with experience in physical computing to help either co-design and produce new circuits, or program existing DIY electronics, such as Arduino LilyPads. I also work with web designers to develop online strategies, and writers/assistants for grant writing or general research for pitches, and moodboards. When we do fashion presentations and events, I bring in models (often students from Concordia, who are eager to know more about fashion-tech), makeup and hair professionals, and sound and video artists for the staging, as well as stage managers, photographers, and general coordinators.

4. What functions/contributions do the collaborators bring to the research and designs?

VL: I collaborate in different ways depending on the project. Some works, such as *Strokes&Dots*, are developed over a long period of reflection and collaboration, as I did with my former assistant, Isabelle Campeau. Other works are based on an idea where I need help on specific things, like testing e-textile methods via paper origami, or printing thermochromic inks in a lab. Essentially, collaborators permit me to expand my material palette to new styles or forms that I would not otherwise accomplish as quickly or professionally. I think it is important to give room to the collaborators to express their ideas. Often I am working with designers, artists, and creatives, who have a lot of experience in their field and material expertise, so I defer to their interests and skill sets. Because I operate on art budgets (not large research budgets), I often pay less than "normal" jobs. So, I am aware that I have to make the collaboration exciting and useful for my team. I often try to find something that we are both interested in trying out. This way, it is also more of a true collaboration. As I am pretty open about the outcomes, we experiment quite a bit. I find that once you have found a good collaborator and you are on the same wavelength, you can pretty much let them do their thing. So, it is not a very controlled process.

5. What kinds of materials do you work with?

VL: I work principally with e-textiles. This includes working with conductive threads, wools, inks, and hardware. Otherwise, I have done a lot of textile prints on Mimaki machines, both at Concordia University and through commercial services like Spoonflower. I also work with electronics, and that includes designing and developing custom circuits for various projects, as well as programming for existing ones. Finally, we also use audio, mechanical systems (like fans and pumps), and other types of outputs for the designs. I work with a variety of input sensors (light, accelerometer, heartbeat, weather data), which are mostly commercially bought.

6. How do you research new materials and their uses for your practice?

VL: Research is done in a variety of ways. Often it is a combination of online sleuthing and recommendations from my large network of friends and designers working in wearables and fashion-tech. Because I have been in the field for so long (over ten years), I have the advantage of having worked, presented, collaborated, or somehow interfaced with many of the people in the field of fashion-tech. It is a supportive community, made up of a lot of women, and we tend to share quite openly. Another way to research is by visiting labs and companies developing materials and processes for smart fabrics or design; I try to do this wherever I travel. Also, by meeting people one-on-one, you expand the network. Finally, conferences are really key to knowledge sharing, where you not only get to meet new people and see what they are working on, but also touch base with your network and compare notes.

7. How do you implement new materials in your practice?

VL: Usually the implementation happens through an idea or concept. Because I am trained as a visual artist, I am motivated by ideas. Although materials are important, they are never the starting point. An early project was based on Charles Perrault's tale *Peau d'Âne*. I had remembered that in this tale, there was a challenge to create three impossible dresses. So, I had the idea that wearable technology could be the solution to creating these (impossible) dresses. In the tale, the dresses were to be made of the sun, moon, and sky. I began to research what kinds of materials could express these cosmic and seemingly immaterial garments. Through a process of testing various materials, and working with Patrice Coulombe, we came up with three different state outputs—LEDs (sun), thermochromic inks (moon), and inflatables (sky)—and used a weather system that you place locally on a roof, as input from UV/heat, wind velocity/direction, and moon fluctuations. In this way, the materiality of the dresses was not apparent until we began to unpack the conceptual elements.

8. What role does experimentation play in your (or your studio/atelier/laboratory's) research process?

VL: Experimentation is the best element of this process. I always think that while you are experimenting on a design, it always has the potential to be perfect. Once you see the final design or artwork, of course, you are satisfied that you have done the best that you can, but you also see and have to embrace its limitations as an aesthetic and conceptual object. However, while you are in the experimentation process, anything is possible. Completing a design always propels me to the next idea, concept, or material challenge. So, you could say that the process of experimentation is continuous through all the works.

9. What is the balance between technical innovation and artistic/design innovation in your practice?

VL: Although I always try to integrate new technologies, I think that there is still so much work to do in finessing the aesthetics of wearables, that this is the reason I mostly focus on design. Hence, I often reuse the same technologies more than once and try to find new ways of embedding them into designs and expressions. In this way, design and artistic innovation are definitely at the forefront. That is what I am chasing: better design, better art.

10. Describe the steps in creating a new design.

VL: As previously mentioned, I often start with an inspiration or idea. For example, with the project *Strokes&Dots*, I began with the idea/inspiration of Sonia Delaunay. I had always admired how Delaunay straddled fine arts with textiles and other forms of decorative arts. Her work was an early influence on my idea of art as polydisciplinary. So, I began to research her textile designs, and, inspired by her style, I created a series of watercolors. In fact, as I discovered how she executed her textile designs via small gouache paintings, I copied her process. These patterns became the foundation for four garment designs, and were integrated into the textile print of the garment. Instead of creating an all-over pattern, we strategically placed the designs in specific areas of the garment, and deconstructed some of the shapes over two overlapping layers of silk. The aim was to create a design that could function as both as a garment pattern (as in Vogue/McCall's) and a circuit template (like a DIY LEGO Mindstorms kit). So, working with Isabelle Campeau, we proceeded to create large Illustrator renderings of the garments that contained the garment pattern layout, the Delaunay motifs, and a graphic illustration of where all the electronic components should be placed (thus, a bit like paint-by-numbers or assembly logic). Our aim was to create an all-in-one design that would contain all the necessary information to create the fashion-tech garment on the textile. It was also a way of creating a mini-production chain, where we could easily reproduce several designs (and customize colors) without having to start from scratch every time. After sorting out the digital document and printing out test after test to correct elements that were not apparent on the screen, we assembled all the parts together with an e-textile machine and through hand sewing. In this case, the electronics were all Arduino LilyPads, since we knew that other people could get their hands on these, and that they are easy to use, and in this way we could share the designs. We ended up making four colors of each design, resulting in twelve designs in total.

11. How do you present your work: via runways, exhibitions, video documentation, conference presentations, or a combination?

VL: I have presented my designs in all of the above contexts. Runway presentations, as previously mentioned, are really about creating a "show." You need to be sensitive to atmosphere, and (if possible) control the lighting, music, visual, etc., so as to create the mood. It is a form of theater, and since the public does not get very close to the garments, it is really about creating a cohesive spectacle. Exhibitions come with their own challenges. I have curated and collaborated on a number of museum and gallery exhibitions with wearables, such as: *Sartorial Flux*, at the A+D Gallery, Columbia College, Chicago, in 2006; *Electromode*, at the 2010 Vancouver Winter Olympics; and *The Future of Fashion Is Now*, at the Museum Boijmans Van Beuningen, Rotterdam, in 2014. In each case, it is important to exhibit things that can work on an intimate scale, like sculpture, because very often the works cannot be activated for the full duration of the exhibition. When the works are activated, you often need to train staff to: a) take care of the work, and b) explain to the public what it is doing. One of the funny challenges of exhibiting fashion-tech is that people often touch the works. The public has this intuitively intimate relationship with garments, where they feel that it is okay to touch them—as opposed to art. This becomes a challenge if the work is interactive and you want the public to touch it, but *in a certain way.* That is where staff or facilitators are key. Another way of exhibiting wearables is by leaving them static and showing a video alongside. Videos can be nice opportunities to show how the interaction works, as well as the story/process behind the work. Finally, conferences are an important way of disseminating your work, and when accompanied by a published paper (such as at the ACM/IEEE conferences), they also give you an opportunity to reflect on your process and get feedback.

12. What is the role of the body in informing your designs, both from an aesthetic and a technological perspective?

VL: I wish I could say that it is central. But oddly, I feel as if I have increasingly moved away from the body. I got interested in wearable technologies because I was doing performance art, and costume was an integral element. I thought, what if the garment could perform instead of the body? Of course, I am still interested in the body, but increasingly the aesthetic of the wearable object is central. However, fashion-tech makes no sense without bodies, and one of the things that I have enjoyed about the wearables I have developed is creating different scenarios for the bodies that wear them. So, beyond the runway shows previously mentioned, my garments have been worn by real people at parties and events, media presenters, dancers, models, kids, and people of all kinds of ages, body types, and attitudes. I am particularly interested in seeing how individuals appropriate the technology and give it their own meaning. In other words, I love that people can wear my designs (for real), and I am always touched at how transformed they feel by wearing the technology, even if at times it is really simple sensors and circuits making LEDs blink.

13. How is your work informed by performance? Please consider how bodies/fashion/technology perform in your work?

VL: For me, the three perform together; this is the argument of my thesis.

14. Describe the "performance" that occurs in your studio/atelier/laboratory on a regular day involving bodies/fashion/technology. Who is there, what is happening, what equipment in involved?

VL: The performance of the studio begins with talking. If I am working on the design elements with fashion or graphic designers, we tend to be quite visual and will pull up books and images from the Internet to brainstorm. If I am working with an engineer, there is always drawing involved, as we try to map out the schema and logic of the circuit. Then we Google a lot of parts for the project, which we either need or want to test. The process of garment construction is very hands-on: drawing patterns, cutting fabric, trying things on mannequins and bodies. Finally, the process of production often requires a bit more structure. I try to divide the process in three phases: 1. brainstorming: sharing of ideas, resources, and experiences; 2. experimenting: testing materials, forms, and processes; and 3. production: making everything come together. Each phase has its time structure and budget. Often at the end of the project there is a photo shoot, performance, or other event. This is a nice way for the process to culminate in the "performance."

15. How do you imagine the research you are doing impacting the future of technology and of wearables?

VL: How I believe that I contribute in the evolution of wearables is by showing that it is a field that can straddle research and art. I am very focused on my designs being able to operate as art works, which can also inspire other fields, such as engineering or fashion. I still think that I am more of an artist than a fashion designer or technologist, but as these categories are becoming more intertwined (at least from an inspiration/knowledge-sharing point of view), I imagine that I am connected to them all in some way.

16. Are you inspired (or frustrated) by the hype around Wearable Tech? Describe how, or give an example.

VL: Wearable Tech, for the moment, is the most expedient way to get this technology into the market and the hands of consumers. I believe that as soon as we can easily and functionally produce interactive textiles otherwise than via plastic encasing or craft methods of e-textiles (which we are beginning to do), we are going to see much more diversified types of use for this technology. But for now, I think of Wearable Tech as a gadget that is more akin to a (medical) sensor mixed in with a bit of the connectivity of the Internet and speculative gadget culture.

17. Are there historical references, or artists/designers, that you are inspired by (or draw from) when you create your work?

VL: My four case studies—Loïe Fuller, Paul Poiret, Giacommo Balla, and Oskar Schlemmer—are very inspirational for me. In fact, I generally try to be inspired by history. I find that creating a continuum with the past expands the meaning of what I do in the present. For example, I am presently working on a project called *Frankfurt Kitchen* (FK), inspired by Austrian architect Margarete Schütte-Lihotzky's designs for social housing architecture in the 1920s. I find the designs really inspiring through their form and their intent. The FK as a concept was meant both to liberate women through the ergonomic functionality and logic of the kitchen space, and to be shared over socio-economic contexts. And the fact that a woman designed it is a nice added bonus.

18. Rank what is most important to you in a wearable: a) wearability (form-fitting on the body, comfortable, etc.); b) aesthetics and design innovation (new styles, new expressions); and c) technological advancement (improvement or innovation in computation hardware and software or interaction).

1. b) Aesthetics and design innovation (new styles, new expressions).

2. c) Technological advancement (improvement or innovation in computation hardware and software or interaction).

3. a) Wearability (form-fitting on the body, comfortable, etc.).

19. In your wildest dream (if all technology and fabrication processes were possible), what kind of wearable would you like to create and why?

VL: I think that wearables have this incredible relational capacity, between people, but also through space and time. My wildest wearables would somehow converge all space and all time into one object. If we think of how the Internet has made the idea of the archive infinitely expandable and retrievable, what might we do with the personal archives that we carry in our memories? How could we develop a wearable that tells stories, remembers, and lives with us? An example would be when I walk down a street and I tell my son that I used to live on this street when I was his age. To be honest, he is not very interested—but what if in that moment I could share even something as simple as a location-triggered medium (video/film) of me in that space, or a recorded memory, or a feeling? I think that wearables could become the new, infinitely expandable yet personal archive of the future. I'm not sure how to make this, but that is why it is a fantasy project, right?

20. If you could create a wearable for one specific or particular body/person, who might they be and what would they be doing?

VL: The problem with wearable tech is that it is too often approached as a tool, to fix something, while fashion is seen as frivolous, emotional, and psychological. So, you have two polar opposites: the body versus the mind, or the technological versus the aesthetic. If we could successfully address the body/mind "chiasma" in wearables in a way that is aesthetic, emotional, and personal, we could create a really holistic platform—for anyone. Any wearable that could create a balance between these two polarities would be magic.

APPENDIX D: XS Labs Interview

Designer: XS Labs / Joanna Berzowska

URL: http://www.xslabs.net/

Date: January 26, 2016

Location: Montreal, Canada

1. Describe your studio/atelier/laboratory.

JB: I refer to XS Labs as a design/research/studio (which is a way of not committing to one specific description) that encompasses a very exploratory and interdisciplinary approach. Studio: because we do not necessarily start out [upon our research] with a hypothesis; design: because we have an interdisciplinary approach between fashion, design, and fine arts practices; and research: because we try to innovate, both in terms of materials, technology, and methodologies, as well as conceptually. XS Labs is physically situated at Concordia University. I am an associate professor of Design and Computation Arts, and my research is embedded within the university. The research lab is physically located within the research spaces at Concordia, within the Fine Arts Faculty. XS Labs' research is fully funded by the different federal and provincial research grants [the Fonds de recherche Société et culture (FRQSC) and the Social Sciences and Humanities Research Council (SSHRC)]. I work at the lab and have employed, over the last ten years, anywhere between two to almost twenty research assistants and collaborators at a time.

2. What kinds of equipment do you use and have access to in your studio/atelier/laboratory?

JB: XS Labs is composed of a space that situated in the Department of Fine Arts, and also has a lot of satellite spaces where we use existing facilities within the larger research facilities at Concordia University. In the XS Labs space, we have basic sewing and embroidery equipment, as well as electronics and computers to design, program, and build micro-controllers, but more at the prototype stage. Then we have access to the satellite facilities at Concordia, which include a Jacquard loom, Mimaki textile printers (which we also use for design exploration), and other rapid-prototyping equipment, such as additive and subtractive rapid-prototyping equipment, 3D printers, laser cutters, and the recent addition of a laying and embroidery Tajima machine.

3. Whom (professionals/students/interns) do you collaborate with?

JB: I have always worked in different ways with different kinds of collaborators, from interns to research assistants. It has always been extremely varied. I do not believe in one particular model, and that is one of the wonderful things about being at a university: we have access to different modes of working with either students, other professors, or outside professionals. So, at any one time, I may have research assistants, who are purely employees, in a sense that they are being paid to produce work, but which has a very strong pedagogical component. I always tell them that fifty percent of their work is learning and fifty percent is producing. I encourage the making of mistakes as part of not just learning, but also because it is often how we arrive at something innovative. It is by screwing up, repeatedly, that we actually discover new things. So, it is a very experimental approach. I have also worked with interns. Interns are a little bit more time-consuming, so I have limited it in the past.

4. What functions/contributions do the collaborators bring to the research and designs?

JB: For instance, I have hired as research assistants fashion students from other institutions, since we do not have a fashion program at Concordia (and I am not trained in fashion design), in order to develop garments that are more complex in terms of their silhouette, structure—and to just bring in the expertise in terms of fashion design history, as well as what is happening in the contemporary fashion design scene. For other research projects, where I wanted to use materials that are not readily available in a commercial context, I have collaborated with professors or scientists who work with innovative materials. For instance, Maksim Skorobogatiy from the École Polytechnique de Montréal, who is a Canada Research Chair in photonics, and with him we developed a whole bunch of new functional fibers in terms of the *Karma Chameleon* project. I have worked with experts from industry at Johnson & Johnson developing stents for heart bypass procedures, to developing the nitinol structures for the *Skorpions* dresses. So, I work with expertise that is really based around material innovation, where we have to bring in expertise from specific industrial or academic research settings. I either hire consultants, or do joint research grants where then the money is split between the different collaborators.

5. What kinds of materials do you work with?

JB: So, one of my beliefs, in this field of electronics textiles, is that electronics are just an extension of traditional materials insofar as a lot of the textile technologies are technologies in themselves, and the new technologies that we use are a continuation of old technologies, not something completely new. So, it is really important for me to give that same importance to a spinning machine that actually makes the fiber, and the loom that weaves the fiber, as well as a 3D printer that adds things to it. It is the same story for materials. To give you an example, with the *Skorpions* dresses, we worked with raw wool, and we actually felted by hand because it has a lot of natural insulating and fire-retardant properties that were necessary for passing electricity to the nitinol, which uses resistive heating in order to activate shape change. So, this actually very old material, which is felted raw sheep wool, because it is an amazing insulator and fire retardant, mitigated the possible flammable aspects of the restive heating in the nitinol dresses. At the same time, I like to misuse materials that are used in the high-tech industries. So, nitinol is not naturally used in textiles—it mostly has uses in medicine, as well as some other places—but it is mostly studied and deployed in medical research and applications. I like to bring in materials that are well used in other disciplines, and see how they can enrich textiles, especially any kind of material that has state change, that can be activated, and reactive—anything that can change shape, color, diffuse light differently, etc. So, for example, nitinol, different kinds of photonics, color-change materials, whether they are thermochromic or photochromic, or any materials that reflect different wavelengths of light under different conditions—and to merge that with traditional materials. I really think that true innovation happens when we respect old materials and new materials in the same way, and see how we can force them to co-habit, co-exist together, in order to create a new expressive form.

6. How do you research new material and their uses for your practice?

JB: I read a lot of technology magazines, such as the *MIT Technology Review*, and any kind of new material that is being used in aerospace or medical or industry, I think of how we can use these in a much more physical, embodied, textile-based way. With some of them it is possible, and with some of the others it is not. But I like to misuse things.

7. How do you implement new materials in your practice?

See questions 5 and 6, above

8. What role does experimentation play in your (or your studio/atelier/laboratory's) research process?

JB: I deeply believe in my instinct as a designer and researcher. I have often defined instinct as a more subconscious way of actually processing all of the knowledge that I have come across. I work with a whole team of students, usually, and through writing a research grant proposal I already have a very strong idea of what I want. I always tell the students and/or the research assistants that there are so many questions, elements that have not been defined, and that many of the formal components, such as colors, shapes, or even the way that things might be attached to one another, have not yet been answered. I lead these very intensive brainstorming sessions, and then bodystorming sessions, and then prototyping sessions, where I go very broad, then narrow down, and them go very broad again. I often describe this to my researchers as making three sausages, where we start out with the concept that comes from the research grant proposal, and then we get very broad, and we try different things and then I squeeze it again to kind of narrow it into a new vision of where we are going, and then we broaden it again. So, the first stage [that] will be the first sausage is sketching; the second one would be actual physical prototypes that don't necessarily have all of the interactive aspects yet, and are just frozen moments in time; and then, finally, producing prototypes that are fully enabled with whatever materials or technologies we have decide to deploy, culminating in the final piece.

9. What is the balance between technical innovation and artistic/design innovation in your practice?

JB: I have always privileged technical innovation, because I understand all of the outcomes of research that can lead to dissemination and publication. It is much easier for me to get dissemination opportunities when there is a technical innovation present in the work. At the same time, based on how I approach design, and the whole practice within XS Labs, I have also always tried to embed a sense of humor, or dark humor even, as well as discomfort in a lot of the pieces. So, I suppose that it is also design innovation, although I am not really sure. I am definitely more comfortable with technical innovation, or placing the XS Labs work on a technical continuum, than within a design continuum. Technical innovation is more important, and I have found it crucial to be able to present the results of the work both in technical contexts, which for me means IEEE or ACM conferences, such as SIGGRAPH, SIG-CHI, and ISWIC, as well as to be able to publish the work in more art/design/cultural kinds of contexts. I try to be provocative in both [contexts] and always try to have the work startle both.

10. Describe the steps in creating a new design.

JB: The team is extremely important, more that anybody ever realizes. This is true in a start-up company as well as in a research lab. Having a good synergy within the team, where everyone respects one another and everyone learns from one another, is a crucial component to innovating and good research. In the early days, I would often have social events and parties to implement these different ways of building respect and trust between the team members. For instance, students who came from electrical engineering, I would make them sit at the sewing machine, and vice versa. Everyone had to have at least a superficial knowledge of everyone else's strengths. By actually doing it [the other field's practice] with their hands, that tacit knowledge exposes them to both the difficulties and the potentials inherent in the other disciplines.

For example, when I started working with Maksim Skorobogatiy, from the Polytechnique, his fibers were too brittle to be woven on a loom. I could spend ten hours explaining it to him, and he would just argue with me. So, the best thing was to make him sit at the loom and weave for an hour to actually experience how the threads break, and the kinds of forces that are at play when you are weaving. It was a huge breakthrough moment for him, because not only did he understand that I was not just being difficult, but he actually understood why there were not more functional fibers in the textile world. It is because textile-fabrication technologies have these restrictions on them that … you cannot really understand it until you have that tacit knowledge of experiencing it with your hands. That was an amazing kind of start to the collaboration, because he actually changed a lot of the polymers that we were using in the fabrication of the fibers, as well as some of the techniques. So, this is an example of building up a strong team, where people have a very good understanding of each other's expertise as a way of collaborating and innovating.

11. How do you present your work: via runways, exhibitions, video documentation, conference presentations, or a combination?

JB: Being a professor, I am always interested in dissemination that has pedagogical outcomes. How can I use this work to make the world a better place—which sounds super-cheesy, but that is ultimately why I am doing it, right? I do not believe in only presenting in a high design or art context. I think that the work needs to be accessible in high and low, and technology and art, for old people and for young people—which is kind of ambitious, in a way. I think you can present your work in a way that is relevant to many different demographics and many different kinds of contexts. So, I have done runway shows, exhibitions, video documentation, conference papers, and conference presentations. But I also do a lot of popular dissemination, such as give interviews on T.V., act as a mentor for hackathons, or I give keynote addresses at various little conferences that are not necessarily very famous but that are important in order to foster a local community around these practices. I mentor kids, not just at Concordia, but also I volunteer through different programs, working with high-school kids, LEGO robotics competitions. I really believe that there are many dissemination outcomes to this work that can be much broader that just showing the design pieces themselves. I do not consider myself an artist or a designer. If I did, then I would probably stick more to runway, exhibition, or publications outlets. I see myself as a much broader kind of researcher, educator, and pedagogue, and that is why my dissemination techniques are much more varied than most other people in this area.

12. What is the role of the body in informing your designs, both from an aesthetic as well as a technological perspective?

JB: The body is crucial to XS Labs' research: the body in time, the way it moves, and the specifics of how the design is to be used. What I mean by that is, we cannot design a piece for everybody. On the one hand, there are modes of looking at modular approaches. On the other hand, I think the strongest research and design in this field of electronic textiles and reactive garments really comes from looking at very specific scenarios, not just scenarios of use but scenarios for bodies. What kind of movement is the body making? Even something such as eating, the way that your arm moves when you are eating. How can these bodily qualities be leveraged to create something useful, or interesting, or challenging? For example, the *Captain Electric and Battery Boy* pieces are all about harnessing kinetic energy from the body and translating it into electric energy. They are parasitic garments that harness energy from the body. Each one of them is a player in a conversation with a specific body. They are called *Itchy*, *Sticky*, and *Stiff*. *Itchy* is designed specifically around the idea of creating these itchy collars around your neck, and as you start to scratch yourself and move, you are actually activating a power generator that then fuels the garment. *Sticky* is the same idea: your arms are actually tethered to your body, and, as you try to feed yourself, or open a door, or shake somebody's hand—these everyday actions—you are again powering the generator. So, the body is central to making really interesting and specific work by looking at the specific actions that the body does in order to design a specific wearable.

13. How is your work informed by performance? Please consider how the bodies/fashion/technology perform in your work?

JB: The way that I have been thinking about performance in my work has been by approaching it from the perspective of active materials and functional fibers. What I mean by this is, like when you are designing a theater set, or a set for Cirque du Soleil, you do not just design a set with five movable parts. Maybe that was the case for lower-budget productions, or in the past, but in these new productions everything evolves over time, where there are moments in time that are completely transformative. It is my belief that with these new fibers that I have been developing, this is the second phase of the XS Labs' research life. XS Labs has had these seven-year plans, where the first seven years was about design prototypes, and the second seven years was about material innovation. What came out of the material innovation phase is that you cannot just design a garment and then attach a function, as we did with a lot of the prototypes in the first stages of XS Labs. Design a dress and that does one thing—such as the flap goes up and down, or the hemline goes up and down. I think that if we really want to challenge the future of electronic textiles, and the future of materiality, we have to take a more performative approach, meaning that everything can change fundamentally. The garment is not just a static object with one function or one transformation, but as we start developing these new fibers, etc., the garment can change in a fundamental way. So, what I have been doing now, in many of my design research projects, is working with fashion designers to imagine the garment at different moments in time, and to produce multiples of the one garment. As these fibers are not yet available, this is more design research, and performance, in terms of the garment itself—changing form, changing shape, changing rigidity. It is like a theater piece or a circus piece that has these different states at different moments in time, and has a narrative that is time-based.

14. Describe the "performance" that occurs in your studio/atelier/laboratory on a regular day involving bodies/fashion/technology. Who is there, what is happening, what equipment in involved?

JB: Everyone has always described my lab as very fun, and that is because we laugh a lot. Because we involve our bodies in the design process, we are always picking up little bits of materials and things and placing them on our bodies and asking how that might perform or fulfill a function. Sometimes we even get undressed and dressed again, to try things on. There is definitely this aspect of play. I have a bit of a background in theater, and I guess I see that continuation there. Like what happens backstage—or like what happens in the dressing room, when you are trying on makeup, and costumes, and getting into your role. This becomes part of our design process. It is a very physical design process, where, as we are trying on things, we are not afraid to touch each other's bodies. Like, what if we put that element here? What if there was pressure on this part of your body? What would that do? And then, of course, there are long periods of just sitting there and sewing, or programming a micro-controller, or stuffing a circuit board. But I would say what really characterizes this lab, which relates to a performance, is definitely this playful, body-centered, bodystorming, brainstorming approach that I have always encouraged.

15. How do you imagine the research you are doing impacting the future of technology and of wearables?

JB: I feel I have a very strong impact on the future of technology through my main product, which are my students. That has been a big part of the motivation with XS Labs, which is a pedagogical research environment, where the training of what we call highly qualified people (HQP, which is the term that we use when writing research-grant proposals) is actually one of the main deliverables of a research project. So, I have had some amazing students who have contributed a lot to XS Labs, and have then gone on to have extremely productive careers, such as Vincent Leclerc, Marcelo Coelho, Di Mainstone, Christine Charlebois. You know, actually, all of my students, all of my interns, I think, are shaping the future of this space, and it makes me very happy to be able to contribute to the future of technology in that way.

16. Are you inspired (or frustrated) by the hype around Wearable Tech? Describe how, or give an example.

JB: The only thing that frustrates me is when the media has a hard time differentiating between different kinds of reports. For instance, the way that research happens is that it starts, very often, with fundamental science research. When I was working with Maksim is a perfect example. We developed a fiber that is a capacitor, and suddenly that exploded in the news—and these fibers that change colors, and that also exploded in the news. But what does it mean to develop a fiber that is a capacitor? It means we spent about $50,000 to make a meter that works in the lab, and that it takes fifty hours to connect properly to all kinds of measuring devices. We measured all of its capabilities, and that resulted in several papers, that were published in scientific journals. It got picked up by the news media, and suddenly everyone was saying: "Lab in Montreal makes capacitive fibers, the future of wearables is revolutionized!" But you know, that is just the first step in research. Then that needs to be re-designed, and to address the cost of making this fiber, and to address the uses of these fibers. Because these fibers will be useless if it costs $500 per meter—right?—and it will be useless if we cannot come up with a good connection scheme. Or how we can actually weave it in, and then connect it into a textile? So, the really frustrating part of the hype around this is was that they did not differentiate between fundamental science research, design research, and engineering research, prototypes, and actual products. Everything [today] is reported with the same level of excitement, and with the same level of coverage. A lot of people think that when they see Project Jacquard—Google that—it is a product. It is not; it was an early prototype in the lab where the fibers were literally soldered. This will never work in a product. It is not even a proper product prototype. And yet, it is picked up with the same level of excitement as the OMsignal bra, which actually *has* gone through all of the production prototypes, and that actually *is* a production-ready product. So, there is fifteen years of research in between those two steps, and yet they are reported with the same level of seriousness, and [in] the same language. That confuses people, and it makes the space really murky and unclear.

17. Are there historical references, or artists/designers, that you are inspired by (or draw from) when you create your work?

JB: There are some fashion designers that have inspired me a lot, such as Hussein Chalayan or Alexander McQueen. But on a deeper level, I am much more inspired by mythology, philosophy, and other kinds of storytelling.

18. Rank what is most important to you in a wearable: a) wearability (form-fitting on the body, comfortable, etc.); b) aesthetics and design innovation (new styles, new expressions); and c) technological advancement (improvement or innovation in computation hardware and software or interaction).

JB: I think that technological advancement is the most important to me insofar as, even though we have at XS Labs produced pieces that are more speculative design, I deeply believe that technology needs to be implemented, or be implementable, in order to function as research, as opposed to just being speculative. I would say that is number one. Then, in the XS Labs work, wearability would be last. So, aesthetics and design innovation would come second. But at XS Labs, wearability is usually last because a lot of the work is kind of weird. And it is meant to be weird. It is meant to have an element of discomfort, engaging with a deeper discourse around its functionality.

19. In your wildest dream (if all technology and fabrication processes were possible), what kind of wearable would you like to create, and why?

JB: I am really looking forward to this future where we have many different kinds of functional fibers. That you can go to IKEA, and, instead of just buying cool prints, the prints will be made with different functional inks, and the textile itself will be woven with different functional fibers. This way, we will be able to make garments that have very subtle interactions, or reactions that are almost organic, in the sense that when you touch them, something will move or shift or change color. This will occur in simple design techniques, such as cutting through the fabric will influence the function; depending on whether you cut through this yellow circle or around it, the programming of the fibers will be impacted. I am really looking forward to a future where we program by giving form to these materials the same way that, when we work with paper, depending how you fold it, you can give it a different kind of behavior. Actually, with my students, we do a lot of paper folding, and I show them how you can fold these intricate shapes that then move in a different way. Same with functional fibers and functional textiles—I am looking forward to a future in which, by way of cutting and sewing, you will be able to program and influence its behavior. That is more long-term research, but that is also part of why we need to start educating the designers to start opening their minds to this new kind of materiality, which is deeply connected to performance, or performativity—where materials will perform on the body the same way that complex folded structures can, or costuming can perform on the body.

20. If you could create a wearable for one specific or particular body/person, who might they be and what would they be doing?

JB: I'm going pass on that question, I really don't have an answer.