# Towards a Postphenomenological Approach to Wearable Technology through Design Journeys

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The field of wearable technology has extensively described the opportunities, challenges as well as the concerns around integrating digital technologies into fashion. However, it has so far not provided a sufficiently clear and embodied understanding of technology. Technology therefore is often still limited to something that adds functionality to textiles or clothing. Additionally, technology is seen as a way to enhance the visual expression and thereby the representational character of clothing. Both approaches seem to hinder the intersection of digital technologies and textiles on a material and embodied level. While the role of wearable technologies in the everyday could benefit from it. In this paper, we therefore argue for reframing the understanding of technology to better facilitate the integration of digital technologies (i.e. electronics and software) into everyday fashion. A reflective analysis of the process of designing wearable technologies, based on the design practice of the first author, reveals that technology is considered a material and that its material qualities are not thought of as either functional or aesthetic. These insights, arising from practice, have led us to turn to postphenomenology (a strand of philosophy of technology) to come to further conceptualization. Postphenomenology looks at the ways in which technologies mediate or "coshape" the relationship between human beings and the world. By seeing technologies as the media that connect humans to the world, they acquire a material and contextual dimension. The idea that artifacts mediate materially thus offers a very useful starting point for understanding and designing wearable technologies. The contribution of this article is twofold, namely, first, to provide a material understanding of the technology on the basis of design practice. And secondly, to bridge design practice with theory by suggesting to bring postphenomenology into fashion to better facilitate the design of wearable technologies for the everyday.

Additional Key Words and Phrases: wearable technology; design practice; materiality; fashion; postphenomenology

## 1 INTRODUCTION

Wearable technologies or 'wearables' have progressed significantly in terms in both research and commercial applications. Electronics and digital materials enable new capabilities in garments that increase awareness of personal health and activity levels (e.g. OM signal [41]), support communication and staying connected (e.g. Levis Commuter Jacket [33]), and augment human performance (e.g. NadiX [26]). These successes reveal the potential and ambition for wearable technologies to become a greater part of our everyday lives. However, these "soft wearables" [45] are still not commonplace. We argue that reframing of the understanding of technology is necessary to facilitate the integration of wearable technologies into everyday fashion. In this paper we suggest to combine design research with postphenomenology (a strand of philosophy of technology) to overcome the binary and disembodied understanding of technology that currently hinders the intersection of digital technologies and textiles on a material and embodied level. Further, we illustrate through reflections on design journeys, how theory and practice can inform each other to contribute to a more embodied understanding of wearable technologies.

Fashion, as an embodied practice [10,11,28], has a level of unrivalled intimacy and pervades the daily experiences and practices of every one of us. Therefore, we see the need and opportunity for a more embodied approach to technologies in fashion. The field of wearable technology has extensively described the opportunities, challenges as well as the concerns around integrating digital technologies into fashion [22,42]. However, it has so far not provided a sufficiently clear and embodied understanding of technology. The benefit of which will be a fuller understanding and potential for wearables to become part of everyday fashion and to have a more meaningful impact on everyday life.


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## 2 A BINARY AND DISEMBODIED UNDERSTANDING OF TECHNOLOGY

A review of the literature on wearable technology [9,25,35,36,46,54] reveals that there is a binary approach to technology. On one hand, technology is limited to something that adds functionality to textiles and clothing. On the other hand, technology is seen as a way to enhance the visual expression and thereby the representational character of clothing, thus emphasizing the symbolic over the material. In short, technology in fashion is considered part function, part semiotics or aesthetic expression. Despite attempts to reconcile approaches [38,12], a combination of functionality and aesthetics alone cannot sufficiently explain technology in the context of wearables. An underlying problem that reveals itself is that the instrumental use of technology and dematerialized understanding of aesthetics diminish the importance of embodiment, which in turn forms the basis on which fashion shapes the relations between humans and the world. This perspective thus hides the more complex human perceptions and understandings of how wearables exist and are understood in our world. The literature strongly expresses the challenge for fashion designers to deal with digital matter in relation to the physicality of textiles and the body [39,15,32].

In the field of human computer interaction (HCI) it has become quite common to approach computational technology as a "design material" [16]. In fashion practice, however, this way of thinking is relatively underexplored. A material approach to technology emphasizes the embodied character of technologies. As a result, the understanding and use of technology in fashion suffers from being disembodied. Challenges of the experience of materiality through embodiment have been identified, but there is only a limited amount of literature that gives suggestions and examples for successfully incorporating these thoughts into practice [45,27,39]. Joanna Berzowska has written extensively on her own practice with electronic textiles, soft computation and the concept of "second skins" [2–4]. But she is one of the few design researchers who has published in journals in both the fashion and HCI domains. Most fashion publications discuss materiality and technology from a cultural and predominantly theoretical perspective [7,21,24,40]. This analytical approach tends to emphasize the differences between technology, material, and body that leads to a disembodied understanding of technology. However, design practice that is a generative approach, works with the messiness of these concepts that can lead to emphasizing a synthesized approach to technology, material and body. And so, we argue that the voice of the designer can provide a different perspective on the intersection of digital technologies and textiles on a material and embodied level.

The binary approach to technology and the fairly disembodied understanding of technology due to the lack of in-depth reflective accounts of the design process, seem to hinder the intersection of digital technologies and textiles on a material and embodied level. Our approach to answering to this problem lies in a combination of Research through Design (RtD) and theory. RtD is a method by which new knowledge is generated through design actions [31] and whereby part of the knowledge is embedded in concrete design exemplars [55]. Additionally, we are following a tradition of practice approaches to theory such as "critical technical practice" [1], "strong concepts" [18], "conceptual constructs" [42], and the contribution made with the recent book *Making Design Theory* [43]. In this paper we share how we tried to address the stated problem through combining reflections on practice with philosophical theories. We provide insights from design journeys of the first author, which in her broader research led to further investigations of postphenomenology. Here, however, they serve to illustrate how theories and practice can interweave to support the need and opportunity in wearable technology design practice to work with technology as a design material. The position taken in this paper is informed by the first author who is a fashion practitioner with a professional design studio focused on the creation of wearable technologies. For her PhD dissertation [48] she developed a framework to facilitate the analysis of wearable technologies based on concepts of postphenomenology.

## 3 POSTPHENOMENOLOGY AND FASHION

Design research is turning to philosophy of technology to address the effects and meanings of the shifts and transformations that are the result of the continuous expansion of digital capabilities [13,37]. Postphenomenology, a strand of philosophy of technology first introduced by Don Ihde [19], is seen by design researchers as a useful approach to understand technology [17,30,32,34,52]. Postphenomenology looks at the way artefacts mediate the relation between humans and the world [19,50,52]. Humans and technologies continuously shape one another and the world as it is perceived and experienced by humans. It introduces a relational understanding of technology, whereby subjects and objects are the product of relations. In that respect, it is more radical than phenomenology, in the way that "subject and object are not merely intertwined with each other but constitute each other" [50]. While phenomenology has already

proven to offer valuable theoretical and practical contributions to the field of fashion design [10,11,28, 39,45], postphenomenology has not yet been widely explored in the field of fashion. Only recently, a number of strong claims for its relevance and potential have been made [46,47,17]. Other contemporary perspectives that provide a productive lens to look at fashion, like new materialism [6,39,40] and post humanism [14,49], show some affinity to postphenomenology when it comes to topics like materiality and non-human agency.

Our experience of making wearables motivated us to better understand design practice through postphenomenology and to show the potential for further theorizing about wearables in a way that is grounded in practice. In the remainder of the paper, we start with a brief description of the ideas of postphenomenology that have informed our design research. We then describe our method of design journeys and how the insights from the design journeys reveal an embodied understanding of technologies or what postphenomenology refers to as "material aesthetics" [50].

## 4 THEORIES INTO PRACTICE

Later in the paper we will discuss three insights from our research: 1) Technology is a material, 2) The interplay between technologies and textiles is based on a negotiation of their respective material qualities, 3) Material qualities should not be thought of as either functional or aesthetic. These three insights have a strong relationship with postphenomenological theory, including the ideas and concepts of postphenomenologists such as Don Ihde [19], Peter-Paul Verbeek [50,51] and Robert Rosenberger [52]. Built on the phenomenological tradition, postphenomenology takes an "embodied and situated perspective", thus emphasizing concrete experiences in the empirical analysis of the mediating roles of technologies [19]. Postphenomenology holds that technologies cannot be understood a priori, because the role and meaning of technological artefacts is continuously shaped and reshaped through our practical dealings with them. It therefore does not speak of artefacts in terms of functions and signs but understands them in terms of how they mediate human perceptions and actions [19,50]. Thus wearables, and in fact every piece of clothing, actively shape how humans act in the world and how the world presents itself to them. Verbeek stresses the importance of this thought for designers by emphasizing that artefacts mediate between humans and the world in a material way [50]. Thus, a material understanding of technology provides the starting point for designers to attend to the mediations of wearables [50,51].

These thoughts are very much in line with the insights of our analysis that follow of the role of technology in design practice. We therefore see potential to bridge practice with postphenomenological theory to help overcome the prevailing binary approach of technology that challenges the design of wearables.

## 5 METHODOLOGICAL APPROACH

In our broader research we take a RtD approach as we mentioned earlier. In this paper, we focus on design journeys as a research tool to investigate the mutual shaping of theory and practice. As a result of the RtD process, the first author brings forward a first-person perspective of designing and making on one hand and reflecting on the design process on the other. We present the design process in the form of "design journeys". Design journeys are not unlike autoethnography or autobiographical design [4,8,27,39]. They provide a detailed and contextual description of the design process that result from personal observations and interpretations and are richly illustrated with visual material. We find the term "design journey" appropriate here, because in the form of an annotated journey [20,23] it follows the design development chronologically with an emphasis on visually communicating the designer's practical dealings with materials. We focus on the design process of two design exemplar, named the Solar Dress and the Solar Shirt. The first author's PhD dissertation [48] gives a broad account of the design journeys. Due to limited space, a selection excerpts of the design journeys are presented to provide key insights on how technology was dealt with both conceptually and practically. It is important to note that the design process of the two exemplars has not been actively informed by postphenomenological thinking. Postphenomenology has been used afterwards as a lens to reflect on the considerations and actions taken during the process of designing.

Fig. 1. Solar Dress, 2013 (Photography: Mike Nicolaassen)

The first author designed a series of wearables that are part of an overarching research project known as *Wearable Solar*, which investigates the integration of solar technology in textiles and clothing. The two design exemplars that will be discussed in this paper, the *Solar Dress* (2013) and the *Solar Shirt* (2015) (see Figure 1 and 2), each have their own method of integrating solar cells and circuitry. The two projects are chosen because they are well suited for a comparative analysis, given that they center around the same technology. Next, we present excerpts of the design journeys of both exemplars. The *Solar Dress* is an elegant black dress that integrates 72 thin film solar cells, supported by a transformable silhouette. The *Solar Shirt* is a dark blue T-shirt in which 120 thin film solar cells are playfully integrated using printed electronics. Both garments were designed in response to the growing demand for and dependence on connectivity in people's everyday lives and the need to find more sustainable solutions. They generate enough energy to charge small portable devices like a smartphone that can be connected using a USB cable.

Fig. 2. Solar Shirt, 2015 (Photography: Liselotte Fleur)

## 6 EXCERPTS OF THE DESIGN JOURNEYS

### 6.1 Excerpts of the design journey of the Solar Dress

*6.1.1 Solar technology and the body.* Initial desk research revealed two main approaches: a representational or semiotic approach that viewed the solar cells in terms of the way they could form a visual statement to attract attention and a functional approach that viewed the cells in terms of their instrumental value. We found this separation very problematic. Instead, we studied solar technologies in

terms of their presence in the environment and their relationship with the human body. One element we found particularly striking was the comparison that could be drawn between the layered build of solar panels and the stratification of human skin (Figure 3).

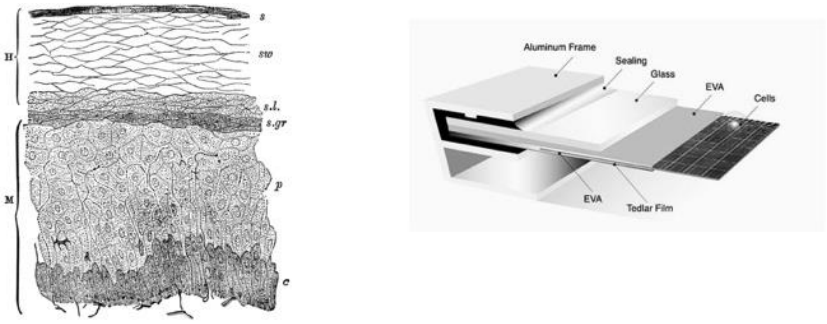


Fig. 3. Comparison between the stratification of human skin and a solar panel

*6.1.2 Familiarizing through sketching and on-body explorations.* Anticipating the use of thin film solar cells, we began familiarizing ourselves with these materials by incorporating them in digital collages and sketches. One of the ideas was based on 'weaving' long strips of the material (Figure 4), which would make the solar cells a structural part of the garment while simultaneously creating a pattern and tactility.


Fig. 4. Design collage to give expression to ideas of integration based on the concept of weaving

Next to sketching we explored the qualities and properties of the cells by working directly on the human body (Figure 5). A tension emerged between our concern for wearability (considering both aesthetics and comfort) and durability on one hand and the performance of the solar cells (the energy efficiency of the garment) and complexity in terms of integration on the other. Wearability, durability and the overall expression would benefit from using many small cells, strategically placed on the body, while a single large cell would technically generate great results by optimizing efficiency and ease of integration.

Fig. 5. On-body explorations with solar cells (left) and cardboard strips that mimic solar cells (right).

*6.1.3 Layers and folds.* Based on the on-body explorations, a small type of solar cell was chosen, after which we returned to the concept of layering. We experimented with layers that contained the cells and that would be exposed by folding. We were drawn to the idea that the cells would be directed towards the body (the active layers facing each other) because it underlined how the 'potential energy' of the cells would be embodied. This way the wearer could decide when to 'materialize' this potential energy by revealing the cells to the light. Anticipating the interconnections between the cells, we placed them in a vertical array on the upper body in close proximity to each other, to ensure that interconnection remained short and the inside of the dress would not become a clutter of wires. The two vertical arrays of solar cells made it possible to create compartments that would fold open sideways (Figure 6). The act of folding would also change the silhouette: the exaggerated shoulders literally made the dress "powerful".

Fig. 6. Folded compartments with cardboard strips as solar cells

*6.1.4 Integration with leather.* Additionally, we explored how the cells could be combined with other materials. It was important to find a refined method that would contribute to the overall appearance of the design but would not compromise the operation of the cells too much. Textiles are typically joined together by sewing but piercing a solar cell would cause a short circuit. By cutting small slits in the leather, both ends of a rectangular cell would disappear (Figure 7). The stiffness of the leather contrasted with the fluidity of a crepe wool. The crimped appearance and texture of the wool also contrasted nicely with the smooth surface of the leather and the solar cells.

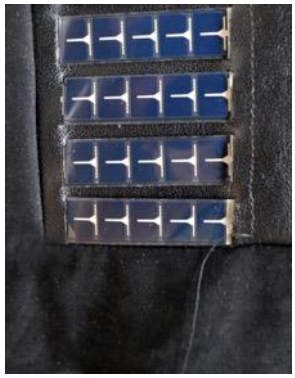

Fig. 7. Solar cells fixated inside leather

### 6.2 Excerpts of the design journey of the Solar Shirt

*6.2.1 A more seamless integration.* The *Solar Dress* had revealed a number of challenges. It proved very difficult to create an efficient assembly process between electronic and textile parts (Figure 8) as well as a robust integration of the solar cells and wiring. Both the complexity of the making process and the overall high-fashion appeal of the dress made it an exclusive product.

Fig. 8. The wiring of the solar cells on the inside of the Solar Dress

For a follow up project, we turned to printed electronics (Figure 9) because it offered freedom in the composition of the solar cells and the lamination process could facilitate their integration. Instead of a linear placement and integration, more playful compositions could now be made.

Fig. 9. Solar cells combined with printed electronics, laminated to textile

*6.2.2 Composition.* Through sketching and on-body explorations we developed compositions that looked more fluid and organic than the typical array or grid-like structures. On one hand, we studied the placement of the modules on an archetypal T-shirt, while on the other hand we looked at how the placement of solar cell modules could inform a redesign of the classical T-shirt shape by considering volume, drape, layering and other characteristics (Figure 10). The printing and lamination process not only enabled more seamless integration with textiles, but also, we found that the circuit could be exposed and become a graphic feature of the design.

Fig. 10. Making compositions through on-body exploration (left), sketches (middle) and digital collages (right)

*6.2.3 Choosing the right fabric.* Our decision to design a T-shirt was motivated by the fact that the printed electronics could be laminated on a knitted fabric, which would allow for stretch and comfort. Even though the printed circuit would be flexible, the fabric did have to provide a rather stable and protective surface to reduce the strain on the circuit. The inks available for printing were silver and the solar cells had a deep blue color. We decided to choose a blue-colored fabric, because it would make the circuitry stand out and emphasize its meandering shape, while the cells would blend in with the background. Among our fabric selection was a dark-blue double-knit fabric that seemed suitable since it matched the stretchability of the circuit and its sculptural character would enhance the silhouette of the T-shirt.

## 7 COMMITMENTS OF THE DESIGN PRACTICE

A critical analysis of the practical involvement with technologies – presented through the design journeys – enables us to give expression and depth to the interpretation of technology. Our analysis cuts across the two design journeys to examine the relationship between technology and material. This led to three main insights that can be considered the commitments of the design practice concerning this relationship. On the basis of these three commitments, we flesh out the foundational assumption that technology takes on material qualities. Below, each commitment is explained in more detail on the basis of examples from the design journeys.

### 7.1 Technology is a material

Throughout the design process of the *Solar Dress* and *Solar Shirt*, technology is treated as an emergent phenomenon. The design journeys do not speak of "a" or "the" technology. Instead of being something fixed or opaque like a black box [5], the journeys describe technology as something that can be touched and transformed. Technologies are considered a material, which prevents them from being understood in general terms. Solar cells, for example, are generally conceptualized through the phenomenon of generating electricity from sunlight. What matters in the design process, however, is not the universal technical principle of the technology, but the "ultimate particular" [29] of its material properties. Different types of solar cells will offer the same functionality, but they are materially different. "Energy harvester" and "sustainability" is what solar cells may represent, but their role in the design process is not confined to this functional representation. Their materiality is what gives shape to the garment.

### 7.2 The interplay between technologies and textiles is based on a negotiation of their respective material qualities

The design journeys reveal an explicit awareness of the material qualities of technologies There is no predetermined hierarchy among the material qualities of a specific solar cell. Time is devoted to the

exploration of these material qualities, which generates tacit knowledge driving a continuous process of negotiation. The negotiation of material qualities of the solar cells informs an iterative process of joining and shaping with textiles and other materials that ultimately leads to the creation of a garment. The design journey of the *Solar Shirt* states that the knitted fabric was chosen because of the way in which its texture contrasts with the smooth surface of the encapsulated electronics. This indicates that the solar cell modules are considered for their tactility. Similarly, the leather of the *Solar Dress* complements the solar cells in terms of flexibility and smoothness. The materiality of the solar cells influenced the design of the garments on many different levels. Concerns about aspects such as form, performance, placement, patterns, integration, interconnection and body movement are intricately connected.

### 7.3 Material qualities should not be thought of as either functional or aesthetic.

The design journeys illustrate that functionality and aesthetics are not considered as two opposite ends of a scale because the material qualities of a technology cannot easily be defined as either functional or aesthetic. Additionally, the design journey of the *Solar Shirt* shows that "printing" as a material quality of the electronic circuit offers both functional and aesthetic opportunities. Functionally it allows the solar cells to be combined into "modules", improving the interconnection between the cells and simplifying the integration through the lamination process, while printing the traces simultaneously turns the wiring into a visible and tactile design element. The printing process allows the circuit to take on a custom-designed shape. The meandering shape of the printed traces is functional by allowing the traces to be stretched further without breaking. To an engineer it is firstly a technical solution in response to a mechanical problem. When viewed through an aesthetic lens the meandering shape can be seen as a decorative pattern, which because of its delicate look may be interpreted as embroidery. A separation between functionality and aesthetics of "technical" materials is not productive, because practically these qualities are already combined in a material whole.

The above list of commitments is not comprehensive. However, in view of the aim of this paper, it effectively illustrates how the understanding of technology in relation to wearables can be reframed through postphenomenology. In the next section we will make explicit how postphenomenology can help further conceptualize the commitments we found in design practice.

## 8 DISCUSSION

In our attempt to move beyond a binary approach of technology in wearables, we would like to stress that we do not intend to undermine functionality. However, we do argue against a techno-centric vision that does not consider an artefact beyond its functionality. Our analysis has pointed out how technology should be seen as a material, which rejects the idea of using a garment as a mere vehicle for the technology. This analysis is resonant with postphenomenology and makes the philosophical ideas more concrete and practical. In this way theory and practice inform each other. Further, the idea of technology as material aligns with the postphenomenological concept of "material aesthetics" that highlights the material nature in which mediation occurs and how technology is embodied [50].

Postphenomenological thinking can enable a move away from the current emphasis on functional and instrumental roles of technology. Moreover, the relational understanding of technology does not limit wearables to matters of representation. Finally, the pragmatic orientation of postphenomenology emphasizes the importance of concrete and subjective experiences with a technology in context. In this paper we have only looked at the design process as the context. However, the analysis of wearable technology exemplars themselves and peoples' relations with these artefacts can be supported by postphenomenological concepts as well that we have explored elsewhere [48,53].

We believe it is important that future work enables postphenomenological theory to become more easily accessible to designers. And it should also focus on developing methodological tools and guidelines for postphenomenological concepts to become actionable for designers. Ultimately a designerly treatment of postphenomenology and its concepts may also challenge philosophers of technology by shedding a different light on their theoretical frameworks and empirical studies.

## 9 LIMITATIONS

The insights from design practice presented in this paper are based on personal observations and interpretations that are confined to the work of one designer. The proposition to turn to postphenomenology is one that we have applied ourselves rather than a validated method. While aware of

these limitations, we aim to catalyze others into engaging our approach as a matter of discursiveness in practice.

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