
This is an electronic reprint of the original article.
This reprint may differ from the original in pagination and typographic detail.

Särmäkari, Natalia

Digital 3D Fashion Designers: Cases of Atacac and The Fabricant

Published in:

FASHION THEORY: THE JOURNAL OF DRESS BODY AND CULTURE

DOI:

[10.1080/1362704X.2021.1981657](https://doi.org/10.1080/1362704X.2021.1981657)

E-pub ahead of print: 11/10/2021

Document Version

Publisher's PDF, also known as Version of record

Published under the following license:

CC BY-NC-ND

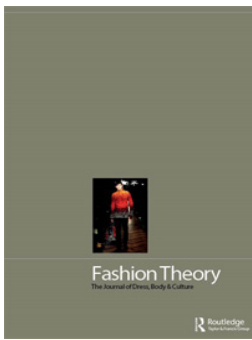
Please cite the original version:

Särmäkari, N. (2021). Digital 3D Fashion Designers: Cases of Atacac and The Fabricant. *FASHION THEORY: THE JOURNAL OF DRESS BODY AND CULTURE*. <https://doi.org/10.1080/1362704X.2021.1981657>

This material is protected by copyright and other intellectual property rights, and duplication or sale of all or part of any of the repository collections is not permitted, except that material may be duplicated by you for your research use or educational purposes in electronic or print form. You must obtain permission for any other use. Electronic or print copies may not be offered, whether for sale or otherwise to anyone who is not an authorised user.

Fashion Theory

The Journal of Dress, Body and Culture



ISSN: (Print) (Online) Journal homepage: <https://www.tandfonline.com/loi/rfft20>

Digital 3D Fashion Designers: Cases of Atacac and The Fabricant

Natalia Särmäkari

To cite this article: Natalia Särmäkari (2021): Digital 3D Fashion Designers: Cases of Atacac and The Fabricant, Fashion Theory, DOI: [10.1080/1362704X.2021.1981657](https://doi.org/10.1080/1362704X.2021.1981657)

To link to this article: <https://doi.org/10.1080/1362704X.2021.1981657>



© 2021 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group.



Published online: 11 Oct 2021.



Submit your article to this journal [↗](#)



View related articles [↗](#)



View Crossmark data [↗](#)

Digital 3D Fashion Designers: Cases of Atacac and The Fabricant

Natalia Särmäkari 

Natalia Särmäkari is a Doctoral Candidate at Aalto University, Finland. Särmäkari's professional background is in fashion design and her research interests concern fashion studies and design research, authorship and professionalism of fashion designers as well as the digitalization and datafication of the field of fashion design.
natalia.sarmakari@aalto.fi

Abstract

The phenomenon of “digital fashion” has been lately addressed in media as the next significant step in the fashion industry. The increasing use of the 3D-software in fashion design processes is part of a wider “fashion 4.0” digitalization process. This article frames the phenomenon of digital fashion and presents an in-depth case study research on two pioneering companies in this area, Atacac and The Fabricant. How and why are they building their fashion design practice on digital 3D-design? How are these companies redefining the fashion design culture and the fashion designer? Drawing from sociology of professions, this article proposes that digital fashion is an emerging subfield within the field of fashion design, differentiating itself from the professional conventions and building new strategies of jurisdiction and legitimation. Driven by *sociotechnical affordances* and *elevation of professional pride* through ethical, conceptual, artistic and skill differentiation, digital fashion designer becomes also a digital artisan. In the increasingly virtual, or “phygital” space and a networked synergetic community of digital fashion, the professional, authorial, bodily and material boundaries of

designers become *fluid*, transforming the traditional figure of fashion designer.

Keywords: digital fashion, figure of fashion designer, fashion 4.0, 3D-technology, professionalism

Introduction

Digitalization has led cultural industries such as film, music and media, toward increasing dematerialization. Digital visualization has evolved because of the needs of the film and gaming industries, providing new possibilities also to the fashion industry that, by its nature, relies heavily on imagery dissemination (Black 2019; Rocamora 2017; Makryniotis 2018). Yet, fashion is fundamentally an embodied practice (Raebild 2015; Entwistle 2000). The contemporary virtual dimensions of fashion are arguably remediated and refashioned, with new digitized practices relationally coexisting with the traditional and material ones (Crewe 2017). Late developments in the area of garment-specific 3D-software have given possibilities to digitalize the traditional fashion design processes and virtualize the fashion imagery, products and spaces (Arribas and Alfaro 2018). Ethical, economical and creative controversies of the fashion industry have shoved new designer generations to search for alternative ways of providing clothing and fashion experiences that waste less resources, turning to experimentation with service models, production methods and technologies (Black 2019; Särämäkari and Vänskä 2020). Some of such designers rely on 3D-technology that enables not only digital prototyping and sampling but also digital-only fashion collections. Among practitioners, consultants and fashion media, these practices are called “digital fashion” (e.g. Milne 2019).

A Dutch fashion startup, *The Fabricant*, came under the spotlight in May 2019 after they auctioned a digital-only Iridescence-dress in Ethereum Summit-blockchain event (New York), for cryptocurrency worth \$9500 (Renwick 2019). As *The Fabricant*’s website shows, this was covered largely by media, from *Vogue* to *Cosmopolitan* and *BBC*, bringing “digital fashion” into the mainstream awareness. The dress was tailored on a photographed body of its owner and journalists were asking whether a dress needs to exist in real life. In their study on *Habbo Hotel*—online game, Lehdonvirta, Wilska, and Johnson (2009, 1075) found that even nonrealistic digital apparel is treated as commodities rather than media surfaces. Therefore, people are willing to pay for artificially scarce virtual goods as “lack of trendy sneakers at school could be compensated with virtual dragons and record players” (Lehdonvirta, Wilska, and Johnson 2009, 1075). Digital “skins”¹ in games have long been familiar to players. Late examples of collaborations between fashion brands and games show that digital fashion might

become an integral part of fashion design practice and business (Yotka 2020; Makryniotis 2018). Recently, digital garments started to interest the major fashion companies also beyond gaming. For example, Tommy Hilfiger is planning to virtualize their design processes and showrooms entirely by 2022 (Milne 2019; McDowell 2019).

Research on digital 3D-fashion design calls for more empirical case studies in the area (e.g. Arribas and Alfaro 2018). The purpose of this article is to frame the phenomenon of “digital fashion” from the perspective of sociology of occupations through an in-depth case study investigation of two pioneering companies—Atacac and The Fabricant. Consisting from primary and secondary research material, this article sheds light on digital(-only) fashion as another layer of fashion design practice, professionalism, authorship, materiality, business and culture. This article contributes to the discussion on the implications of digitalization on the field of fashion design in the context of the “fourth industrial revolution,” or *fashion 4.0*, characterized by fusion of smart technologies that are blurring boundaries between the digital and the physical (Bertola and Teunissen 2018). How and why the presented case studies are building their fashion design practice on digital fashion 4.0 processes? How are these cases redefining the fashion design culture and the professional role of the fashion designer? First, the theoretical foundations of this research are introduced and the field of digital fashion contextualized. Second, the methods are presented and followed by analysis of the cases.

Professional fashion designer and fashion 4.0

This article approaches fashion design as an occupation and an embodied practice, reflecting the traditional *figure of fashion designer* against the digitalized ontology of *fashion 4.0*. The figure of fashion designer refers to an object of sociological investigation, located in a particular sociotechnical discourse and environment (Volonté 2012).

Traditional figure of fashion designer

The foundations of fashion designership were laid over 150 years ago by arguably the first fashion designer, C.F. Worth. However, the figure of fashion designer has since then become highly fragmented and complex due to the technological, societal and cultural changes of the globalized world (Kawamura 2018; Volonté 2012, 400).

Traditionally, an “artist” status of fashion designer is a professional legitimation strategy and stratification element (Steele 2017; Kawamura 2018; Crane 2019; Särämäkari 2020). This is linked to the Modern concept of *art* being above *craft*, and to the Romantic notion of authorship, emerged during industrialization when the *work* and the *artifact* were separated (Shiner 2001; Woodmansee 1994). Dematerialization,

conceptualization and intellectualization of fashion have been evolving since WWII, contrasting the increasing dominance of mass-produced fashion and legitimizing fashion design as a valorized cultural practice (Van de Peer 2014; Clark 2012; Crane 2019; McRobbie 1998). However, design processes are intimately associated with designers' hands-on activities, such as sketching, draping, handling materials and fitting (Raebild 2015). These require a combination of technical and esthetic skills together with temporal sensitivity, creativity, as well as cultural and commercial understanding, juggling between newness and continuity (Bye and Sohn 2010; Vangkilde 2017). Thus, the professional fashion design practice stands on the *embodied tacit knowledge* of the designer as a fleshy human body in action—an assemblage of sensuous, emotional and physical encounters between humans and nonhumans, such as textiles, garments, brands, society and technology (Entwistle 2000; Raebild 2015; Petreca 2017; Vangkilde 2017, 186; D. Atkinson 2017, 149).

The balance between the culture of wearability and the culture of image-making depends on the market level and the educational, production and cultural specificities of certain locations (Renfrew and Renfrew 2009, 78; McRobbie 1998; Volonté 2012). The field-specific value system transforms over time because of the constant struggle between different actors and institutions, negotiating the professional boundaries and legitimacy (Bourdieu 1993, 138; Van de Peer 2014, 446; Volonté 2012, 401). I argue that the contextual embodied knowledge of fashion designer is the professional *jurisdiction*—the link between their occupation and the work itself (Abbott 1988). Designers' authorial, intermediary and institutional recognition construct fashion designers' socio-professional *legitimation* in the field of fashion and among other design fields (Bourdieu 1993; McRobbie 1998; Kawamura 2018). The *figure of fashion designer* is treated in this article as a situated blend of jurisdiction and legitimation.

Fashion 4.0

The figure of fashion designer is essentially affected by technological environments as “fashion itself can be considered as a history of technology” (Quinn 2002, 3). Fashion practice was paradigmatically shaped by the First, Second, Third, and now, the Fourth Industrial Revolution (Bertola and Teunissen 2018). “Fashion 4.0” stands for the new technological and organizational paradigm linked to the loose concept of Industry 4.0 that operates in cyber-physical space and develops toward smart products, production and networks, automation, optimization, flexibility, as well as sustainability-oriented, datafied and customer-driven processes (Bertola and Teunissen 2018). Hermann, Pentek, and Otto (2015) argue that Industry 4.0 is characterized by six design principles—*interoperability, virtualization, decentralization, modularity, service orientation and real-time capability*.

Fashion 4.0 can be placed in the larger context of postindustrial network society where experiences are favored over products, and people are less tied to time and places (Castells 2010). Hunt's (2005) utopian Manifesto for Postindustrial Design states that the heavy mechanical mass production is becoming extinct, together with authoritative, centrally positioned designers. Propelled by distributed intelligence, computer-aided-design (CAD) and ecological realities, postindustrial design relies on the flexibility and evolving nature of code (Hunt 2005). Accordingly, the dynamics within the otherwise conservative fashion industry are slowly liberating from time, place, actor and constellation constraints (Black 2019). Digital platforms and social media have boosted fashion dissemination, immediacy and accessibility, distributing fashion authority to diverse assemblage of participants, blurring boundaries between production and consumption, professionals and amateurs, physical and virtual, material and intangible, as well as object and image (Crewe 2017, 129–130; P. Atkinson 2010).

Until recently, the niche area of “techno fashion” has been dominated by physical garment and material applications, such as smart clothing and digital garment fabrication (Quinn 2002; Braddock Clarke and Harris 2012). The overlapping streams of design-related fashion 4.0 technology focus arguably on (1) new service models, including mass-customization and customized digital production on-demand (e.g. Mattila 2016); (2) smart garments, textiles and IoT systems (e.g. Farren and Hutchison 2004); (3) utilization of AI (e.g. Luce 2019); and (4) digital fashion where 3D-technology is used in design processes, product development, visualization, distribution and marketing (e.g. Black 2019). This article focuses on the fourth area and the ways it shapes fashion designship.

Digital fashion—merging the physical and the virtual

Recently, virtual 3D-fashion, or so-called “digital fashion”, has caught wide media attention, accelerated by the global COVID-19 situation that forced companies to digitize their processes and user experiences (McDowell 2020). Digital 3D-models can be displayed before the products are manufactured, as the car industry has been doing for decades. In this way, the production processes require less labor, material, logistical and time investment, which might also generate novel and arguably more sustainable business models (Black 2019; Volino, Cordier, and Magnenat-Thalmann 2005, 597; Sun, Li, and Wang 2014; Mattila 2016). Proponents of digital-*only* fashion believe that the dematerialized fashion is a way for self-expression and a long-awaited answer to the overproduction and generic offerings of the fashion industry (Milne 2019).

Virtual representations and 3D-design are nothing new in visual effect field, industrial design, architecture, animation and game design, yet, a rather late addition to the fashion designers' two-dimensional

digital toolset (Bye and Sohn 2010, 200; Sun et al. 2014, 1042). The key is the 3D-technology itself, which until recently has served mainly hard surfaced objects, designers with engineering mindsets and pattern-makers (Volino et al. 2005, 597; Sun et al. 2014; Mattila 2016, 1–2; Sun and Zhao 2018, 369). Lately, computation speed and algorithmic methods have enabled better soft material simulation techniques, real-time garment animation, interactive design systems as well as hyper-realistic digital 3D draping, resulting in increasingly popular virtual draping software developed *with* and *for* fashion designers (Volino et al. 2005, 593–594; Mattila 2016, 1; Arribas and Alfaro 2018; Makryniotis 2018, 101–102; Jhanji 2018). Software such as Browzwear and CLO3D, simulate the behavior of the garment on a moving avatar, merging patternmaking, imagery production and fashion design (Spahiu et al. 2014; Mattila 2016; Makryniotis 2018; Black 2019). The term “digital fashion” is used by the media and practitioners to refer to a *processual tool* for virtual product development and visualization; *marketing or educational tool* for online stores and virtual museums; and *digital-only end-product* for virtual use. 3D-file as a container of all the garment and material data that can be used in various platforms.

Digital 3D fashion design has been studied in academia mainly from design research perspective looking into new processual, operational, technical and economic aspects (e.g. Volino et al. 2005; Bye and Sohn 2010; Arribas and Alfaro 2018). Before the late phenomenon of digital fashion, Jane Harris has experimented with the 3D computer graphic imaging (CGI) in fashion and textile design, seeing it substantially informed by the tacit knowledge, analogue craft skills and vocabulary of designers (Harris 2005; Braddock Clarke and Harris 2012). Several scholars have explored the possibilities of digital 3D-fashion for sustainability and inclusivity, for example, localization of garment production (Mattila 2016), design for disabilities (Kaiser et al. 2014), realistic 3D-design for on-demand model (Black 2019) and zero-waste design (McQuillan 2020). Digital 3D-fashion design is also addressed in research on producing virtual fashion experiences, such as tactility of digital textiles (Petreca 2017), virtual fitting (e.g. Baytar and Ashdown 2015) and design for social games (Makryniotis 2018).

The earliest commercial examples of digital fashion are arguably Atacac (2016–), Neuro Studio (2016?), Carlings’s digital-only collection (2017–), The Fabricant (2018–) and DIGI-GXL-community of freelancing womxn, intersex, trans and non-binary designers (2018–). The gaming world has embraced digital apparel considerably earlier. Makryniotis (2018) argues that in-game-purchase-based online gaming (e.g. Fortnite) has bridged the gap between character and fashion design. In styling games, such as Drest, any companies can show, test, collect data, optimize and sell their products. Virtual reality (VR) spaces, such as Second Life and Sansar, are marketplaces for amateur designs and brand stores of digital-only clothing. In games and VR, the avatars

range from hyper-realistic to surreal. Because the VR representations of bodies, gender, sexuality and beauty ideals are typically narrow and conservative, the key figures behind the ethos of digital fashion, such as Cattytay—a digital designer, influencer, founder of DIGI-GXL and co-founder of The Institute of Digital Fashion²—advocate for diversity, inclusivity and queering practices to ensure the space in the “metaverse” (three-dimensional virtual space) for the voices that are underrepresented and marginalized in the traditional fashion world and, especially, digital culture.

Many new brands, such as Tribute Brand (2020–), started to tailor digital-only 3D-garments on photographed bodies as “phygital” AR-experiences that blur the distinction between the “real” and the “simulated”, mixing physical and digital worlds (Gaggioli 2017, 774). During 2020–2021, digital fashion has mainstreamed, numbers of digital fashion designers increased and stores have appeared.³ Zooming into the actual digital fashion design practices is essential to understand transformations in the figure of fashion designer.

Methods

This article investigates two pioneering cases of digital fashion, Atacac and The Fabricant. A qualitative case study strategy helps to understand the “how” and “why” behind the unexplored complexity of two contemporary practices in real-world settings and to construct new knowledge through personal interpretation of the data (Yin 2018, 2–4; Stake 1995, 37). I approached the companies via e-mail, introducing myself as a researcher with fashion design background and explaining the goals of the research project. I also met the founder and designer of Atacac in a 3D-fashion seminar that I assisted in organizing at Aalto University in 2018. I heard about The Fabricant during my fieldwork at Atacac studio in Gothenburg (Sweden). The Fabricant was mentioned as Atacac’s closest “partner in crime.” I contacted the already hyped company later in 2019 and, luckily, was welcomed to visit their studio in Amsterdam (The Netherlands) later the same year.

This empirical study focuses predominantly on their reflections about and content of their actual work (Abbott 1988, 19). The primary ethnographic research material was collected through semi-structured interviews, conversations and observation. I personally experienced the field (Moon 2016, 67) and spent 3 days at Atacac (March 6–8, 2019), and 2 days at The Fabricant (November 19–20, 2019). I took notes and photographs during their work, meetings, discussions and workshops to capture the aspects that cannot be expressed explicitly and verbally (Atkinson and Hammersley 1994). I later turned fieldnotes, taken by hand and on computer, into reports as Word-files. I interviewed 7 out of 8 Atacac workers and 4 out of 5 The Fabricant workers, focusing on certain themes and topics. I sound-recorded and transcribed the

interviews, the length of which varied from 15 min to 3 h. Additionally, I collected, compiled in text files and analyzed a vast amount of case-related media articles, talks, videos, podcasts, websites, reports and social media content of the companies. I applied a reflexive thematic analysis method to generate themes using my creativity, subjectivity and reflexivity as a resource for positioned, context-bound and situated meaning-making (Braun and Clarke 2019). After exploring the cases in their physical locations and everyday activities, and an immersive familiarization with the data, I executed an organic and iterative coding process in dialogue with evolving themes and theoretical assumptions (Braun and Clarke 2019). I utilized Atlas.ti-software in the coding stage.

Cases: Atacac and The Fabricant

Atacac

Atacac is a small Swedish fashion company, founded in 2016 by a fashion designer-researcher Rickard Lindqvist and a digital creative Jimmy Herdberg. At the time of my fieldwork, the company consisted of nine people. One intern, Tom Robertson, was concentrating on the communication and garment representation side whereas another intern, Wilma Kuipers, was working on the Sharewear⁴ platform and patterns, focusing on the processual dimensions of digital fashion design. Cristian Alvarez Mergas, having fashion design background and tech-savviness, digitized the physical fabrics and performed other technical tasks. The project manager, Anna Lebar, made sure that everything works; the patternmaker, Amandine Roudaut, prepared the patterns for production; and two micro-factory tailors, with origins from Syria, made the garments.

Rickard's design and research work are deeply rooted in his original background as a tailor and patternmaker. Atacac is committed to serve the physical human body building on the *kinetic garment construction theory* which Rickard developed during his PhD research. The theory proposes an alternative pattern-cutting paradigm based on balance directions, key biomechanical and a particular draping method that challenge the "static matrix of a non-moving body" and the "fundamental relationship between dress, garment construction, and the body, working from the body outward" (Lindqvist 2015, 348). When Rickard and Jimmy tested CLO3D-software, they saw immediately business and artistic possibilities in its utilization in relation to Lindqvist's theory. Combining virtual and physical worlds, Rickard starts designing with CLO3D from the pattern. Atacac also created a reverse process where sales happen predominantly before the production, and the garments are presented virtually before sampling. The preordered garments are produced mostly on-demand in their in-house micro-factory. Atacac uses a flight ticket logic in pricing: the earlier the garment is purchased, the

less it costs, thus, the inventory is the most expensive and remains minimal. This also allows microtrend forecasting, informing designers which products should be evolved further. Rickard highlights the importance of physical prototyping and fittings, materiality, and preservation of the physical garment construction craft. However, Atacac has expanded their action space in VR and the gaming world. Inspired by the wealthy e-sports studio from the neighborhood, Lindqvist anticipated that in the future, the fashion businesses could make profit from e-clothes instead of perfumes and designer bags and that digital fashion can be closer to imaginative and unique haute couture (Figures 1 and 2).

The Fabricant

According to their webpage, The Fabricant is positioned at the intersection between fashion and technology, being the first “Digital Fashion House” that makes *digital-only* clothing, “wastes nothing but data and exploits nothing but imagination.” They talk about a new order of human existence, enabled and normalized by technologies, such as social media and games. The Fabricant wants to revolutionize the mindset of the fashion world and the idea of fashion as a *material* practice and reduce the environmental impact by eliminating the manufacturing. The startup comprised 5 people at the time of my fieldwork in November 2019 (and almost six-times this amount in September 2021!). The Fabricant was founded at the beginning of 2018 by Kerry Murphy, a filmmaker and visual effect specialist who has worked also in advertising. Shortly after, The Fabricant’s co-founder and creative director Amber Jae Slooten joined the company. Amber was the first fashion design student to produce an entirely digital-only graduation collection at AMFI (Amsterdam Fashion Institute) where she later taught digital 3D fashion design, inspiring new designers (such as Atacac’s interns). The Fabricant’s creative producer, Marlous Custers, plays an essential role in company operations and creative processes as she manages the practical side of everyone’s work as well as the large network of clients and freelancers. Another co-founder, Andrea Hoppenbrouwer, has solid corporate experience and is responsible for commercial direction. Bram Siebers was a newly hired 3D product expert with technical fashion production background. Their blog content and a range of slogans are generated by a freelance writer Mickey Larosse. The later increase of their workforce shows that the company has grown very fast since 2019.

The design process at The Fabricant starts from the concept or brief of a client, and a storyboard. The garment design process begins from draping on an avatar or, in case of a client project, from visualization based on provided tech-packs, flat drawings and photos or examination of physical garments. The digital garment, the story and the digital experience are the *end-products*, merging fashion design and animated film. The Fabricant wishes to start selling increasingly their own designs and create a digital-only fashion industry. For The Fabricant, digital

Figure 1

Rickard Lindqvist working simultaneously on a computer screen (modifying pattern in CLO) and a human-sized screen (visualization of the garment). Photo: author.



fashion is a space for dreaming, free from the constraints of the physical reality and providing anyone “the entire fashion industry on their hard drive” (Larosse 2019). The Fabricant is developing a fashion platform called Leela that they hope to be their main business in the future. The beta version was tested during 2020 and is intended for sharing, showing and selling both their own designs and digital garments of other companies. The users will have their personal avatars that can wear the garments in the platform (Figures 3 and 4).



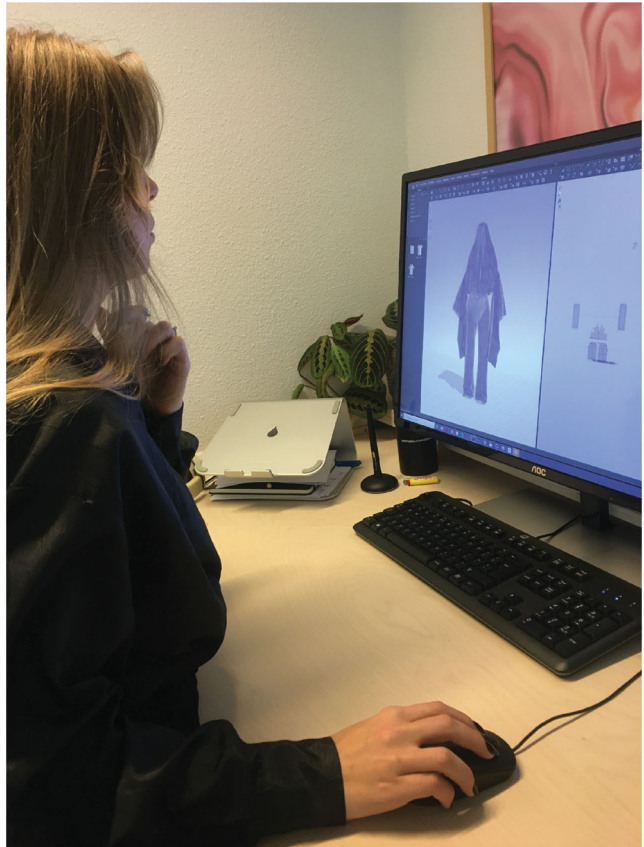
Figure 2
The micro-factory of Atacac in an industrial area near the center of Gothenburg. Photo: author.

Findings

The phenomenon of digital fashion occurs in the context of fashion 4.0, and although the practices operate on the fringes of the industry and take distance from the industrial manufacturing, they arguably entail the aforementioned six design principles of Industry 4.0—interoperability, virtualization, decentralization, real-time capability, service orientation and modularity (Hermann et al. 2015; Bertola and Teunissen 2018).

Figure 3

The Fabricant's creative director Amber Jae Slooten draping directly on an avatar.
Photo: author.



The analysis of the research material resulted in three main themes and several subthemes that concern fashion designship. To answer *how* the case studies are building their fashion design practice on digital 3D-design, a theme of *sociotechnical affordances* (cf. Davis and Chouinard 2016) unfolds the technology, processes and end-products of digital fashion practice. The *why* behind such practices are recognized in the theme called *elevation of professional pride* which regards several differentiation strategies and disruption of the status quo. Finally, the question on how these companies are redefining the fashion design culture and the fashion designer, a theme of *fluid boundaries of fashion culture and fashion designer 4.0* examines the findings through the six principles of Industry 4.0 and outlines further characteristics identified in the practice of digital fashion.



Figure 4

The producer of The Fabricant talking virtually to a client in their spacious studio, shared with another company and located in the center of Amsterdam. Photo: author.

Sociotechnical affordances

This theme unravels the internal and external professional disturbances (Abbott 1988, 215) such as software, workflows, operational models, new skills, and the evolving tacit knowledge, as well as the dimensions of digital 3D-fashion stretching from the function of being a tool to

create physical garments to a virtual fashion culture of digital-only end-products for humans, avatars or cyborgs.

Technology

After testing other similar software, both fashion designers of Atacac and The Fabricant chose CLO3D due to its intuitive interface, appealing visual representation, *interoperability* with other software and compatibility with their skills. In fact, the software inspired Atacac to start their business:

When we came across this 3D solution with this software [...] we realized that now [in 2016] the digital 3D tools are advanced on such a level that it's possible to do a lot of those experimentations [kinetic garment theory and draping] digitally to a large part, which was not possible when I started the research project six years earlier. (Rickard)

The Fabricant's Amber has a traditional fashion school background that taught how to cut, design, sew and drape: "I was always in my room with piles of fabrics and pen and pattern paper and sewing outfits for my design classes." Amber had her first encounter with a 3D-software (Lectra) during her studies at AMFI, when she realized the potential of digital 3D-tools. Amber took a semester off from school to explore 3D-programs, ending up with CLO3D which could be seen to entail the *sociotechnical affordances*, that take the existing fashion designer skillset and operational ecosystem into account, pushing and encouraging its users toward new actions, workflows, product-types and ultimately, culture of work (Davis and Chouinard 2016). Generally, *affordance* refers to a "range of functions and constraints that an object provides for, and places upon, structurally situated subjects" (Davis and Chouinard 2016, 241). The social acceptance of CLO3D among peers and accessibility for fashion designers without earlier 3D-modeling competence nudges the designers to learn digital fashion design. Both cases found that the visual quality of the digital garments also increases the appeal of digital garments from the perspective of the audience. Furthermore, the development of efficient and affordable hardware has enabled such 3D-software to be accessible to amateurs, laypeople and students. As Bram from The Fabricant recalled: "[...] I saw how good the product looks like in digital, and then I quit my job, started freelancing and studied CLO for like one year now and, uh, yeah, and I'm here." While it is relatively easy to learn CLO, true mastery requires extensive practice. As all the case designers pointed out, physical training and knowledge in garment construction help to adopt digital workflow and create hyper-realistic digital garments. Concurrently, the software educates the less experienced users how a garment is constructed, and different materials behave.

In addition to CLO3D, both companies use a range of other software, such as Adobe Photoshop and Illustrator, and (free) open-source 3D-rendering software Blender. Atacac also uses an inexpensive Chinese software Bok for pattern development and grading. The Fabricant does not invest in pattern-development. Instead they use film-specific software such as Cinema 4D, Houdini and After Effects. The primary hardware that both cases use are computers. Additionally, Atacac's micro-factory is equipped with a rather traditional machinery, purchased from closing down Swedish tailors. The only digital production hardware in their plans is an automatic CNC cutting machine.

Processes

Digital fashion transforms the fashion design process for both physical and virtual practices. In physical practices, it enables instant preorder data in a Design/Sell/Make-model, contrasting the traditional Design/Make/Sell-model where designers are guessing and dictating the future demand (Black 2019, 113–132). Digital fabrics, patterns and assets hypothetically reduce the physical traffic between the supplier and the designer. Designers can visualize their work, fit on digital models (of any size and shape) and make decisions immediately, without waiting for samples. Abandoning the traditional bulk-based business model requires a flexible infrastructure and modular production system in order to provide affordable customized on-demand garments—and stay in business. Atacac relies on 3D-technology and in-house micro-factory to shorten lead times from typical 6–18 months to three weeks. Atacac describes their model as “design-present-sell-produce” including the essential element of fashion as not only a commodity but also a visual culture (“present”). For The Fabricant the “producing” part is virtual as they craft highly detailed digital-only garments and animated fashion experiences. The Fabricant wants to bring their design process from six weeks to five days by automating workflows from the creation of digital bodies and motion libraries to rendering and environment simulation.

The design processes, defined by contexts, collaborators, outcome and professional backgrounds, are seemingly more pattern-driven when the garments are meant to become physical, and more image-driven as a visualization method or in cases when the garments remain digital-only. At Atacac, the 3D-file of a garment takes two directions from Rickard's table: pattern (Amandine) and image development (Jimmy's team). While digital prototyping saves time and money, Rickard still finds important to fit the prototypes physically, entailing materiality, haptic handling and thinking through designer's own body (Raebild 2015; D. Atkinson 2017, 149). Designers of The Fabricant translate their material and embodied knowledge into digital-only form (cf. Harris 2005, 24; Santos, Montagna, and Neto 2020). Amber showed me on the computer how she starts the process of “sculpting on the body.” She chose a light silk chiffon that falls lightly on the avatar's body. The simulation made

me feel the goosebumps from chiffon falling on the body. Seemingly, the element of motion makes the digital garment behavior relatable. As in traditional fashion design, digital fashion designers design something new but also something familiar (cf. Raebild 2015). The Fabricant wants to question bodily constraints whereas Atacac places the fleshy body at the center of their design process. Both companies emphasize that 3D-design affords a quick and intuitive experimentation:

I always work with concepts, so it's always like concepts that underlie the feeling that I have, and this feeling is translated into images. Then those images translated into kind of the feeling that I need for designing. [...] Then I just throw it on the doll and start working and sometimes it ends up being completely different from what I intended. But I like that as well because it's so free. And I save like 10 different versions of the same thing. Just to be able to go back to the original. And the thing is: in digital, when you cut, you can always click control-z. [...] It's super playful. Well, you also have to say no sometimes just to stop because it's also never finished. (Amber)

Amber's design process resembles the traditional draping, but without piles of fabrics, prototypes, failed toile tests and nights spent on sewing. The fabric library of CLO3D contains a large selection of materials that can be twisted with own scanned textures and prints. Atacac enriches this library with chosen physical fabrics that they digitize using CLO3D Fabric Kit.

End-products

Digital garments are more than just designs – they are *artifacts* in digital form. The garments can be palimpsests: multilayered objects that different creators can build on. Both Atacac and The Fabricant share their digital garment files and invite everyone to modify the designs. However, designers of these two companies have rather different tasks: Atacac's end-goal are both physical and virtual garments whereas The Fabricant aims at digital-only garments. For Atacac, virtual garments are *representing* mainly the physical garments while The Fabricant's designs *simulate* the reality with “small links” to physical clothes such as labels, yet, taking distance from and pushing the boundaries of the reality, creating surreal experiences. The Fabricant's end-products are also stories, concepts and short animated movies.

Before The Fabricant, Amber designed an installation showing her future vision of fashion where people wear simple everyday outfits whereas the *expression layer* is projected on the body as a hologram. Amber's idea was to literally divide the protection and expression functions of clothing (cf. Kawamura 2018). Digital-only fashion tackles the expression function, already virtualized by the social media. The

Fabricant suggests that virtual clothes could satisfy the needs for sartorial self-expression, echoing Baudrillard's (1994, 8) concept of postmodern "society of simulation" where cultural modes of representation simulate reality in media, cyberspace, and virtual reality, and identities are constructed by the appropriation of images instead of tangible objects. Atacac has similar views and finds virtual worlds as new creative spaces for professional and nonprofessional fashion designers to create imaginative rather than everyday outfits.

Elevation of professional pride

The controversial status quo of the fashion industry in combination with the appreciation toward fashion as a culture and craft inspired both cases to reposition fashion design practice within the interdependent system of professions (Abbott 1988, 86). The founders had experienced overall frustration in their respective fields earlier. For example, before The Fabricant, Amber did not want to work in the fashion industry because she was afraid to be drawn by the flow. Instead, she supported herself partly by restaurant work and, in this way, maintained her artistic integrity (cf. McRobbie 1998). Atacac and The Fabricant could be seen as "architects of digital fashion" (Wilcox 2019), building the whole culture, visual language, rules and operational models from scratch, which is an advantage and a challenge at the same time. Uncertainty is tackled through learning from each other and collaborators. Failure is accepted as part of their startup-minded activity.

A second leading theme demonstrating the reasons behind the digital fashion practices is related to professionalization. Even though the cases contest exclusivity and protection of professional jurisdiction, they do explicitly and implicitly pursue *elevation of professional pride* through *ethical, artistic, intellectual and skill differentiation* in the field of fashion.

Ethical differentiation

Although this article does not evaluate ethical responsibility of digital fashion, my study shows that both cases consider digital fashion as a more sustainable and inclusive approach to fashion practice and use *ethical differentiation* from the traditional fashion industry as a professional legitimization strategy. The Fabricant eliminates all the physical production, whereas Atacac minimizes the material, logistic and overall production impact. Both companies want to transform the prevalent fashion field through talks, consulting and serving as an example.

Besides environmental aspects, Atacac and The Fabricant accentuate the social freedom that the virtual sartorial world might offer. For Amber, digital fashion is an "open space for people to be themselves" and she wants to design for bodies outside the limits of beauty and size standards, gender norms, ability, wealth and dressing conventions.

Despite the aspirations of the cases and other digital fashion influencers, including Cattyay, digital fashion is not entirely liberated from the pressures on “fashioned bodies to conform and perform to socially defined standards” (D. Atkinson 2017, 159; Boler 2007). The virtual fashion imagery tends to mirror the narrow norms and ideals of the physical reality. Therefore, it is yet to achieve the state of an “open space” for everyone.

Another form of inclusivity that Atacac and The Fabricant wish to tackle is the one of skills. Traditional fashion education is exclusive and often expensive. The cases highlight accessibility of digital fashion design practice to anyone with a laptop, internet connection and 3D-software license. They share willingly their knowledge among the online communities. Nonetheless, such inclusivity has its limits as well: digital devices, licenses and their adoption require financial resources, suitable infrastructure, time to learn and play with the software, and, presumably, digital nativeness. Furthermore, as both cases show, the physical tacit knowledge of a traditional fashion designer and patternmaker, combined with the skills of a digital designer and visual effects specialist, contribute to the digital craftsmanship and storytelling abilities. Such tacit knowledge is acquired through education or hobbies.

The cases find 3D-fashion design also as a pathway to improve the position of professional fashion designers. Technologizing and expanding fashion design profession might offer a thicker paycheck than the traditional fashion field that carries a high risk of self-exploitation, and where the socio-economic privilege reaches only a fraction of designers (McRobbie 1998). The cases pursue sustainability of work and togetherness on many levels. As Kerry reflects: “I want to wake up every single morning and look forward to coming here, to meet all the people that are my colleagues as well as friends.” At Atacac, leisure activities and families were integral part of daily conversations; long hours were not encouraged; and niceness was a default.

Artistic and intellectual differentiation

The driving force behind both cases is frustration toward the conservative fashion world: the outdated processes, authoritative designership, conventional fashion spaces and static physicality of the object. Such thoughts resemble the foundations of conceptual fashion and open-source philosophy (cf. Clark 2012; Särmäkari and Vänskä 2020). Conceptual art arose from the disappointment toward human civilization by questioning the principles of artmaking, the artist, the predominance of the visual, the galleries, commodification, as well as the permanent art object, resulting in new temporal and performative art forms (Clark 2012, 67–68). Later, conceptual fashion designers contested the foundations of the fashion culture in a similar way (Clark 2012, 74). A narrativization and intellectualization of fashion worlds (Van de Peer 2014) continues in digital fashion settings where even film-

style storylines become part of fashion designer's work. Furthermore, digital fashion may be paralleled with the post-digital art discourse that debates on the human existence, embodiment and authorship in the networked digital age, yet, focuses on specific media and materialities in the screen-dominated data-world (Paul 2017; Kholeif 2018).

The Fabricant draws concepts from the societal questions and zeitgeist in a critical manner and talks about designing fashion experiences, not just artifacts. Likewise, Atacac subverts the fundamentals of fashion-making: as Rickard said, their primary motivation is to find "more intelligent ways of doing." Possibly due to Rickard's academic background, they pursue a fashion practice where new work is "standing on the shoulders of giants" and works are open for use if the original author is referenced. For The Fabricant, doing fashion is a form of research – as Amber describes their conceptual process, "[...] it's kind of a mood-board, but it's also a research paper." Furthermore, Amber found experimenting with non-textile materials, non-human bodies, AI-generated design process, and surreal environments more rewarding than working with physical realm.

Intellectualization and artification of fashion practice have a similar legitimation role as abstract academic knowledge that traces the foundations of professional work to major cultural values (Abbott 1988, 54; Crane 2019). For both cases, the excessive and exclusive fashion culture no longer fits the reality 21st century, therefore, differentiation happens through the concept, process, and creativity.

Skill differentiation

While fashion artists-designers even hide their sewing skills (McRobbie 1998), digital fashion valorizes the technical and patternmaking skills. Digital fashion designer is also a maker. Atacac builds on their patternmaking mastery, whereas The Fabricant highlights that they are a digital fashion house, practicing digital craftsmanship far from the "gamey" esthetics. Both companies are based on a union between professionals with fashion design and digital skills, yet, the tasks are rather divided, and the fashion designers are primarily responsible for the garments. Fashion designers are thus taking over the jurisdiction of garment 3D-design processes and visualization, vacating a number of jurisdictions central in fashion designers' work: the time-consuming 2D-drawings, instructions, and sampling.

In addition to technical, digital and fashion skills, digital fashion practices require advanced organizational and communication skills due to the fragmented teamwork and global collaboration. Therefore, the role of producer/product manager is central in managing workflows, collaborations, communication with clients and freelancers, recruitment, budgeting and scheduling. Communication skills are equally important for the digital fashion designer: e.g. Amber briefs and communicates daily with globally located 3D-designers, environment designers, sound

designers and other freelancers, recruited on the basis of their special skills and particular project needs. In comparison to the traditional fashion design, the nature of teamwork expands dramatically and calls for the empathic skill to “read people” worldwide.

Fluid boundaries of fashion culture and fashion designer 4.0

The most frequent code that appeared during the analysis of the research material was “open-source philosophy” which refers to a mindset and design approach stemming from digital culture that cherishes transparency, co-design, modifiability of products, rapid and DIY on-demand making as well as overall togetherness (Särämäkari and Vänskä 2020, 2420). I argue that such mindset is mainstreaming and results in fluid boundaries of fashion culture and fashion designer 4.0, which are not limited to the social, processual and professional boundaries but also material and bodily boundaries. In the six principles of industry 4.0 (Hermann et al. 2015), I find the elements of open-source philosophy and the fluidity between the physical and the virtual worlds, products and processes, as well as slowness and immediacy tied to evolving professional jurisdiction. Interoperability is important between different software as well as different professionals, nonprofessionals and cultures. Virtualization transmits the designer to phygitality and digital craftsmanship, turning the designer-artist into a digital artisan, designer-maker and designer-communicator. Virtualization of garments quantifies the artifact and datifies the human body, behavior and action space. Open-source philosophy, community-based legitimation and using extensive networks as well as blockchain technology comprise the decentralization elements. Real-time capability appears in the immediacy of visualization, testing, sampling and selling as well as in quick reaction data and short lead times. Service orientation underlies the prioritization of processes over products, and services as source of revenue. Modularity is essential in customization, co-creation, and overall flexibility of processes.

Fluid professional and authorial boundaries

Abbott argues that the clarity with which professional borders are defined toward other professions (or other players in the field) may affect the jurisdictions’ vulnerability (Abbott 1988, 56). In digital fashion, the designer’s role is fluid and deeply contextual. The assemblages of the professional backgrounds, hobbies, experiences and technologies form what these two companies are and how they work.

[...] I used to play hours and hours of Sims, just dressing the dolls. Because I love the fact that I could, you know, download

things and hack the software to create like green skin or things like that. (Amber)

Both companies combine own product development with *service orientation* Atacac and The Fabricant finance their artistic work with revenue from varying client projects, consulting and, in case of Atacac, micro-manufacturing income. The cases work in networks of small businesses, freelancers and big companies within and beyond the fashion world. Interdisciplinary collaboration happens also locally among studio members and with neighbors. The relationship between digital fashion designers and patternmakers or manufacturing is more intimate, even symbiotic (Sun and Zhao 2018, 368–369).

Professional and authorial boundaries are contested by the open-source attitude of both cases who find the secrecy of the fashion industry irrational because it is easy to copy a garment. By sharing their designs and files they want to ensure decent copies, modifications and customer engagement. As Jimmy reflects: “[...] if someone downloads our pattern and makes their own garment, they are spending so much time with our brand, learn everything about how it’s done, then they post it in the social media, talk about it, share links to us. The value of that is so much more than selling a piece.” In contrast to the specialized and unattainable technologies of earlier industrial phases, the contemporary technologies might reduce dependence on professional design and production (P. Atkinson 2010). Customers have also indirect impact on designs by clicking and preordering garments. Data-driven product evolution happens iteratively and rather effortlessly because the file can be opened and modified. Frequent “drops” generate instant feedback and enable bold testing. Furthermore, the evolution of the product can be tokenized, traced and authenticated with blockchain technology, making digital garments collectible, unique artifacts (cf. Crane 2019) that are called non-fungible tokens (NFTs) (Hernandez, Vogelsteller, and Sieler 2019). Hence, the design and artifact are converged, while authorship can be prescribed to all the *designer-makers* of the artifact.

The digital-only design process potentially turns the experience of the fashion design increasingly into what Hayles (2012) calls “technogenesis” where humans think through, with and alongside digital media. When the products, wearers and environments are partly or entirely virtual, the garments are *mediatized* to work in virtual spaces (Rocamora 2017). Furthermore, Douglas Atkinson (2017, 152) argues that contemporary fashion designers are estranged from the craft and manufacturing processes, therefore, digital 3D-design might be their only way to mediate design “in a world of limited resources but great computational power.” In technogenesis, digital fashion designers design also *for* fluid identities, or cyborgs that are dynamic, co-evolving, heterogeneous and historically situated assemblages of humans and non-humans, the real and the virtual bodies, established through relational

encounters and forming phygital, digital-material existence (Haraway 1997; Gaggioli 2017; Pink, Lingard, and Harley 2017; Makryniotis 2018). In digital-only fashion, instead of manipulating Instagram-bodies or pursuing muscular corsets (Steele 2003, 143), bodies do not have physical constraints, though, it is difficult to escape the social fabric of body stereotypes (Boler 2007). Always intrigued with the possibility to shift identities, Amber thinks that the “virtual layer of expression” and “thought couture” extend the spirit, body, dress and embodiment (or disembodiment as a new digital Cartesianism?, Boler 2007) of humans who can wear durable slow fashion in the physical lives. In such situation, the gap between the artist-designer and the designer of functional everyday commodities might grow wider. If the tasks and the jurisdiction become significantly different, will this create two separate occupations, and if so, with what kind of other occupations would these fields merge?

Legitimation of digital fashion by communities and the fashion world

Digital fashion reveals the social meanings that we give to objects, artifacts, spaces and garments. Even though non-tokenized digital garment might be copy-pastable, the context counts: who the garment is bought from, what it represents, and on which platform it is sold, given, won or worn. White t-shirt by Balenciaga has different meaning than the one by Target: the process, designer or brand myth makes the t-shirt desirable (Kawamura 2018; Crane 2019). Instead of only the professional fashion world, digital fashion practices rely on and are largely legitimized by their globally dispersed communities, grown by sharing files and knowledge. According to Atacac’s Jimmy, the function of a brand turns from a specialized provider of products into a community and a design method because “[...] almost anyone can produce anything, there is an online service somewhere where you can order whatever you want.” Both companies believe that community is the key to building the future revenue, however, the dominant fashion world has also gradually granted acceptance, as the digital fashion practices are suddenly appearing in the trend reports, fashion media and are approached by major fashion companies and institutions. For The Fabricant, the success came as a surprise because the initial reception of the fashion world was suspicious—sometimes even hostile—yet curious. They were told that fashion will never be digital because of the lack of tactility. At the beginning the founders found confidence from each other and fellow digital fashion practitioners. Today, they feel that the leap of faith was worthwhile, and digital fashion is better understood because of the media coverage, gaming world and social media filters. Both case studies firmly believe that *digital fashion designer* will be a career for many. They might be hired by fashion houses or games, or might start a fashion brand selling virtual garments and, sometimes, physical collections.

However, Rickard compares the emerging fashion practice to the digitalized music industry in which it is easy to enter but difficult to stand out.

Conclusions

This article analyzed two cases studies, Atacac and The Fabricant, to shed light on how the fashion subfield of digital 3D fashion design shapes the figure of fashion designers. Both companies rely on open-source philosophy and decentralized community-based legitimation, typical for the digital age. Both differentiate themselves from the traditional fashion world through their discourse, working culture, processes and outcome. They add technological expertise, dynamic collaborative interoperability to the traditional fashion designer skillset, filling the vacant jurisdiction of fashion design as a digital culture and craft where designer becomes a *digital artisan* with artistic independence. As Abbott (1988, 3) argues, “[p]rofessions develop when jurisdictions become vacant, which may happen because they are newly created or because an earlier tenant has left them altogether or lost its firm grip on them.” Technological disturbances and general shifts in culturally accepted values can shake the system of professions dramatically (Abbott 1988, 57). I argue that the socio-technical affordances and the value shift toward flatter, open, fluid and interactive network structures in precarious fashion 4.0 are expanding, liquifying and multiplying the professional figure of fashion designer.

The cases differ from each other in terms of their relationship to physical dimension, professional assemblages and end-products. According to The Fabricant, digital-only fashion has encountered criticism mostly regarding the lack of emotional and embodied attachment that designers and wearers have with physical garments: “the tactile experience of running your fingers over a satin dress” (Semic 2019). To what extent digital-only clothing could become affective enough to induce large-scale consumption? Increasing digital competencies in fashion design education might decrease the haptic, material and embodied knowledge of fashion designers (D. Atkinson 2017, 149–150). How the technological mediation of materials would change the relationships to and the knowledge of the material? Does digital fashion enforce fantasies about disembodiment and predominance of the mind? (Boyer 2007). Does cyberworld continue to maintain, reproduce and even fortify the old social and body stereotypes instead of shattering and queering them—something that fashion has always done to some extent? (Vänskä 2014). Many questions ought to be answered in the face of mainstreamization of digital fashion.

Late hype around the blockchain-authenticated digital collectibles NFTs has raised interest toward digital fashion among the biggest players, who rely on evidence-based reasons to transform their operational models. Simultaneously, there is an increasing number of freelancing

professional and amateur digital fashion designers. The non-tokenized digital garments are still copy-pastable which, in case of companies and designers that do not have an open-source attitude as the presented cases, poses questions regarding intellectual property rights. Further research is needed in various academic fields to study digital fashion phenomenon empirically on a larger scale, both qualitatively and quantitatively.

Notes

1. Virtual outfit or appearance of a character or player's avatar in a video game. Skins are either bought or won, and they typically communicate the status of the character/player. For free online games, such as Fortnite, skins are the main revenue (see Makryniotis 2018).
2. The Institute of Digital Fashion (IoDF), <https://institute-digital.fashion>, was founded by Cattytay and a fashion consultant Leanne-Elliot Young in late 2020. They created a manifesto, <https://indd.adobe.com/view/3991a46d-a089-4278-a11e-64f1710d7cc2>, that promotes the ethos of digital fashion. IoDF collaborates with the top fashion schools, institutions and companies worldwide.
3. For example, a multi-brand retailer Dress-X sells digital-only designer clothing, <https://dress-x.com/>
4. Sharewear is Atacac's "transparency project" that shares garment 3D-files and patterns online for free.

Acknowledgment

Many thanks to Atacac and The Fabricant for letting me into their studios, giving their time, and sharing their thoughts. I am grateful to Aalto University, Finnish Cultural Foundation, Fulbright Finland Foundation, and Parsons School of Design for enabling this research as well as to Prof. Annamari Vänskä and our research group, Prof. Hazel Clark, and the peer-reviewers for their invaluable guidance, support and constructive feedback.

ORCID

Natalia Särmäkari  <http://orcid.org/0000-0001-7848-084X>

References

Abbott, Andrew. 1988. *The System of Professions. An Essay on the Division of Expert Labor*. Chicago: The University of Chicago Press.

- Arribas, Veronica, and José A. Alfaro. 2018. "3D Technology in Fashion: From Concept to Consumer." *Journal of Fashion Marketing and Management: An International Journal* 22 (2): 240–251. doi:10.1108/JFMM-10-2017-0114.
- Atkinson, Douglas. 2017. "Post-Industrial Fashion and the Digital Body." In *Digital Bodies: Creativity and Technology in the Arts and Humanities*, edited by Susan Broadhurst and Sara Price, 147–160. London: Palgrave Macmillan Limited.
- Atkinson, Paul. 2010. "Boundaries? What Boundaries? The Crisis of Design in a Post-Professional Era." *The Design Journal* 13 (2): 137–155. doi:10.2752/175470710X12735884220817.
- Atkinson, Paul, and Martin Hammersley. 1994. "Ethnography and Participant Observation." In *Handbook of Qualitative Research*, edited by Norman Denzin and Yvonna S. Lincoln, 248–261. Thousands Oaks: SAGE.
- Baudrillard, Jean. 1994. *Simulacra and Simulation*. Translated by Sheila Faria Glaser. Ann Arbor: The University of Michigan Press.
- Baytar, Fatma, and Susan Ashdown. 2015. "An Exploratory Study of Interaction Patterns around the Use of Virtual Apparel Design and Try-on Technology." *Fashion Practice* 7 (1): 31–52. doi:10.2752/175693815X14182200335655.
- Bertola, Paola, and José Teunissen. 2018. "Fashion 4.0. Innovating Fashion Industry through Digital Transformation." *Research Journal of Textile and Apparel* 22 (4): 352–369. doi:10.1108/RJTA-03-2018-0023.
- Black, Sandy. 2019. "Sustainability and Digitalization." In *The End of Fashion: Clothing and Dress in the Age of Globalization*, edited by Adam Geczy and Vicki Karminas, 113–132. London: Bloomsbury Visual Arts. doi:10.5040/9781350045071.ch-009.
- Boler, Megan. 2007. "Hypes, Hopes and Actualities: New Digital Cartesianism and Bodies in Cyberspace." *New Media & Society* 9 (1): 139–168. doi:10.1177/1461444807067586.
- Bourdieu, Pierre. 1993. *Sociology in Question*. Translated by Richard Nice. London: SAGE Publications.
- Braddock Clarke, Sarah E., and Jane Harris. 2012. *Digital Visions for Fashion + Textiles. Made in Code*. New York: Thames & Hudson.
- Braun, Virginia, and Victoria Clarke. 2019. "Reflecting on Reflexive Thematic Analysis." *Qualitative Research in Sport, Exercise and Health* 11 (4): 589–597. doi:10.1080/2159676X.2019.1628806.
- Bye, Elizabeth, and MyungHee Sohn. 2010. "Technology, Tradition, and Creativity in Apparel Designers: A Study of Designers in Three US Companies." *Fashion Practice* 2 (2): 199–222. doi:10.2752/175693810X12774625387477.
- Castells, Manuel. 2010. *The Rise of the Network Society*. 2nd ed. West Sussex: Wiley-Blackwell.

- Clark, Hazel. 2012. "Conceptual Art." In *Fashion and Art*, edited by Adam Geczy and Vicki Karaminas. New York: Bloomsbury.
- Crane, Diana. 2019. "Fashion and Artification in the French Luxury Fashion Industry." *Cultural Sociology* 13 (3): 293–304. doi:10.1177/1749975519853667.
- Crewe, Louise. 2017. "Soft: Ware: Wear: Where—Virtual Fashion Spaces in the Digital Age." In *The Geographies of Fashion: Consumption, Space, and Value*, Chap. 7. London: Bloomsbury Academic. doi:10.5040/9781474286091.ch-007.
- Davis, Jenny L., and James B. Chouinard. 2016. "Theorizing Affordances: From Request to Refuse." *Bulletin of Science, Technology & Society* 36 (4): 241–248. doi:10.1177/0270467617714944.
- Entwistle, Joanne. 2000. "Fashion and the Fleishy Body: Dress as Embodied Practice." *Fashion Theory* 4 (3): 323–347. doi:10.2752/136270400778995471.
- Farren, Anne, and Andrew Hutchison. 2004. "Cyborgs, New Technology, and the Body: The Changing Nature of Garments." *Fashion Theory* 8 (4): 461–475. doi:10.2752/136270404778051618.
- Gaggioli, Andrea. 2017. "Phygital Spaces: When Atoms Meet Bits." *Cyberpsychology, Behavior, and Social Networking* 20 (12): 774–774. doi:10.1089/cyber.2017.29093.csi.
- Haraway, Donna. 1997. *Modest_Witness@Second_Millennium. FemaleMan©_Meets_OncoMouseTM. Feminism and Technoscience*. New York: Routledge.
- Hayles, Katherine N. 2012. *How We Think: Digital Media and Contemporary Technogenesis*. Chicago, IL: University of Chicago Press.
- Harris, Jane. 2005. "'Crafting' Computer Graphics—A Convergence of Traditional and 'New' Media." *Textile* 3 (1): 20–35. doi:10.2752/147597505778052666.
- Hermann, Mario, Tobias Pentek, and Boris Otto. 2015. "Design Principles for Industrie 4.0 Scenarios: A literature review." Working Paper No. 01. TU Dortmund. doi:10.13140/RG.2.2.29269.22248. Accessed 11 June 2020. https://www.researchgate.net/publication/307864150_Design_Principles_for_Industrie_40_Scenarios_A_Literature_Review
- Hernandez, Marjorie, Fabian Vogelsteller, and Steffen Sieler. 2019. *Blueprint for the New Creative Economies*. Berlin: LUKSO Blockchain. E-book. Accessed 14 January 2020. https://uploads-ssl.webflow.com/5d9bba6a630fbc14e6677051/5dde60f606fb58bf38d86478_Lukso_Blueprint_digital_pages.pdf
- Hunt, Jamer. 2005. "A Manifesto for Post-Industrial Design." *ID Magazine*, December. Accessed 24 May 2020. http://www.jamerhunt.com/assets/manifesto_postindustrial_jamer.pdf.

- Jhanji, Yamini. 2018. "Computer-Aided Design—Garment Designing and Patternmaking." In *Automation in Garment Manufacturing*, edited by Rajkishore Nayak and Rajiv Padhye, 253–290. Duxford: Woodhead Publishing doi: [10.1016/B978-0-08-101211-6.00011-2](https://doi.org/10.1016/B978-0-08-101211-6.00011-2).
- Kaiser, Christian, Thomas V. Fischer, Timo Schmeltzpfenning, Michael Stöhr, and Alexander Artschwager. 2014. "Case Study: Mass Customisation of Individualized orthotics—The FASHION-ABLE Virtual Development and Production Framework." *Procedia CIRP* 21 (C): 105–110. doi:[10.1016/j.procir.2014.03.189](https://doi.org/10.1016/j.procir.2014.03.189).
- Kawamura, Yuniya. 2018. *Fashion-Ology: An Introduction to Fashion Studies*. 2nd ed. New York: Bloomsbury Academic.
- Kholeif, Omar. 2018. *Goodbye, World! Looking at Art in the Digital Age*. Berlin: Sternberg Press.
- Larosse, Mickey. 2019. "We're Not Fashionistas, We're Fashionauts." *The Fabricant-blog*, April 1. Accessed 24 August 2020. <https://www.thefabricant.com/blog/2019/3/29/were-not-fashionistas-were-fashionauts-announcing-ffrop-3>
- Lehdonvirta, Vili, Terhi-Anna Wilska, and Mikael Johnson. 2009. "Virtual Consumerism: Case Habbo Hotel." *Information, Communication & Society* 12 (7): 1059–1079. doi:[10.1080/13691180802587813](https://doi.org/10.1080/13691180802587813).
- Lindqvist, Rickard. 2015. "Kinetic Garment Construction: Remarks on the Foundations of Pattern Cutting." Doctoral dissertation, University of Borås.
- Luce, Leanne. 2019. *Artificial Intelligence for Fashion: How AI Is Revolutionizing the Fashion Industry*. San Fransisco: Apress. doi:[10.1007/978-1-4842-3931-5](https://doi.org/10.1007/978-1-4842-3931-5).
- Makryniotis, Thomas. 2018. "Fashion and Costume Design in Electronic Entertainment—Bridging the Gap between Character and Fashion Design." *Fashion Practice* 10 (1): 99–118. doi:[10.1080/17569370.2017.1412595](https://doi.org/10.1080/17569370.2017.1412595).
- Mattila, Heikki. 2016. "Digital Fashion – How and When?" *Tekstil: Journal of Clothing and Textile Technology* 65 (9–10): 334–339.
- McDowell, Maghan. 2019. "Tommy Hilfiger Goes All in on Digital Design." *Vogue Business Tech Edit*, November 7. Accessed 22 January 2020. <https://www.voguebusiness.com/technology/tommy-hilfiger-pvh-corp-3d-design-digital-clothing-innovation-sustainability>
- McDowell, Maghan. 2020. "Fashion Brands Embrace 3D Design." *Vogue Business Tech Edit*, April 28. Accessed 30 April 2020. <https://www.voguebusiness.com/technology/fashion-brands-embrace-3d-design>
- McQuillan, Holly. 2020. "Digital 3D Design as a Tool for Augmenting Zero-Waste Fashion Design Practice." *International Journal of Fashion Design, Technology and Education* 13 (1): 89–100. doi:[10.1080/17543266.2020.1737248](https://doi.org/10.1080/17543266.2020.1737248).

- McRobbie, Angela. 1998. *British Fashion Design: Rag Trade or Image Industry?* London: Routledge.
- Milne, Rebecca. 2019. "The rise of digital clothing – Q&A with digital fashion expert and founder of HOT: SECOND Karinna Nobbs." *Edited*, November 18. Accessed 13 January 2020. <https://edited.com/resources/the-rise-of-digital-fashion-qa/>
- Moon, Christina H. 2016. "Ethnographic Entanglements: Memory and Narrative in the Global Fashion Industry." In *Fashion Studies: Research Methods, Sites and Practices*, edited by Heike Jenss, 66–82. London, New York: Bloomsbury Academic.
- Quinn, Bradley. 2002. "Introduction." In *Techno Fashion*, 1–10. Oxford: Berg Publishers.
- Paul, Christiane. 2017. "Digital Art Now: The Evolution of the Post-Digital Age." In *ARS 17 Hello World! Art after the Internet*, edited by Leevi Haapala, Eija Aarnio, and Jari-Pekka Vanhala, 37–41. Helsinki: Finnish National Gallery.
- Petrecu, Bruna. 2017. "Giving Body to the Digital Fashion Tools." In *Digital Bodies: Creativity and Technology in the Arts and Humanities*, edited by Susan Broadhurst and Sara Price. London: Palgrave Macmillan Limited.
- Pink, Sarah, Helen Lingard, and James Harley. 2017. "Refiguring Creativity in Virtual Work: The Digital-Material Construction Site." *New Technology, Work, and Employment* 32 (1): 12–27. doi:10.1111/ntwe.12075.
- Raebild, Ulla. 2015. "Uncovering Fashion Design Method Practice: The Influence of Body, Time and Collection." PhD thesis, Designskolen Kolding, TEKO – VIA University College.
- Renfrew, Elinor, and Colin Renfrew. 2009. *Basics Fashion Design 04: Developing a Collection*. Lausanne: AVA publishing SA.
- Renwick, Finlay. 2019. "In the Future Your Clothes Will Be Made Out of Pixels: Inside the 'Wild West' World of Digital Fashion." *Esquire*, December 31. Accessed 10 September 2020. <https://www.esquire.com/uk/style/fashion/a30150947/digital-fashion-the-fabricant-menswear-future-trends/>
- Rocamora, Agnès. 2017. "Mediatization and Digital Media in the Field of Fashion." *Fashion Theory* 21 (5): 505–522. doi:10.1080/1362704X.2016.1173349.
- Santos, Luis Ricardo, Gianni Montagna, and Maria João Pereira Neto. 2020. "The Virtualization of the Fashion Product." In *Advances in Industrial Design*, edited by G. Di Bucchianico, C. Shin, S. Shim, S. Fukuda, G. Montagna, and C. Carvalho, 820–830. AHFE 2020: Advances in Intelligent Systems and Computing, vol. 1202. Cham: Springer. doi:10.1007/978-3-030-51194-4_106.
- Semic, Sara. 2019. "Virtual Fashion: The Digitally Generated Clothes Appearing On Your IG Influencer Feeds." *Elle UK*, July 2. Accessed

- 22 January 2020. <https://www.elle.com/uk/fashion/a28166986/digital-fashion-dressing-virtually/>
- Shiner, Larry. 2001. *The Invention of Art. A Cultural History*. Chicago: The University of Chicago Press.
- Spahiu, Tatjana, Ermira Shehi, and Erald Piperi. 2014. "Advanced CAD/CAM Systems for Garment Design and Simulation." Paper presented at 6th International Conference of Textile, Tirana, Albania, 20 November 2014.
- Stake, Robert E. 1995. *The Art of Case Study Research*. Thousand Oaks: Sage Publications.
- Steele, Valerie. 2003. *The Corset: A Cultural History*. New Haven: Yale University Press.
- Steele, Valerie. 2017. *Paris Fashion: A Cultural History*. 3rd ed. Oxford: Berg. doi:10.5040/9781474269711.
- Sun, Jian, Peng Li, and Wei Jun Wang. 2014. "3D Garment Design of the Computer Virtual Reality Environment." *Applied Mechanics and Materials* 484-485: 1041–1044. www.scientific.net/AMM.484-485.1041. doi:10.4028/.
- Sun, Lushan, and Li Zhao. 2018. "Technology Disruptions: Exploring the Changing Roles of Designers, Makers, and Users in the Fashion Industry." *International Journal of Fashion Design, Technology and Education* 11 (3): 362–374. doi:10.1080/17543266.2018.1448462.
- Särmäkari, Natalia. 2020. "From Worth to Algorithms: The Role and Dimensions of Authorship in the Field(s) of Fashion Design." In *Aesthetics in Dialogue: Applying Philosophy of Art in a Global World*, edited by Zoltán Somhegyi and Max Rynänen, 149–167. Berlin: Peter Lang.
- Särmäkari, Natalia, and Annamari Vänskä. 2020. "Open-Source Philosophy in Fashion Design: Contesting Authorship Conventions and Professionalism." In *Synergy – DRS International Conference 2020, 11-14 August*, edited by Stella Boess, Ming Cheung, and Rebecca Cain, 2410-2426. Brisbane: Design Research Society. doi:10.21606/drs.2020.195.
- Van de Peer, Aurélie. 2014. "Re-artification in a World of De-artification: Materiality and Intellectualization in Fashion Media Discourse (1949–2010)." *Cultural Sociology* 8 (4): 443–461. doi: 10.1177/1749975514539799.
- Vangkilde, Kasper Tang. 2017. "Creativity versus Branding: Totemism, Animism and the Pursuit of Uniqueness in Fashion." *Journal of Cultural Economy* 10 (2): 178–190. doi:10.1080/17530350.2016.1248473.
- Vänskä, Annamari. 2014. "From Gay to Queer—Or, Wasn't Fashion Always Already a Very Queer Thing?" *Fashion Theory* 18 (4): 447–463. doi:10.2752/175174114X13996533400079.
- Volino, Pascal, Frederic Cordier, and Nadia Magnenat-Thalmann. 2005. "From Early Virtual Garment Simulation to Interactive Fashion

- Design.” *Computer-Aided Design* 37 (6): 593–608. doi:[10.1016/j.cad.2004.09.003](https://doi.org/10.1016/j.cad.2004.09.003).
- Volonté, Paolo. 2012. “Social and Cultural Features of Fashion Design in Milan.” *Fashion Theory* 16 (4): 399–431. doi:[10.2752/175174112X13427906403723](https://doi.org/10.2752/175174112X13427906403723).
- Wilcox, David. 2019. “FASHION MADE: The Future of Digital Fashion with Kerry Murphy, The Fabricant.” Video on *Product Innovation* YouTube-channel, November 19. Accessed 16 May 2020. <https://www.youtube.com/watch?v=Up8B9WUoKg4>
- Woodmansee, Martha. 1994. *The Author, Art, and the Market: Rereading the History of Aesthetics*. New York: Columbia University Press.
- Yin, Robert K. 2018. *Case Study Research and Applications: Design and Methods*. 6th ed. Los Angeles: SAGE.
- Yotka, Steff. 2020. “The World’s First Animal Crossing Fashion Show Is Here” *Vogue*, May 25. Accessed 1 October 2020. <https://www.vogue.com/article/animal-crossing-fashion-show-reference-berlin>