8

3D-Printing in the Fashion Industry: A Fad or the Future?

Helen McCormick, Ran Zhang, Rosy Boardman, Celina Jones, and Claudia E. Henninger

8.1   3D-Printing in the Fashion Industry: Its Origin and Current Use

The twenty-first century has seen the emergence of disruptive innovations that have changed business models used within the fashion industry, such as renting and swapping, as well as new technologies, including but not limited to three-dimensional (3D)-printed fashion, zero-waste garments and those designed for circularity (Henninger et al. 2017a; Park and Armstrong 2017). This chapter focuses on 3D-printing technologies and, more specifically, Chinese millennial consumers' perceptions of 3D-printed garments, which currently lack research (Perry 2018).

The 3D-printing technology is not a new phenomenon per se but was introduced three decades ago when Charles W. Hall patented the process of stereolithography (Huang et al. 2015). Three-dimensional printing can best be defined as "an automated additive manufacturing process that

H. McCormick (✉) • R. Zhang • R. Boardman • C. Jones • C. E. Henninger
School of Materials, University of Manchester, Manchester, UK
e-mail: Helen.Mccormick@manchester.ac.uk

builds a product by depositing material into successive layers until it is complete" (Vanderploeg et al. 2017: 170). Within the fashion industry, automated additive manufacturing, also known as three-dimensional (3D) printing, is predominantly used to visualise and test new product developments for fit and form. This implies that prototypes are often created using this technology. A key advantage of implementing an additive manufacturing process is that it reduces risks in the manufacturing process, as items can be tested prior to being mass produced. However, prototyping is not the only use of 3D-printing; it is further utilised for customised made-to-order garments and within haute couture fashion houses (Fitzgerald 2013; Perry 2018). A key question often posed and addressed in this chapter is *are we ready to 3D print our own clothes?*" (Mariott 2015).

As indicated, the predominant use of 3D-printing technologies or additive manufacturing processes is within the prototyping phase of producing new garments and/or accessories (Yap and Yeong 2014). Today, this has changed, with a Dutch designer Iris van Herpen making 3D-printed garments more accessible, as she introduced 3D-printing as a "staple piece" to the haute couture fashion scene almost one decade ago (Lewis 2013; Logan 2015). Today 3D-printed fashion items are increasingly popular and have trickled down from being solely used within haute couture fashion (Yap and Yeong 2014) to being used for jewellery (Shapeways 2018a), bikinis (aRks 2016) and shoes (Heater 2018) and thus have become available for a wider audience. To reiterate this further, the popularity of 3D-printed garments excelled in 2014 when a red dress dominated the media, which was inspired by nature to replicate fish scales and thus created an elegant flow that looked irresistibly light and fashionable. Newspaper outlets indicated that there was *"finally a 3D-printed dress that drapes, [and] moves like actual fabric"* (Meinhold 2014), as opposed to being static and artificial looking. The "red dress" is revolutionary in that it is not only 3D-printed but also a kinematics dress and quite literally printed to order. This provides a sense of exclusivity, further enhanced through the fact that it was featured as *future couture* in the Museum of Modern Art in New York, thereby adding to the luxury vibe (Lenander 2015). The term "kinematics" finds its origin in the field of

mathematics and describes the motions of points. Three-dimensional printing enables designers to make use of these *motion of points*, allowing the creation of geometrically complex structures that are not only elegant but also fluid, translating into a naturally flowing fabric (Rosen 2014). Figure 8.1 provides a visualisation of the geometrical pattern used to create the red kinematics dress. Triangular shapes are carefully positioned next to one another, which allows for movement and makes it easy to wear.

Traditionally, garments are initially designed as a sketchup, which is transferred into a pattern that can be applied to a fabric of choice, cut and sewn together to create a finished prototype (Berman 2012). The 3D-printing technology revolutionises the traditional supply chain process by reducing not only the steps necessary to create a finished garment but also the waste created when manufacturing a garment and/or a collection. Additive manufacturing is a "cost-effective and time-efficient way to produce low-volume, customized products with complicated geometries and advanced material properties and functionality" (Huang et al. 2015: 1). To reiterate this further, traditional garment manufacturing processes produce off cuts (unwanted surplus material) as patterns are transferred onto fabrics, leaving enough space to cut the shapes out of the material (Berman 2012; Economist 2012). Contrarily, for the 3D-printing manufacturing process, only the necessary amount of raw material is used, resulting
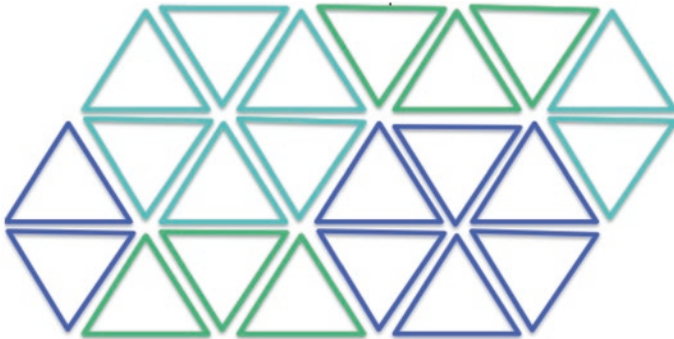

Fig. 8.1   Red kinematics dress pattern (authors' own)

in zero waste (Bak 2003; Vanderploeg et al. 2017). Although 3D-printing has its advantages over the traditional way of manufacturing clothes, a key drawback is the time and energy it takes to create a piece, which further implies that only low volumes will be produced, making 3D-printing more relevant for the luxury market as opposed to fast fashion. To provide an example clearly illustrating the energy and time usage, in 2016, threeASFOUR created the Pangolin dress, which used 10 printers simultaneously, working for a total of 500 hours, not including the assembly process (Jacobson 2017), thereby highlighting a "shattering truth of 3D-printed clothing" (Jacobson 2017). Current 3D-printed garments are available only to a fashion elite that is able to spend large sums of disposable income on these items. Yet, massification can still be reached, as jewellery provides an entry level item that can be affordable, depending on the material used for printing (Shapeways 2018b).

8.2   Chinese Millennial Consumers and Their Perceptions: Luxury Fashion Industry

This chapter focuses on Chinese millennial consumers who were chosen purposively for this research. As highlighted, 3D-printing technologies within the fashion industry are predominantly used within the luxury fashion industry and the haute couture setting. Chinese consumers are key economic drivers of this luxury sector (Deloitte 2017), as one-third of global luxury sales is attributed to them (Hancock 2017). Bu et al. (2017) highlight that Chinese consumers are not only becoming more global, enabled through China opening up its borders, but also increasingly demanding new products, new technologies, and new ways to interact and engage with them (e.g. Mackerras et al. 1998; Wang 2017). Enhanced through the one-child policy, millennial consumers feel a sense of entitlement (Wang 2017) and are currently aged between 19 and 35 years (Economist 2016). The key characteristics of millennial consumers are as follows (Doctoroff 2007; Solomon 2017; Bu et al. 2017; Henninger et al. 2017b):

- Technology savvy and accepting new technologies
- Social generation: not only sharing their lives on digital platforms but also seeking social acceptance through showing off wealth (especially in China)
- Looking for new opportunities and adventures, which is also linked to purchasing items that are new and novel and pushing boundaries
- Passionate about values, including companies they may purchase items from

Despite the economic importance of Chinese millennial consumers, current research lacks investigations into this consumer group (Kapferer and Michaut-Denizeau 2014; Henninger et al. 2017b), which is addressed in our chapter.

Annually, Chinese consumers are spending an average of 71,000 RMB on luxury goods, making them a key target market for 3D-printed garments and accessories (Bu et al. 2017). Bu et al. (2017) highlight that a key driver in the decision-making process is the initial consideration phase, whereby brands that are recalled are the ones that are at the forefront of consumers' minds, known as the "top-of-mind" recall. This top-of-mind recall mechanism is enhanced through consumer perceptions, defined as "the process by which an individual selects stimuli from his or her environment, organises information about those stimulus, and interprets the information to form a coherent, meaningful view of the world" (Wells and Prensky 1996: 257). As such, consumer perceptions are rather subjective and can be influenced by an individual's culture (Kastanakis and Voyer 2014). Prior to 1978, China's value system was dominated by Confucius values, which see individuals sacrificing their own interests for the benefit of society at large (An et al. 1999). Yet, this has since changed with China opening up in 1978, exposing Chinese consumers, especially millennials, to the West and Western values, making it increasingly acceptable to broadcast one's own individuality and wealth through materialistic items, such as garments. Three-dimensional printed items allow for high customisation and uniqueness, and thus, designers, such as Iris van Herpen, who currently use additive manufacturing processes, have an opportunity to market their products to an increasingly affluent market (Doctoroff 2007; Deloitte 2017; Henninger et al. 2017b). Peng

(2017) further indicates that Chinese middle-class consumers follow a *xiaozi* (小资) lifestyle, which implies that they are increasingly showing off their uniqueness and wealth through their consumption behaviour (Henningsen 2012; Ibrahim 2015). For Chinese millennial consumers, fashion products are one way of portraying their uniqueness and individuality to their peers (Ye et al. 2012; O'Cass and Siahtiri 2014). This further justifies this research context of 3D-printed garments and accessories, as these are classified as customised luxury products that allow consumers to portray their individuality.

8.3   Methodology

This qualitative research explores Chinese millennial consumers' perceptions of 3D-printed garments and their likelihood of purchasing these. A total of 15 in-depth semi-structured interviews were conducted with Chinese millennial consumers. Interviews were conducted in Mandarin Chinese in order to make it easier for participants to fully express themselves. Interviews were carefully translated from Chinese into English and back again in order to ensure that no meaning was lost. All interviews were conducted on a face-to-face basis and lasted on average 35 minutes. Participants in this research were recruited following a snowball sampling technique, which implies that interviewees recommended others to participate in the study. Key requirements to participate in the study were as follows: (1) must be aged between 18 and 35 years and thus can be classified as millennials; (2) are Chinese and (3) consume luxury goods and have an interest in new innovative luxury items allowing them to express their uniqueness.

Participants were almost equally distributed between males and females, with the majority of them being in their mid-20s (Table 8.1). Interview questions for this research were guided by topics concerning 3D-printed garments and current reports in the media, as well as their perceptions of brands utilising adaptive manufacturing processes (e.g. Nike, Iris van Herpen, Shapeways).

Although 3D-printing in the fashion industry is not new per se, it has thus far not been explored from a marketing perspective, more specifically to investigate consumer perceptions towards these products and the

Table 8.1 Summary of the data set (authors' own)

Participant	Age	Gender	City	Field of work
1	19	Male	Foshan	Engineering
2	18	Male	Chengdu	UG student
3	30	Female	Zhuzhou	Medicine
4	23	Female	Wenzhou	Fashion retailing
5	24	Female	Nanjing	Business
6	22	Female	Hangzhou	Education
7	24	Male	Hangzhou	Computer engineering
8	22	Female	Ganzhou	Chemistry
9	24	Male	Guangdong	Social development
10	22	Male	Handan	Business
11	28	Female	Xinyang	Fashion management
12	22	Female	Haerbin	Chemistry
13	24	Female	Linyi	PGT student (business)
14	23	Male	Xingtai	Business
15	23	Male	Cangzhou	Engineering

likelihood of purchasing these items. As such, this qualitative research allowed us to gain an insight into how consumers feel about these products (Bodgan et al. 2015). Following in line with Easterby-Smith et al.'s (2012) grounded analysis approach, rich data sets were coded and recoded multiple times, first individually by each of the researchers, before discussing the emerging themes and discrepancies. The latter were carefully reviewed and recoded.

A limitation of this research could be the interpretivist nature of the study and its limited sample size of only 15 participants. Yet, findings provide an interesting insight into the perceptions Chinese millennial luxury consumers have about 3D-printed garments and their likelihood to purchasing these in the future.

8.4   Findings and Discussion

8.4.1   Perceptions of 3D-Printed Garments

Prior to exploring the perceptions of 3D-printing technologies, it was vital to understand why these millennial Chinese consumers engage in luxury shopping. The majority of participants indicated that they felt

a lot of pressure in their everyday life with individuals seeking to not only please their managers but also fulfil family expectations at being the best. Participants 3, 7, 8 and 15 insist that although the pressure is high, they seek to enjoy life more and reward themselves with gifts. To reiterate this further, participant 7 stated "I work for pleasure and my work should be entertainment-focused." From the conversation it is apparent that one way of gaining this "pleasure" is by purchasing luxury items that clearly demonstrate how well they are doing in their career. At the same time, the act of purchasing luxury items is a part of their "retail therapy," which enhances their personal well-being. This concurs with the research by Henninger et al. (2017b) highlighting that key drivers to purchasing luxury items are expression of wealth and well-being.

An interesting observation that could not be fully explored due to the scope of this chapter is the fact that Chinese consumers' attitude towards materialism is changing. Whilst Chinese consumers previously were heavily influenced by Confucianism and Daoism (An et al. 1999), which implies a more communal spirit and looking after individuals in society, this has changed with the emergence of new technologies (Wang et al. 2016). Participant 5 states that "material is the base for everything," which further reinforces this point. This cultural shift could have implications for today's market economy and is an area that should be explored further in future research.

Key to this research was to understand how Chinese millennial consumers perceive 3D-printed garments and/or accessories. The interview began by discussing 3D-printed garments in general terms and whether participants had previous experience in purchasing anything that was 3D-printed. The majority of participants were aware of the Iris van Herpen dress "having seeing it on social media" (P3), with only Participant 1 indicating that they had previously bought 3D-printed accessories, which was a gift for a friend.

The general feeling about 3D-printed garments was mixed with some indicating that they felt these products were too unique and extravagant, implying that they would not be able to wear them on a daily basis (P2, 3, 5, 7 and 8). This notion emerged from the Iris van Herpen dress, as it is a part of the haute couture scene. Although all participants in this

research have previously bought luxury fashion and accessories, none of them would associate themselves with haute couture, stating "the rich and famous … only they can buy stuff like that" (P2). Participants 6, 9, 11 and 12 expressed their thoughts on additive manufacturing implying limited functionality. As the printed fabric is always based on complex geometrical forms, "they cannot replace what normal fabrics do … it's just less functional … look at the red dress, it's transparent, when can you wear that?" (P11). Issues surrounding the materials used within 3D-printing are not a new phenomenon: Sun (2016) indicates that raw materials, such as poly-lactic acid are neither comfortable nor flexible enough for fashion garments. Similarly, in an interview with Wired's Bradley Rothenberg, co-designer on the threeASFOUR project, it is highlighted that "with fashion there is the potential to control the weave and control the structure to get exactly the properties you want. […] The issue is that today, it's still potential. That's why I think Gabo (Asfour) is, like, the most exciting person in fashion. We need people like him to push the limits, to show what's conceivable" (Jacobson 2017). This clearly highlights that although 3D-printing has made a début in the fashion industry, it is still in its infancy, which may explain the negative connotations towards it from the side of the consumer. The material aspect is further linked to low quality: "I thought the clothes looked quite fragile because of the exaggerated design and I had to be really careful about it" (P10). Similarly, participant 4 states that "3D-printing products are fashionable and creative but they seem to be too fragile at the same time." Although the highly complex geometrical structures can create elegant and fluid-looking materials (Rosen 2014) as well as be cost effective and time efficient in terms of production (Huang et al. 2015), consumers enrolled in this research felt that it also made them look more fragile and something that they would not want to wear. During the interviews it became apparent that although they wanted to have unique luxury fashion items that are slightly unusual, they felt that 3D-printed garments are taking this one step too far. Whilst 3D-printed garments may have unique designs and look unique, their performance properties are seen to be inferior to those of traditionally manufactured garments. Similar to Bradley Rothenberg, participants 7 and 11 believe that 3D-printing technologies have not yet matured enough to be part of the luxury fashion scene.

In summary it could be said that Chinese millennial consumers currently remain unconvinced of 3D-printing technologies. Although millennials are seen to be technology-accepting, using additive manufacturing processes for fashion items seems to be too *avant-garde.* Three-dimensional printed garments are associated with haute couture fashion that is not within their reach and, as a result, is seemingly impractical, as the elegant, yet fragile-looking structures are not seen to be suitable for everyday use.

8.4.2   Purchase Intentions and Attitudes Towards New Technologies (3D-Printing)

The previous section paints a rather bleak picture for 3D-printed garments and accessories, as the majority of participants had negative connotations towards them. An explanation could be that only one out of the 15 people interviewed had an actual purchase experience. Participant 1 highlights that they liked the fact that products could be printed to order, yet also pointed out that it can be challenging to create your own set of 3D-printed earrings. Looking at the example of Shapeways (2018c), this remark may become more obvious, as customers who wish to get their own object 3D-printed need to upload a 3D model. Although support is available on the website in terms of a detailed tutorial, this may not always be a possibility due to time commitments or the inability to work with different software components.

Interestingly participants also insisted that although they had heard of Iris van Herpen and the kinematics dress, they felt that 3D-printed fashion garments and accessories are not well advertised. The majority of participants felt that 3D-printed items could have great potential in China, as new technologies are readily accepted in the market, and if promoted correctly, it could be adopted very quickly. Participants 8 and 10 indicate that if their friends would purchase 3D-printed items, they would too, even though they may be hesitant in the first instance due to the feeling that 3D-printed items are inferior, if the majority of people adopt these technologies, they would too. Participant 9 further insists:

> 3D-printing not only has potential in China, but all over the world. It could probably be a revolution in the manufacturing industry. If 3D-printing technology matures enough to become a household appliance, then, what retailers sell will no longer be the products, but the materials and data used for printing the products … but the selling of data would bring out a series of problems like the protection of intellectual property rights and some regulations and laws should be established to protect them.

This quote further supports Huang et al. (2015), who highlight that 3D-printing can have an impact on the manufacturing process as a whole, whist further demonstrates the new business opportunities of the digital age: the collection of data. Ethical implications associated with this aspect are beyond the scope of this chapter yet are an interesting area of research for the future.

When asked whether participants would purchase 3D-printed items, the answer was surprisingly positive, as individuals could see themselves engaging with products that are described as "high-tech" and revolutionising in the industry. This links to an earlier point made, in that the way that 3D-printed garments are portrayed is vital. Retailers need to clearly communicate the positioning of their 3D-printed products; if seen to be high-tech and revolutionary, then consumers in this research seem to be more inclined to purchase them, whilst simply promoting them as customised items used in the haute couture scene seems to make them unattainable and not targeted towards them. A further interesting finding is that currently our participants feel that 3D-printed garments should be marketed as low-end fashion, whilst if there was a shift to broadcast the high-tech aspects, 3D-printed items could move into high-end and luxury markets. This demonstrates that participants were aware of neither the amount of energy 3D-printing needs nor the long production times or the design efforts currently going into the additive manufacturing process (e.g. Jacobson 2017; Chandavarkar 2018). This further highlights that retailers need to strengthen their communication strategies when it comes to promoting 3D-printing. This may also explain why only one-third of the participants indicated that they see 3D-printed garments as a type of luxury product.

The background information presented is essential when exploring purchase intentions of 3D-printed garments and accessories from the point of view of Chinese millennial consumers. The previous sections indicate that 3D-printed garments are currently seen as not matured enough to be classified as luxury—only 5 out of the 15 participants could see a resemblance with the luxury market. This has key implications for retailers in terms of price. Whilst some participants indicate that they would pay up to £500 for an item that was 3D-printed (e.g. luxury bag or jewellery) (P6), others do not want to invest more than £200 for a 3D-printed garment and between £30 and £40 for accessories (P2). Participant 3 highlights that "I do not think that 3D-printed products have an obvious advantage, I would pay the same price as I usually spend on other high-street brands, around £100." Participant 5 further emphasises:

> I think the price of 3D-printed products should be around £20 as these kind of products are relatively unknown by people. Retailers should lower their costs and produce them in huge quantities to generate awareness of the products and attract consumers' attention.

Interestingly, participant 15 points out that items that are produced using automated machine processes, such as additive manufacturing, should never be more expensive than those that are manmade, as costs, such as wages and people insurance (e.g. medical), do not have to be paid. He further highlights that there are no "obvious advantages of 3D-printed garments" and that one of the only reasons these items are currently high-priced "is the fact that the technology has not matured yet … but the technology will mature one day so the costs will be reduced dramatically then." On the other hand, it was pointed out that:

> How much I pay for products depends on the positioning of the product. If it has been positioned as a luxury 3D-printed product, made with really sophisticated techniques and fashionable design, I would probably spend hundreds or even thousands of pounds. If it has been labeled as a high-street brand, I would probably spend less than £100 on it. The point is not about the technology, it is about how designers use this technology. (P9)

Overall it becomes apparent that the willingness to pay for 3D-printed garments and accessories depends on the individual and how they perceive these items, and highlights the power of branding in determining price points for 3D-printed garments/accessories. From the interviews it becomes apparent that these consumers would like to see more inclusive designs, which implies being able to actually wear 3D-printed garments, rather than seeing kinematic dresses that are for the elite only (P2, 11). Our participants insisted that marketing communication is vital, as 3D-printed garments, at the moment, are seen more as a gimmick rather than a luxury item, as consumers are unable to identify any advantages that 3D-printed clothes have over "normal" garments. The only "benefits" that were identified are cost effectiveness in the manufacturing process (Huang et al. 2015); yet this is not translated to the end consumer as the production in itself is more expensive, as it can take up to 500 hours to print a dress (Jacobson 2017).

8.5   Conclusion and Future Research

Our research has highlighted that 3D-printed garments currently have a negative connotation, as consumers are unable to associate any benefit with this production technique. Yet, the use of technology within garment production is seen to be novel and of interest to these luxury millennial consumers. We found that the biggest challenge is marketing communication for 3D-printed garments. Only one out of 15 participants had the experience of actually purchasing a 3D-printed item, which highlights that the user experience is missing. Participants based their opinions on media articles and imagery, with the majority of news outlets currently highlighting that additive technologies are currently not mature enough to enter the mass market, yet have great potential in the future.

Future research could look into marketing communication strategies and how 3D-printed garments are advertised to consumers. In line with results reported by Perry (2018), it is suggested that further studies are necessary to explore consumer perceptions, which could also take a quantitative form to obtain generalisable results.

References

An, T., Minghua, L., & Song, Z. (1999). 'Yishizhuxing 50 years' Dui Wai Chuan Bo. *IXUESHU* (Online)*,* Z2, pp. 10–12. Retrieved Feburary 27, 2017, from http://www.ixueshu.com/document/d58437bb9b9933fa31894 7a18e7f9386.html.

aRks. (2016). Multidisciplinary creative duo Samuele and Rosanna of aRks studio present 'coral' – their first 3D printed bikini collection. *aRks* (Online). Retrieved May 18, 2018, from http://www.arks3d.com/en/press.html.

Bak, D. (2003). Rapid prototyping or rapid production? 3D printing processes move industry towards the latter. *Assembly Automation, 23*(4), 340–345.

Berman, B. (2012). 3-D printing: The new industrial revolution. *Business Horizons, 55*, 155–162.

Bodgan, R., Taylor, S. J., & DeVault, M. (2015). *Introduction to qualitative research methods: A guidebook and resource*. Hoboken, NJ: John Wiley & Sons, Inc.

Bu, L., Durand-Servoingt, B., Kim, A., & Yamakawa, N. (2017). Chinese luxury consumers: More global, more demanding, still spending. *McKinsey* (Online). Retrieved May 20, 2018, from https://www.mckinsey.com/business-functions/marketing-and-sales/our-insights/chinese-luxury-consumers-more-global-more-demanding-still-spending.

Chandavarkar, A. (2018). Can 3D printing revolutionise fashion? *Fiber2Fibre* (Online). Retrieved May 21, 2018, from http://www.fibre2fashion.com/industry-article/7528/will-3d-printing-revolutionise-fashion.

Deloitte (2017). Global powers of luxury goods 2017: The new luxury consumer. *Deloitte* (Online). Retrieved May 20, 2018, from https://www2.deloitte.com/content/dam/Deloitte/global/Documents/consumer-industrial-products/gx-cip-global-powers-luxury-2017.pdf.

Doctoroff, T. (2007). *Billions: Selling to the new chinese customer*. New York, NY: Palgrave Macmillan.

Easterby-Smith, M., Thorpe, R., & Jackson, P. R. (2012). *Management research*. London: Sage.

Economist. (2012). A third industrial revolution. *Economist* (Online). Retrieved May 16, 2018, from http://www.economist.com/node/21552901.

Economist. (2016). The new class war. *Economist* (Online). Retrieved May 13, 2017, from www.economist.com/news/special-report/21701653-chinas-middle-class-larger-richer-and-more-vocal-ever-threatens.

Fitzgerald, M. (2013). With 3D printing, the shoe really fits. *MIT Sloan Management Review* (Online). Retrieved May 18, 2018, from https://sloan-review.mit.edu/article/with-3-d-printing-the-shoe-really-fits/.

Hancock, T. (2017). Chinese shoppers begin to buy luxury brands again – At home. *Financial Times* (Online). Retrieved May 13, 2017, from www.ft.com/content/61bc103a-e38a-11e6-8405-9e5580d6e5fb.

Heater, B. (2018). Adidas joins carbon's board as its 3D printed shoes finally drop. *Techcrunch* (Online). Retrieved May 18, 2018, from https://techcrunch.com/2018/01/18/adidas-joins-carbons-board-as-its-3d-printed-shoes-finally-drop/.

Henninger, C. E., Alevizou, P. J., Goworek, H., & Ryding, D. (Eds.). (2017a). *Sustainability in fashion: A cradle to upcycle approach*. Heidelberg: Springer.

Henninger, C. E., Alevizou, P. J., Tan, J. L., Huang, Q., & Ryding, D. (2017b). Consumption strategies and motivations of chinese consumers: The case of UK sustainable luxury fashion. *Journal of Fashion Marketing & Management, 21*(3), 419–434.

Henningsen, L. (2012). Individualism for the masses? Coffee consumption and the chinese middle class' search for authenticity. *Inter-Asia Cultural Studies, 13*(3), 408–327.

Huang, Y., Leu, M. C., Mazumder, J., & Donmez, A. (2015). Additive manufacturing: Current state, future potential, gaps and needs, and recommendations. *Journal of Manufacturing Science and Engineering, 137*(1), 1–10.

Ibrahim, Y. (2015). Food porn and the invitation to gaze: Ephemeral consumption and the digital spectacle. *International Journal of E-Politics, 6*(3), 1–12.

Jacobson, R. (2017). The shattering truth of 3D-printed clothing. *Wired* (Online). Retrieved May 19, 2018, from: https://www.wired.com/2017/05/the-shattering-truth-of-3d-printed-clothing/.

Kapferer, J. N., & Michaut-Denizeau, A. (2014). Is luxury compatible with sustainability? Luxury consumers' viewpoint. *Journal of Brand Management, 21*(1), 1–22.

Kastanakis, M., & Voyer, B. G. (2014). The effect of culture on perception and cognition: A conceptual framework. *Journal of Business Research, 67*(4), 425–433.

Lenander, J. (2015). Future couture: Nervous system's kinematics dress. *MOMA* (Online). Retrieved May 20, 2018, from https://www.moma.org/explore/inside_out/2015/03/26/future-couture-nervous-systems-kinematics-dress/.

Lewis, T. (2013). 3D printing weaves its way into fashion. *LiveScience* (Online). Retrieved May 19, 2018, from https://www.livescience.com/38720-3d-printing-weaves-its-way-into-fashion.html.

Logan, L. (2015). The Dutch designer who is pioneering the use of 3D printing in fashion. *Smithsonian Mag* (Online). Retrieved May 19, 2018, from https://www.smithsonianmag.com/innovation/dutch-designer-who-pioneering-use-3d-printing-fashion-180957184/.

Mackerras, C., Taneja, P., & Young, G. (1998). *China since 1978: Reform, modernisation and socialism with chinese characteristics*. Harlow: Longman.

Marriott, H. (2015). Are we ready to 3D print our own clothes? *The Guardian* (Online). Retrieved May 29, 2019, from https://www.theguardian.com/fashion/2015/jul/28/are-we-ready-to-print-our-own-3dclothes.

Meinhold, B. (2014). Finally a 3D-printed dress that drapes, moves like actual fabric. *Ecouterre* (Online). Retrieved January 28, 2017, from http://www.ecouterre.com/finally-a-3d-printed-dress-that-drapes-moves-like-actual-fabric/.

O'Cass, A., & Siahtiri, V. (2014). Are young adult chinese status and fashion clothing brand conscious? *Journal of Fashion Marketing and Management, 18*(3), 284–300.

Park, H., & Armstrong, C. M. J. (2017). Collaborative apparel consumption in the digital sharing economy. *International Journal of Consumer Studies, 41*, 465–474.

Peng, Y. (2017). Sharing food photographs on social media: Performative Xiaozi lifestyle in young, middle-class chinese urbanites' WeChat moments. *Social Identities, 25*, 269–287.

Perry, A. (2018). 3D-printed apparel and 3D-printer: Exploring advantages, concerns, and purchases. *International Journal of Fashion Design, Technology and Education, 11*(1), 95–103.

Rosen, D. W. (2014). Research supporting principles for design for additive manufacturing. *Virtual and Physical Prototyping, 9*(4), 225–232.

Shapeways. (2018a). About us. *Shapeways* (Online). Retrieved May 18, 2018, from https://www.shapeways.com/about.

Shapeways. (2018b). Earrings. *Shapeways* (Online). Retrieved May 19, 2018, from https://www.shapeways.com/marketplace/jewelry/earrings/?q=&sort=popularity&facet%5BpdcId%5D%5B%5D=392&facet%5Bprice%5D%5Bmin%5D=1&facet%5Bprice%5D%5Bmax%5D=2500&facet%5Bprice%5D%5Bfrom%5D=1&facet%5Bprice%5D%5Bto%5D=2500.

Shapeways. (2018c). Shapeways custom 3D printing service. *Shapeways* (Online). Retrieved May 21, 2018, from https://www.shapeways.com/create.

Solomon, M. (2017). 2015 is the year of the millennial customer: 5 key traits these 80 million consumers share. *Forbes* (Online). Retrieved May 20, 2018,

from   https://www.forbes.com/sites/micahsolomon/2014/12/29/5-traits-that-define-the-80-million-millennial-customers-coming-your-way/#189e7c8525e5.

Sun, D. (2016). 3D printing in fashion promises to be huge – so what's holding us back? *The Conversation* (Online). Retrieved May 21, 2018, from http://theconversation.com/3d-printing-in-fashion-promises-to-be-huge-so-whats-holding-us-back-69655.

Vanderploeg, A., Lee, S. E., & Mamp, M. (2017). The application of 3D printing technology in the fashion industry. *International Journal of Fashion Design, Technology and Education, 10*(2), 170–179.

Wang, H. H. (2017). The real reason Chinese millennials are super consumers. *Forbes* (Online). Retrieved May 19, 2018, from https://www.forbes.com/sites/helenwang/2017/03/27/the-real-reason-chinese-millennials-are-super-consumers/#1a7eaa564053.

Wang, Y. Y., He, X. Q., & Yin, X. (2016). *The impact of consumer materialism in China on online compulsive buying behaviour*. WHICEB 2016 proceedings. Retrieved May 21, 2018, from https://pdfs.semanticscholar.org/6697/019b1419931f070e7d0ac31e3625a124ca21.pdf.

Wells, W., & Prensky, D. (1996). *Consumer behaviour*. New York, NY: John Wiley & Sons.

Yap, Y. L., & Yeong, W. Y. (2014). Additive manufacture of fashion and jewellery products: A mini review. *Virtual and Physical Prototyping, 9*(3), 195–201.

Ye, L., Bose, M., & Pelton, L. (2012). Dispelling the collective myth of chinese consumers: A new generation of brand-conscious individualists. *Journal of Consumer Marketing, 29*(3), 190–201.

Helen McCormick is Senior Lecturer in Online Fashion Retailing and Multichannel Strategy at the University of Manchester. She is a specialist in retail marketing and conducts research in the areas of social media marketing, consumer behaviour, m-commerce, e-commerce, s-commerce and retail design, and also areas that include new technologies and their use, particularly to support business development, such as augmented reality, virtual reality and innovative technologies used in retail. She has undertaken many roles within the university, including Director of Undergraduate Studies for Fashion Business within the School of Materials and more recently as a line manager for the academic staff within the Fashion Business and Technology group. She is passionate about teaching and learning, the student experience and researching the chang-

ing retail environment in the UK, and globally focusing on how technology can support and develop fashion retail and improve business processes.

Ran Zhang is a practitioner in the industry. She has received an MSc in International Fashion Retailing from the University of Manchester in 2016. Her master's dissertation focused on 3D printing and Chinese millennial consumers.

Rosy Boardman   is Lecturer in Fashion Business at the University of Manchester. She teaches Fashion Buying and Merchandising and Contemporary Retailing. Rosy completed her PhD in online retailing and has presented her research at national conferences and published in leading journals. Boardman's research interests include online retailing, website design, social media marketing, omnichannel retailing, in-store technology, mobile commerce and consumer behaviour. She supervises a number of PhD and MSc students in the areas of fashion retailing and social media marketing.

Celina Jones After completing her MSc in Textile Science and Technology from the University of Manchester, Jones was awarded the Doctoral Training Award by EPSRC for her PhD, wherein she created textile materials inspired by structural colour in nature. Prior to her master's, she completed her BA in Textile Design from Chelsea College of Art and Design. Her PhD research has enabled her to fuse her design background with the new knowledge she gained during her MSc.

In her role as Lecturer in Fashion Technology at the University of Manchester, Jones teaches at undergraduate and postgraduate levels and conducts research in the following areas: fashion product development, quality control, garment technology and textile science and technology including fibre sourcing, fabric construction and finishing, and fabric performance analysis.

Claudia E. Henninger is Lecturer in Fashion Marketing Management at the University of Manchester, UK, where she teaches sustainability and strategic management. Henninger has presented her research at national and international conferences and published in leading journals. Henninger is the Deputy Chair of the Academy of Marketing SIG Sustainability. Her first edited book *Sustainability in Fashion—A Cradle to Upcycle Approach* was published in 2017 with Springer and her second edited book *Vintage Luxury Fashion* published in 2018 was also with Springer.