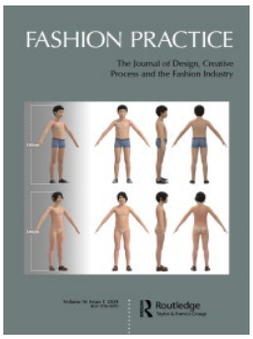

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Gender and the Diversity of the Human Body as Challenges for the Inclusive Design of Wearable Technology

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Abstract

Particularly since the 1990s, there has been an active discussion on inclusive design and on the possibility of designing products that would be suitable for every kind of user. Wearable technology products that need to be in close contact with the user's skin to function must be a good fit for the user's body. As wearable technology has transitioned from a specialty of the "quantify-yourself" movement to a widespread, everyday item, the

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companies that create these products compete to appeal to ever-larger user groups. This study investigates how product designers in wearable technology companies interpret the idea of inclusive design when developing their products to fit large and diverse groups of users. Drawing on four case studies, this research shows how the diversity of the human body poses practical challenges for inclusive design. Yet, the findings also show that in addition to the biological differences between human bodies, inclusive design is also influenced by cultural understandings of gender.

KEYWORDS: wearable technology, inclusive design, user-centered design, gender, human body

Introduction

Wearable technology is situated at the crossroads between design, fashion, and technology. The concept itself covers several kinds of devices and materials ranging from sensors attached to football shoes and aesthetically ambitious intelligent textiles to medical devices and accessories related to augmented reality. The most widely used wearable technologies include products that help users to exercise and maintain well-being, such as fitness trackers and other health-monitoring devices. In particular, smartwatches are rapidly gaining new users (Mordor 2021). This study focuses on the design processes of sport and fitness-related wearable technology because of their increasing and widespread influence on everyday life.

As the use of wearable technology becomes more widespread, companies have noticed that the needs of the users have also changed and multiplied. If wearable technology, like sports watches, was once mainly targeted to and used by male amateur athletes like joggers or divers, today wearable technology has become an everyday item used by people of all genders. Therefore, requirements for their design have also changed, as wearable technology now needs to fit for various situations and many kinds of human bodies. In other words, the design of everyday wearable technology must be more inclusive and approachable for diverse kinds of users.

One way to achieve this goal is to make the devices more desirable as fashion and design items. During the 2010s, wearable technology companies cooperated with fashion brands and designers, such as Apple with Hermés, or Google Watch and Tag with Michael Kors, and fashion brands like Louis Vuitton and Armani produced their own smartwatches (see Allison 2019; Dayaram 2022; Fisher 2017). According to its website, in May 2022, the wearable technology ring company Ōura launched a partnership with Gucci (ouraring.com/gucci). Yet, the aspiration to make fashionable wearable technology includes all kinds of wearable technology companies seeking either to stake out or maintain their share of the increasing wearable technology markets.

This article investigates how the product designers in wearable technology companies interpret the ideas of inclusive design when

developing their products to fit the bodies of large and diverse groups of users. This research is based on interviews of designers and other product development professionals who work for four companies designing and manufacturing wearable technology. Scientifically this article represents sociology of design (Lupton 2018) that seeks to identify design cultures, and the discursive and material practices which design professionals apply in their work and discusses them in their broader social and cultural context. Following this tradition this article concentrates on the experiences and practices of designers and product developers. This kind of inner view of design cultures offers valuable knowledge as such since designers' and other developers' understandings and practices of inclusive design have strong effect on the everyday life of users.

The companies involved are: 1) Ōura, which is famous for its sleep measuring rings, 2) Suunto, which designs and produces sports watches, 3) Moodmetric, which is a micro enterprise producing rings that gauge users' stress levels, and 4) Myontec, which designs smart clothes that are used both for the analysis of high-level sports training and to study ergonomics in workplaces. All the companies originate in Finland but aim for the global market. There are two main reasons for choosing these cases. Firstly, and most importantly, the products are highly interesting from the perspective of inclusive design since all these companies implement the unisex design approach, which has been influential in the history of Nordic design (Clarke 2013; Persson et al. 2015). Secondly, Nordic countries, such as Finland, are cultures with a high reliance on research and great respect for its benefits to society (Wellcome Global Monitor 2018, 79–82), which makes access for researchers and cooperation with these companies quite easy.

Theoretical Background

Inclusive design was originally conceived to improve accessibility for elderly users or users with disabilities. From the 1950s onwards, many projects aimed to improve inclusiveness and accessibility, especially in the United States, the UK, and Nordic countries. One seminal work in this movement was British architect Selwyn Goldsmith's book *Designing for the Disabled* (1964), while in the U.S. architect and designer Ronald L. Mace established the Center for Accessible Housing in 1989, which he re-named the Center for Universal Design in 1996 (Clarkson and Coleman 2015; Persson et al. 2015). However, especially in the Nordic countries, the meaning of "inclusivity" began to shift in the late 1960s from catering to the special needs of the disabled and the elderly to designing products that would be accessible and usable by as broad a range of users as possible. This change in thought was encouraged by the Austrian-born American professor Victor Papanek, author of *Design for the Real World* (1971), who visited Nordic countries multiple times at the end of the 1960s.[1] He had a major influence on Scandinavian

and especially Finnish design, and his ideas about socially and ecologically responsible design were implemented as collaborative and action-based design activism. Papanek acknowledged that working with Nordic design students also influenced his own thinking (Clarke 2013).

The term "inclusive design" was first introduced in 1994 by the British Roger Coleman who with his colleagues further developed it as a particular kind of design approach including certain kinds of design tools, user-research methods, and the quantification of inclusivity. Coleman also emphasized inclusive design's potential commercial benefits for businesses (Clarkson and Coleman 2015). During the 1990s and 2000s, multiple international organizations made public declarations and worked to implement these declarations into legislation, further developing the principles of inclusive design and putting them into action. In 2004, the European Institute for Design and Disability (EIDD) published its "Design for All" declaration in Stockholm, defining the concept as "design for human diversity, social inclusion and equality," and in this way took steps to include financial, cultural and social factors as considerations for inclusive design (Persson et al. 2015).

Further discussion about inclusive design has recently been prompted by Arturo Escobar's influential book *Design for the Pluriverse* (2018),[2] which calls for more environmentally and socially sustainable design that could be achieved through collaborative and place-based approaches. Escobar suggests that cultural studies theories of class, gender, race, and coloniality should be included in design education (58), and his work is most inspired by postconstructivist and neomaterialist feminist theories and emphasizes the need to break down the modernist dualisms, such as mind/body or culture/nature (62–67). Despite that, Escobar has been criticized for essentializing gender and biology and reproducing the interrelated dichotomies of nature/culture – feminine/-masculine (Baker 2020).

In recent years, gender-inclusive design approaches have been used more broadly, especially in the fields of HCI and game design (Kafai, Richard, and Tynes 2016; Oleson et al. 2018; Stumpf et al. 2020). Especially related to the inclusive design of wearable technology, there are few interesting studies that, for example, focus on the default expectations of non-disabled users (Elman 2018) or investigate the potential for gathering new kinds of data of particularly female body functions (Cifor and Garcia 2019). Yet, these studies mainly concentrate on the application features of wearables. In research on the design of wearable tech accessories and clothing as physical objects, in turn, the significance of gender or biological sex to the design is often not even mentioned (Joseph et al. 2017; Mencarini et al. 2019; Tomico et al. 2017). Neglecting gender and biological sex as analytical concepts may lead to historically well-known design approaches (Cifor and Garcia 2019; Lupton, Kafei, and Tobias 2021, 30–33; Oudshoorn, Saetnan, and Lie 2002; Perez 2019, 216–243, 294–314) in which universal design

in practice means design that functions well only for male body proportions.

In fashion research, unlike design research and theory, the embodied relation that people have with clothes and accessories, as well as fashion design's various approaches to the gendered human body, have been the objects of lively discussion since the turn of the century (Eicher 2012; Entwistle 2000; Robinson 2022; Ruggerone 2017). This ongoing conversation about the significance of embodiment and materiality in fashion design often entails a critique of the fashion industry's preference for "exclusively" young, white, fit, and slim body types (Barry 2019; Grimstad Klepp and Rysst 2016; Lewis 2019). The critique has also led to concrete actions by the new generation of fashion designers, who have created collections for plus-size women or disabled children, among other groups (Hudson and Hwang 2022; McBee-Black 2022). On the other hand, in the fields of fashion and fashion research, methods of user-centered research and design have been employed only rarely until quite recently, and mostly in functional clothing design (e.g. McBee-Black 2022; Rahman 2015; Valle-Noronha 2019; Watkins and Dunne 2015, 1–30).

In this article, the two separate theoretical discussions on embodiment in fashion design and inclusive design are brought together through empirical research on the design of wearable technology. In the analysis, biological differences between bodies are taken as material conditions for the design. Thus, following Smelik (2018), materiality in this study does not only refer to materials like fabric or garments, but also to the wearer's or user's body, and the world of production and consumption. Although the concept of inclusive design consists of much more than paying attention to the differences between female and male physiologies, this study focuses on that as it was the aspect of inclusivity that the informants most emphasized. However, focusing on the differences between female and male bodies does not mean that this research would understand biological sex as having any kind of predetermined cultural or social consequences (Dolphin and Tuin 2012, 137–158). Instead, the cultural and historically produced and repeated conceptions of gender are in this study analyzed as regulatory norms and ideals (Butler 1993, xxi–xxiv, 59–60) that may influence designers' interpretations of inclusive design in wearable technology. As the analysis will show, these cultural conceptions related to gender and the material factors related to human bodies often have very little to do with each other.

This article is organized into four parts. In the following section, the research approach and methodology of this research project are explained. After that the background of the analyzed companies and the functionalities of the products are described in detail. The next section moves on to the analysis, which is divided into three chapters. First, it is analyzed how the inclusive design approach is reflected in Suunto's smartwatches. Second, the two smart rings, Ōura and Moodmetric, are

both discussed due to the similarities in their approach toward inclusivity. Thirdly, the study scrutinizes the process of designing Myontec's smart clothing as it relates to the challenges posed by the diversity of the human body.

Materials and Methods

This research in inspired by a particular kind of design research approach, namely the sociology of design. While most design research is object and practice oriented, sociology of design seeks to identify design cultures, and the discursive and material practices which design professionals apply in their work. Further, sociology of design analyses and discusses the broader social, cultural and/or political contexts in which design as a way of thinking is situated. Sociology of design builds on traditions of cultural studies and science and technology studies (STS) that share interest in the working practices of designers of objects, systems and services. (Lupton 2018; Pickering 2008). This research too, following the tradition of cultural studies, concentrates on the experiences and practices of designers and product developers, as they offer a "grassroot" view on the production process. Accordingly, the analysis of designer interviews focuses on the informants' interpretations of their agency and the preconditions of their work in the field of design. Unlike object-oriented design research that seeks to provide innovative and practical solutions for new kinds of design products, sociology of design analyses the ways design cultures are organized and discusses their social and political consequences for everyday life. (For similar approaches see MacLean 2019; Morozova and Gurova 2022; Savolainen and Hyysalo 2021; Schulz 2008.)

Since little prior research on the experiences and everyday practices of wearable technology designers existed at the time the research project started, an exploratory approach was selected. Semi-structured exploratory interviews were used to gain novel insights into the starting points and processes of wearables design in the selected companies. The flexible research design provided the researcher the opportunity to quickly react on informant's answers and to pose ad-hoc follow-up questions when needed. Open-ended questions focused on the following main themes: implementation of user-centred design, use of user research data in design, phases of design process, co-operation between the production team members, and understanding and implementation of inclusive design.

The thematic interviews were conducted during the fall of 2020. The interviewees were selected as follows: from every company, at least one person working in design domain and one person working closely with user research was included. In some cases, one more informant was invited to shed light on particular issues, and altogether ten wearable technology specialists participated in the semi-structured interviews (see Table 1).

Table 1. Information on interviewees and their roles in the companies.

No.	Company	Design/User Research	Main task in the company	Date
1	Moodmetric	Design	Product development (freelancer)	19th Oct 2020
2	Moodmetric	User Research	Management	5th Oct. 2020
3	Myontec	Design	Product development (freelancer)	8th Oct 2020
4	Myontec	User Research	Management	22nd Sept 2020
5	Suunto	Design	Product development	28th Sept 2020
6	Suunto	User Research	Marketing and Product development	20th Oct 2020
7	Suunto	User Research	Data Analysis	30th Oct 2020
8	Ōura	Design	Product development	27th Oct 2020
9	Ōura	User Research	Product development	13th Nov 2020
10	Ōura	User Research	Data Analysis	21st Oct 2020

The companies differ from each other in focus, structure, and size, and therefore the informants who knew most about user research represented varied backgrounds and professions. While Myontec and Moodmetric have 4-5 employees, Ōura and Suunto employed 249 and 325 people respectively in 2021. Their turnover varies from 98,000 euros (Moodmetric), and 241,000 euros (Myontec) to 50.9 million (Suunto) and 83.4 million (Ōura).[3]

In most cases the informants came from management, marketing, or product development. Especially in the micro-sized firms, people working in the management participated actively in every decision related to product development. On the hand, in the large companies, data analysts were working closely with people responsible for solutions on product development as they provided useful data for decision making. The exact titles of the informants are not mentioned to protect their anonymity.

Due to the Covid-19 restrictions, all the interviews were conducted via Zoom.[4] While some in-person interview nuances were perhaps lost amid the virtual platform, the fact that many informants were interviewed from home provided informality and extra richness to the interviews. Interviews were recorded and transcribed with the informants' permission. The transcribed interviews were then coded and categorized with the help of the Atlas.ti qualitative data analysis software.

The analysis phase followed a standard thematic analysis process (Braun and Clarke 2006; Gibson and Brown 2009, 127–144). In order to remain open to a diverse set of perspectives, the selected coding scheme was a combination of both inductive and deductive coding. Some codes came directly from the interviews, whereas others were inspired by prior research literature. This "blended approach" (Graebner et al. 2012) was applied to not to lose the nuances of the collected data while also ensuring the theoretical relevance of the work. The initial coding cycle was mostly descriptive in nature. After this, by combining and merging codes, broader themes were created to structure the findings. As the analysis focused on the implementation of inclusive design, which originally was only one of the chosen themes in the interviews, more precise themes were created to capture the experiences and insights of informants related to the practices of inclusive design. As a

result, the interviews were coded again under themes of user-research and user experiences, conceptions of gendered features (particularly colour and shape), ergonomics and comfort, and the role of technological features. However, because the analysis showed that the type of the product (watch, ring or clothing) had a decisive impact on the possibilities of implementing inclusive design, the analysis of the themes is organized along with types of products.

Case Studies

This study concentrates on the design processes of four Finnish wearable technology products (see Table 2). Probably the most well-known among them is Ōura, a ring and accompanying app that has been publicly praised by celebrities like Kim Kardashian (Hendricks 2021), Jennifer Aniston, and Jimmy Kimmel and was also seen being worn by Prince Harry (Sampson 2021; Rudd 2018). Ōura monitors body temperature, pulse, and heart rate variability (HRV), and respiratory frequency and activity. The ring is particularly focused on the quality of sleep and measures the total duration of sleep, restful periods during the night, the time it takes the user to fall asleep, and resting heart rate. The data collected by the ring is transferred to an application on the user's mobile phone via a Bluetooth connection, and the application provides detailed information about the user's activity, quality of sleep, and recovery and readiness levels.

Another wearable technology ring, Moodmetric, promises to reveal the user's stress levels. The ring measures the electrical conductivity of the skin, which can indicate fluctuations in the individual's stress levels. When the sympathetic autonomic nervous system is activated as part of the body's fight-or-flight response, changes in electrical conductivity can be detected through the skin. The company behind Moodmetric is called Nuanic, but for the sake of clarity, the company is referred to as Moodmetric in this article.

Table 2. Information on the products that were discussed with the informants.

	Product	Year of Launch	Materials	Main functionalities
Moodmetric	Ring	2018	Silver-plated spring steel (ring), polyamide (cover),	Measures user's stress level
Myontec MBody	Shirt, shorts	2021, 2018	Polyamide, elastane, silver-plated textile,	Measures user's muscular activity and movement
Ōura Gen 3	Ring	2021	Titanium ringbody with physical vapor deposited (PVD) gold and silver colours, and black diamond-like coating. Non-allergenic non-metallic inner moulding	Measures user's sleep quality, readiness, and recovery
Suunto Peak 9	Watch	2020	Silicon, glass, titanium	Measures user's exercise, activity, and recovery

The product with the longest history is Suunto. The company by the same name was founded in 1936 by orienteer Tuomas Vohlonen with his partners and first produced the liquid-filled compass. Today, besides smartwatches, Suunto continues manufacturing compasses and dive computers. Their newest product, the Suunto 9 Peak, tracks the user's exercise, daily activity, sleep duration and quality, and stress levels and recovery. The device also includes a compass, altitude navigation, and GPS tracking. Users can store their routes, training times, and data related to their daily activity and sleep in a related mobile application. Drawing from user data, the application can suggest training route options for different sports everywhere in the world.

Myontec is the only company included in this study that designs and makes clothing. Smart clothing by Myontec uses sensors to measure muscular activation, movement, and heart rate during sports performance. Sensors embedded into the fabric of the clothes use a Bluetooth connection to send data to the mobile or computer application. However, Myontec's clothes are not primarily aimed at ordinary users but rather professional-level athletes, as the measured data can only be analyzed by a specialist in physiology. This analysis is essential to the effective use of Myontec's product.

All the wearable tech companies investigated in this study use traditional (Hanington 2003) methods of user-centered design when developing and re-developing their products. In practice, the size of the company determines exactly which methods can be applied for the use of design and development. The interviews revealed that large companies that operate globally, such as Ōura and Suunto, conduct extensive user research by utilizing surveys and focus group interviews, cooperating with leading users, and combining their own user analysis with available market research to grasp the needs of not only existing but also potential users. Micro-sized companies, such as Myontec and Moodmetric, also develop their products based on an acquired knowledge of users' needs, but instead of conducting extensive user research, informants of these companies told that they tailor their products in a close and direct relationship with their clients.

Inclusive Design of Suunto Sport Watches for Everyday Life

As Maragiannis and Ashford (2019) observe, "one of the marginalized groups that have been under-represented regarding choices and design in technology are women" (199). Although technological products may not be explicitly designed for men, often either their size and form or the marketing of the product, has revealed that the imagined user is in fact male (Perez 2019; Oudshoorn et al. 2002). When technology has been designed to attract female consumers, it has often been done through stereotypical color schemes, like "pinking" (Maragiannis and Ashford 2019; Schroeder 2010). This kind of color scheme has been

used to separate the "normal" or advanced technological devices intended for men from "women's" technological devices, where the focus of the design and marketing has been more on the "non-typical" color than on the technical qualities. At the time of writing, FitBit markets their lunar white and orchid (pink) smartwatches with slogans like "Start tracking in style," while FitBit's most advanced health and fitness tracker is only available in black or steel blue (https://www.fitbit.com/global/fi/home). Taken together, the marketing and color scheme repeat and reinforce cultural conceptions of what men and women should prefer, know, and be capable of (Rommes 2014, 44).

According to the informants from Suunto, the development of their newest product, the Suunto 9 Peak (see Figure 1), was preceded by a review of both their design language and product concept. Their marketing research had identified certain cultural trends, such as "humanizing technology" and "tech disconnection" that they wanted their product to reflect. In practice this meant that Suunto wanted to develop and design a smartwatch that was suitable for every situation of human life, including jogging, working, and sleeping. From the design point of view, this meant that the company was looking for as discreet a design as possible, so that the watch would be stylish enough to be worn when not exercising and small enough to sleep with.

> *I think it's just really important to understand what's important for our users and, not just on the top level but really trying to immerse yourself into, what conditions those products are used in. And now in the case of this product we knew that obviously with those tough sports it needs to endure all of those, at the same time we had the feedback that, people, they didn't want to have two watches one for their personal life and one for their sports, but wanted to have one watch that works for both worlds. (Designer at Suunto)*

Figure 1
The colors of the Suunto Peak 9 watch straps are aimed to be inclusive for all genders. *Images by Anna Äärelä.*

Through the design suitable for everyday use, the company could offer something to customers who did not frequently engage in sports but still wanted to track metrics related to their well-being. In addition, the company had noticed that many people were beginning to feel annoyed by the ubiquitous nature of media and technical devices. Therefore, they decided that the users should be able to determine whether they received notifications from their watch or not. All in all, the company wanted to create wearable technology that would function as an unnoticeable extension of the human body.

At some point in the development and user-research process, they noticed that the product had one critical problem that prevented it from being suitable for every occasion. The watch was well-suited for large (male) wrists but was "bulky and hard to integrate into everyday life", as their designer described, for smaller (female) wrists. Thus, they wanted to design and develop a new version that would be inclusive for all genders, both by size and color. From the technological point of view, this meant that the electronic elements would need to significantly diminish to fit into the new, smaller shell.

The color scheme and the form of the watch were, according to the designer, inspired by Finnish nature and the tradition of Nordic functional design. The color palette served two different marketing functions. Firstly, it was intended to reinforce the product brand as a device that would help enable users to exercise outdoors and feel connected to nature. Secondly, it was designed to be approachable and attractive to all genders. One could claim that their design language is in line with the prevailing understanding of the Nordic culture and Nordic design as being close to nature (see Skou and Munch 2016), but it aligns with the idea of gender-neutrality that has long been an important feature of Nordic fashion design, especially since the 1960s and 1970s.

> *It was a really important point actually for us to bring that Nordic feeling into our design language because Suunto is obviously a Nordic brand. I'm fascinated by Nordic design history. I think it carries a lot of the values that we want to see in our product. Nordic design is, like, not overly masculine or feminine. It uses very high-quality materials, it doesn't add too much unnecessary decoration, it's very clean and honest. At the same time, one other aspect we put into the Nordic design values was being gender inclusive. I think the Nordic countries are leading amongst being inclusive for all genders in the world and, so I think this is a point that's very fitting there as well. And, now for Suunto making a smaller scale product that is more inclusive - I feel like that's another Nordic value we are actually communicating. (Designer at Suunto)*

The development process of Suunto's new gender-inclusive sports watch illustrates how technology, but also design, is shaped by social

and economic contexts (Kaygan 2016). Designing and manufacturing a sports watch that is better suited to female users could be seen as a feminist act in the field of design and sports, which have traditionally been focused primarily on athletic men (Osborne and Skillen 2020). Further, when considering the old dichotomy between female and male and feeling and reason, it could be seen as liberating that the device provides full control and agency also to sporting women, enabling them, in principle, to move alone and freely in new environments with the help of the running routes the watch offers. However, the decision to develop a more gender-inclusive product would not have been made if the company's market research had not found potential customers for it. Further, the product that is smaller and therefore more suitable for female customers is in line with the company's other objective which is to make their products more ubiquitous.

Ōura, Moodmetric, and the Design of Unisex Ring

According to Els Rommes (2014), gender-inclusive design has been previously implemented in three ways: 1) Designing based on stereotypes, 2) "I methodology," in which designers take themselves as typical users, or 3) participatory design, in which potential users are directly involved in the design process. All these methods have their downsides. Firstly, gender-specific products based on stereotypes reinforce established gender roles and may turn away some potential customers. Secondly, as most designers are men, their use of "I methodology" may lead to seemingly gender-neutral objects that eventually are more suited for men (Perez 2019). Participatory design methods are most promising in helping to create gender-inclusive products, but only if user researchers pay heed to those participants that are not as accustomed to forming opinions and being heard.

In the field of wearable technology, inclusive design has mostly focused on unisex design. The two wearable smart rings analyzed in this study, Moodmetric (see Figure 2) and Ōura (see Figure 3), provide a further example of this. For both Ōura and Moodmetric, the decision to design a unisex ring was largely an economical one, as the young firms were able to focus on one product at the time. According to the informants, originally Moodmetric's managing team had imagined the primary target group of their stress-measuring ring to be yoga teachers and people interested in mindfulness or meditation. However, after a few years, through the influence of their then-new shareholder, they decided to shift their focus from individual consumers to cooperation with occupational health care and research institutions. Because of this, the Moodmetric ring needed to be as small as possible so that it could be comfortably (in both a material and cultural sense) used in any kind of environment, from the office to while outside exercising. Further, these new target groups entailed the inclusion of all genders, so the ring needed to have a unisex or gender-neutral design.

Figure 2
Moodmetric rings are rounded rectangles which is designer's solution for the challenge for creating a gender-inclusive ring. *Image © Paavo Lehtonen.*

Figure 3
Because in Ōura's ring all the technology is placed inside the ring, the size of the technology parallels directly with size of the whole ring. *Image by ManvsMachine.*

When the initial versions of both the Ōura ring and Moodmetric ring were designed in the 2010s, the designers from both companies considered it to be a challenge to design a unisex ring because of the traditional understandings of in masculine and feminine jewelry. The informant from Ōura explained that since traditionally the use of showy jewelry has been culturally reserved for women, the team gradually ended up aiming to create as discreet a design as possible so that the ring would be appealing to all genders. Also, Moodmetric's original designer explained that the traditional design language for rings favors angular forms for male users, and "softer" round forms for female users. In the designers' understanding, to suit all genders, wearable technology rings needed to be as "neutral" in their design as possible. In this sense, their understanding of inclusivity was more to do with the cultural understanding of gender-appropriate design than any functional features.

> *First there were plans of variations and personalized casings that could suit better for women. Since if you are making something for everyone it will always be a compromise. But in the end, the company only wanted to make one product. However, there still is a possibility to make variations with colors because the shell is 3D-printed. But designing both for men and women is to make as neutral as possible. Not too round for men, not too angular for women. This ring is a rounded rectangle, so it is not very masculine nor very feminine. (Designer at Moodmetric)*

Related to the question of color palette and the gendered cultural coding of colors, Ōura and Moodmetric have implemented various solutions relying on the technologies they use. With Ōura, all the technology is inside the ring, so materials and colors that can be considered neutral and are traditionally associated with rings are used: silver, black, stealth, and gold. In turn, with the Moodmetric ring, the electronic elements are hidden in the 3D-printed casing on top of the ring and separate from the sensors. For the casing, the user can choose from four color options: green, black, gray, and plum. Thus, both use a neutral color palette intended to appeal to both male and female users.

Informants in both companies described similar struggles with developing small enough technology that could be attached to a ring. However, their interpretations of the relation between the size of the ring and their gendered target groups varied because of the different kind of shapes of the ring. As in Ōura's ring the size of technological parts paralleled directly with the size of the whole ring, the company was even considering marketing the ring only for men because of its large size, before the succeeded in making small enough technological parts:

> *Interviewer: Did you consider an option to make a ring only for men?*

Informant: Yes, while developing the Generation 1 version because the ring was so big. So that was because of very concrete reasons. We were struggling to make the technology smaller. But the technology developed and now the ring is more suitable for smaller fingers too. Now in design we should focus more on taste and preferences. (Designer at Ōura)

According to informants, in both companies, the requirement for a small size was also strongly advocated by user research for later versions. This was especially crucial for Ōura since the user was expected to sleep while wearing the ring, which would have been uncomfortable with a very large ring. Thus, the need to develop and design a ring that was as small as possible was not only connected to gender. To conclude, in case of Ōura, user-centered design method did benefit also gender inclusivity of the product even though the need for small size concerned all genders.

Moodmetric's ring, in turn, has a separate gem-like part which has traditionally been considered as feminine kind of jewelry. Referring to the cultural expectations of how large jewelry is traditionally considered to be part of a feminine outfit, Moodmetric's informant admitted to being afraid that men would not be interested in using such a large ring. The designer of the product, too, considered himself wearing the ring awkward to wear as a male because of its large size. Interestingly, informants' fears did not materialize, as the male users did not see any major problems with the size.

The initial version of the Moodmetric ring was designed based on pre-established cultural conceptions of gender and "I methodology." This was not the designers' choice but was determined by a lack of time in the pre-launch design phase. This empirical case emphasizes how gender is often taken to be a static fact in design work, and not as fluid as it is in life (Rommes 2014), resulting in situations in which product designer's stereotyped cultural conceptions of gender do not match with real users' wishes. What is striking in the example from Moodmetric is that even though the designer of the product was male, his own feelings of cultural uncomfortability with the large ring did not match with male users' unproblematic relation to the object. Thus, this example strongly questions "I methodology" in design even in cases when the potential users and the designer would represent same gender.

Myontec Sports Clothing and the Challenge of Diverse Forms of Human Bodies

Myontec is a small enterprise that is intimately familiar with its customers and aims to modify its product versions according to its customers' wishes. Thus, their design is highly user-centered. Their products are used in competitive sports training at the highest level so that the athlete and their trainer can follow the activity and capability of certain muscles

during sports performance. Because of the technologies developed for this purpose, these measurements can be taken in a variety of settings where previously they would have been restricted to a laboratory.

Myontec makes unisex compression sports clothing (see Figure 4). In fashion and streetwear, the concept of unisex clothing has so far been used for many kinds of clothing ranging from clothing that combines features that are considered masculine or feminine to loose, formless clothing with oversized silhouettes (Bardey, Achumba-Wöllenstein, and Chiu 2020). When elastic, second-skin-like materials became more widespread in the 1950s and 1960s, they quickly took their place in women's wardrobes, as the new materials, like Lycra and Nylon, were first used in girdles and stockings. Later, in the 1970s, sports leotards made of Lycra became popular in aerobics, long considered a woman's sport, and because of that stretchy sports clothing was soon classified as a

Figure 4
The differences between female and male bodies but also differences between athletes of different sports form a challenge for the patternmaking of wearable technology clothing. Because of that some items by Myontec are only available as specially ordered and customized. *Image by The Czech Ergonomics Association.*

feminine outfit (O'Connor 2009). Only in the 1990s, through promotion by Nike and other major brands, did a new kind of aerodynamic and stretchable sportswear also become fashionable for men (Quinn 2002, 185–200).

Even though Myontec is more focused on providing a scientific data analysis service than designing attractive sportswear for the masses, fashion has played an important role in the development process of its product. According to the informant working for the company in a management role, the early 2000s transformation of men's sportswear fashion from loose college trousers to elastic and tight clothing helped tremendously in the development of their technology, as the second-skin-like materials made more exact placement of the sensors and wires possible. In this sense, Myontec's history proves the claim by Tomico et al. (2017) that smart clothing must fit into a spectrum of legibility for the wearer. Only after elastic materials became culturally acceptable for men could the technology advance.

Tomico et al. (2017) note that with wearable technology, boundaries between the object of design and the subject of action are blurred, but the "object of design is no longer separated from the subject of the action" (2). In wearable technology clothing, two very different kinds of materials and functions need to be combined: apparel should provide physical comfort and breathability, while electronic systems prioritize stabilizing and protecting the device which requires certain rigidity and flatness. Therefore, the designer needs to understand the conventions of electronic components and how circuits can be formed in textile structures (Watkins and Dunne 2015, 123–158). Especially in sportswear, clothing must be stretchable, and it should not disturb athletes' performance and movement. According to Myontec's clothing designer and pattern maker (who is the same person in this small enterprise), it is not enough that the sensors are well-placed when the user has put the clothes on – they should also remain in place during and after movement so that exact and correct data measurement is possible. Further, the wires that are inside the fabric must be designed in such a way that they do not cross with seams, which also ensures that the clothing is comfortable to use.

Yet, turning the body into an object of digital measurement and research through clothing is not an effortless process. The development process of the products involves a team of professionals with diverse kinds of expertise, from physiology and engineering to clothing design. Especially regarding clothing design, the fleshy, diversified human body is a challenge. In the interview, the designer and pattern maker explained that when designing smart clothing with sensors, the whole pattern design process must be inverted relative to the traditional fashion design process. Since the most important thing in the design process is that the measuring sensors hit the right muscles, the placement of the sensors and wires is the starting point for the whole design. Only after

carefully considering this matter can the pattern maker design the pattern of the garment. In the very last phase, they can begin to think about the look of the garment, which is typically the starting point in traditional fashion design.

> *The lamination technique [to position the sensors] is very restrictive for the pattern and shape of the product. The pattern must be made upon the conditions of lamination, sensors, and wires. There can't be any seams or other things that would impede lamination. So, the design and pattern making starts from the placing of the sensors, and the clothing is built around them. (Designer at Myontec)*

The case of Myontec illustrates how the human body's diversity of shapes and sizes is a significant challenge for the designers of wearable technology clothing. As can be presumed, the differences between female and male bodies also form a challenge, especially regarding shirts. At the moment, Myontec offers three options for their MShirt for the clients, all of them a black color. The shirt that is now in active production comes only with sensors measuring muscles in the arms and shoulders. The version that also has sensors measuring movement in breast muscles must be made separately for women and men, and women's version is only available as a specially ordered and customized product because of the high costs of manufacturing. According to informants, the shirts are more often ordered for male than female athletes since men's sports are more generously funded.

> *Shirt brings new dimension for pattern making since there are so many moving parts more in the upper body than in the lower body. Placing sensors and measuring the pectoral muscles is the hardest thing to do as it is very difficult to place the sensors in a way that they stay in their place during the movement. [...] The fit of the clothing, too, reduces because of the need for many sensors. So, the pattern making for shirts entails lots of challenges. [...] Because of that, the consumer version of the shirt does not include measurement functionality for pectoral muscles but only for arms and shoulders. It would definitely require a different pattern for men and women if pectoral muscles would also be measured. (Designer at Myontec)*

However, requirements related to the customization of the product for different body forms are not solely related to the biological differences of different sexes. Different sports have a strong impact on the human body (Raeve and Vasile 2016). Long-distance runners usually have thin bodies with long leg muscles, whereas ice hockey players have strong and big femur and gluteal muscles. Yet the same pattern should work equally

well with bodies of all shapes. In this sense, designing smart clothing means overcoming human diversity. In practice, Myontec has solved this problem through made-to-measure products once their shorts or shirts have been used by elite athletes in training or for ergonomic testing and research. Based on this example, it does not seem probable that smart sportswear will become products for regular customers in the same way sports watches and data measuring rings have, at least not in the near future, as the technological requirements for the clothing and the diversity of human bodies are difficult to combine in design.

Conclusion

This article discusses how designers and product developers in wearable technology companies understand and implement ideas of inclusive design. The analysis shows that there are three main reasons why these wearable technology companies focus particularly on gender inclusivity. First, the objects they design (rings, wristwatches, and clothing) have a very gendered user history, and the design language around these products has had to overcome the traditional design language. Second, as the use of wearable technology has lately become more widespread among women, the companies have wanted to serve and approach their new user groups with inclusive design. Finally, the Finnish companies analyzed all began as small or micro-sized firms, and because of that, there have been economic reasons for designing products that would appeal to the widest possible range of users.

Even though all the companies have interpreted inclusive design as unisex design, their reasoning for how to implement these ideals in practice has varied. Suunto has modified both the size and the colors of its products and two reasons for this can be identified. First, user feedback of their previous product and the user research in the development phase showed that there was a material and technological need to make the product smaller to better fit smaller (usually female) wrists. Second, the company has wanted to offer a new, culturally unisex color scheme based on Nordic tradition so that the watch would be attractive to all genders. According to informants, the initiative to develop a product that would suit for female users, too, has been based on market-research that has showed a gap in their production, which previously has been focused on male athletes. The case illustrates how thorough user research may lead to developing more inclusive products that also have a consumer market, and that are financially worth making, even though historically, inclusive design has been often framed as an act of goodwill.

For Ōura and Moodmetric, adopting an inclusive design approach has, from a functional point of view, resulted in an attempt to make their rings as small as possible. Because the rings are meant to be worn all the time, they need to be smooth enough to be convenient and comfortable in a variety of everyday situations as well as while sleeping or exercising. In this sense, the diversity of human bodies and material

conditions for use have been central challenges for the companies in their design and development process of their unisex rings. However, the informants at both companies mentioned another reason for designing a small and discreet ring: the designers of the rings suspected that male users would not want to wear a large ring, as the use of large and showy jewelry has previously been regarded as feminine. Thus, the analysis shows that in these companies, the implementation of inclusive design has been very strongly connected to the cultural ideals and norms of gendered accessories. Yet, consumer behavior for these products exemplifies how users do not act upon these gendered, cultural norms. The cases underline the need for an open-minded user-centered design process that does not presume any gender-related user expectations.

Myontec's clothing designer has faced the dilemma of combining inclusivity and human diversity in the same product in most practical ways. User research and testing that are integral parts of their customized design process, has brought out the challenges of inclusive smart clothing. Implementing the inclusive design approach has required very concrete problem-solving related to pattern making and the placement of sensors. Inclusivity has been a challenge, not only from the point of view of differences in biological sex but also from differences in body type resulting from regular engagement in different sports. At the same time, the interrelationship between changes in the cultural conceptions of appropriate clothing for men and changes in sports fashion has paved the way for the technological development of smart sportswear. However, the high costs of production are creating a gender-bias in wearable sporting clothing because men's sports are more generously funded. There is no simple solution that designers and other product developers could take to this problem. Still, the developers of wearable technology should be aware that their products do not repeat the previous mistakes of design history in which 'design for all' in practice means "design for (privileged) men."

The four cases exemplify the practical, economic, and cultural challenges that the designers of wearable technology face. As the examples of Ōura and Suunto demonstrate, market research before starting the development process, user testing while developing the product as well as user research before and after launching the product are essential for the design of wearable technology in which fit with user's body is essential. However, the micro-sized companies are not able to do this in full scale because of economic reasons. Instead, Moodmetric had to mostly rely on user testing among company workers before launching the first version, and on user feedback from their customers while developing the second version. Myontec, in turn, primarily focuses on customized products and therefore uses user testing and research for modifying its product versions according to its customers' wishes. This ensures the contentment of their customers but may impede the growth of the company.

The design of wearable accessories and clothing demands creating fashionable items that still include all the complicated technological

features. However, as the analysis on the informants' views and experiences on the design process show, gender inclusivity, in practice, is not only about finding functional solutions for users with different kinds of propositions. The analysis of designers' experiences on user-centered design process that is informed by the knowledge on user experiences and customer behavior, demonstrate how understanding and respect for the everyday user context, that includes both cultural and material factors, is crucial for the successful product design. At the same time, the analysis on all cases shows how designers' and developers' knowledge and understanding of the cultural factors should be constantly updated as the fixed and possibly stereotyped conceptions of genders may not correspond to users' wishes.

While the empirical results of this paper are limited to the selected companies, the identified challenges are obviously relevant in the field more widely. This study concentrated on Finnish companies in which the need for inclusive design was very much taken for granted, probably because of its influentiality in Nordic design. Future investigation with other companies in other countries would probably both verify and diversify the results.

After these research interviews were conducted, Ōura has launched their co-operation with the Natural Cycles application to offer solution for planning or preventing pregnancy with the help of tracking body temperature, and the company participated the Womens' Health Month campaign in May 2023 through their social media channels delivering information on monthly period, pregnancy, and menopause. Suunto, in turn, has published a story on the thoughts of their leading user, Suunto-athlete Ryan Montgomery, in which he laments that the outdoors still is not a completely safe place for women, LGBTQ communities, racial minorities, or disabled people (Suunto Run blog 2021). While this research has concentrated on gender inclusivity of the objects because of informants' focus on that in their understanding of inclusive design, further research should also expand the focus to diversity in all its forms when analyzing wearables' inclusivity. Furthermore, while the possibilities to increase the inclusivity of wearable technology as objects may be limited, future research should scrutinize the functionalities of both the objects and the applications together in close co-operation with different kinds of users.

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Notes

1. The fact that the first version of Papanek's book *Design for the Real World* (1971) was first published in Swedish (Miljön och miljonerna:

design som tjänst eller förtjänst? 1970) illustrates his close relation with the Nordic designers. (Clarke 2013).

2. In the Introduction, Escobar explains that he continues the groundbreaking work of Victor Papanek in questioning the capitalist ethos of design by criticizing design for exploiting natural resources.
3. The EU and UK define enterprises as micro (less than 10 employees and an annual turnover under €2 million), small (less than 50 employees and an annual turnover under €10 million) and medium-sized (less than 250 employees and an annual turnover under €50 million) businesses. SME definition (europa.eu).
4. In normal circumstances, this research project would have entailed ethnographic observation period at the offices, but because of the Covid-19 situation, access to working places was not possible.

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