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**Fashion: The Missing Element in Wearable Technology Design**

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## Abstract

There have been significant advancements in the research and development of wearable technologies over the last decade; however, only a few of these products are commercially successful. This mixed-methods research project investigates how wearable technology designers could focus more on the aesthetic, fashionability, and wearability of products to attract greater attention from consumers, and potentially achieve greater success on the market. I seek to integrate a fashion design perspective with current wearable technology design processes to improve the attractiveness of wearable technology to the early majority. This research is positioned within the framework of action research informed by a literature review and an analysis of existing wearable products in a particular category (facewear) on the market. It uses design-and-prototype as a process to explore and to demonstrate fashion informed aesthetic possibilities, and uses existing products to inform user needs. This research provides insights to help inform understanding of future wearable technology designs. The project outcomes include facewear designs and prototypes developed by the researcher based on the analysis of the literature and existing products. The findings and creative concepts are incorporated into a written

thesis that discusses and appraises the facewear designs and the integrated fashion-wearables design approach.

*Keywords:* wearable technology, aesthetics, design process, fashionability

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## Attestation of Authorship

"I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning."

Signature:

A handwritten signature in black ink, appearing to read "Elizaveta Lim".

Date: 6/11/2019

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# Chapter 1. Project Introduction

This project investigates an alternative approach to wearable technology (wearables) design, that uses practice to investigate the value of fashion trend forecasting and design methods to develop wearable technology. Incorporation of a fashion perspective allows wearables to extend beyond the functional, objective aspects of the product. It gives the product a social purpose and meaning, above and beyond those of basic technological function. "Clothing is supplemented by semblance and illusion, which are defined as increased value or additional usefulness" (Loschek, 2009, p.134). Such elements are often missing in the existing wearables design. The project attempts to answer the question: Can the integration of fashion design elements, such as trend analysis and inspiration research, along with a more detailed user needs evaluation, lead to an alternative design approach that would benefit the adoption of future wearables? The researcher's background is in fashion marketing, merchandising and consumer behaviour with limited experience in fashion design and wearables development. Due to these limitations, the researcher engaged the assistance of the Textile and Design Lab at AUT. Gordon Fraser is a senior technician at the lab with over 30 years of technical knitting experience. He assisted and advised the researcher on choosing the type of yarns and the knitting techniques to best achieve the design purpose. The researcher chose practice as a key method for the research project because design through practice is one of the most commonly used approaches in both fashion and product design. Also, after reviewing existing wearables design methodologies and considering theoretical design methods, it was decided that through practice, the researcher could best explore and understand the additional elements above and beyond

function.

This thesis starts with a literature review of current wearable technology design approaches and identifies difficulties in wearables gaining market attention. Then, elements of the fashion design process, such as market/trend analysis and inspiration/direction research, are considered in relation to current wearable technology design approaches. Thirdly, the identification of barriers in the current wearable technology design process is identified, including a more detailed discussion of two specific barriers that are central to this research: the correct identification of target customers and the use of trend analysis for wearables design. Fourthly, a comparative product analysis of existing popular anti-pollution facewear/mask is used to assist the development of design criteria for the practice design work. Two approaches to the design of anti-pollution masks are then explored: 1. a series of concept prototypes exploring a wide range of aesthetically focused design approaches based on the previous research on trend analysis and product evaluation; 2. through a series of physical prototypes using digital knit technology, new approaches to facewear design that emphasise fashionability and wearability are developed and documented. Finally, reflection and analysis of the design process and prototypes in relation to the issues identified in the earlier parts of the research (literature review and product evaluation) and a discussion of the future potential of this research form the conclusion and complete the thesis. This research will be helpful for wearables developers in understanding consumer behavior, the importance of incorporating fashion design elements in wearables design and the relationship between functionality, aesthetics and social purpose.

# Chapter 2. Literature Review

## 2.1 Introduction

As early as the 1990s, technology-driven designers started to experiment with miniature electronic devices and the integration of them in wearable technology (Suh, Carroll, & Cassill, 2010). Most wearables designers focus on the functionality and technology aspects of wearables design, neglecting the fashion elements (Ariyatam, Holland, Harrison, & Kazi, 2005). Due to these products being highly technical, most wearable designers are engineers and computer scientists. Only recently, designers and developers have started to move towards developing a fashionable product instead of a high-tech product (Edwards, 2003), because the low adoption rate and slow acceptance are leading technology designers to review their designs. This low adoption rate and slow acceptance by the consumer market are partially due to the difficulties in identifying consumer needs. Surveying people who have never purchased a wearable technology product can be problematic because user perceptions of needs can be very different from actual user needs (Perry, Malinin, Sanders, Li, & Leigh, 2017). Perry et al.'s (2017) research on Designer-Users, who not only design wearables but are also the first ones to adopt them, identify the top three concerns as Affordability, Aesthetics and Hedonic value (pertaining to pleasure). Most designer-users

identify wearable technology as a fashion product; therefore, the fashion element of wearable technology should be explored and incorporated during the product design process.

The adoption of wearables has still been a struggle in the current market, despite the exponential growth in recent years (Adapa, Nah, Hall, Siau, & Smith, 2018). Many researchers try to predict a trend in the wearables market using the technology acceptance model (TAM). What these researchers found is that a positive user experience would promote greater user acceptance of wearable technology. What contributes to a positive user experience is "to be acceptable and comfortable, as a vehicle for self-expression, products must look stylish and attractive and function reliably in relation to the technical and aesthetic concerns of the wearer, as well as from social, cultural and health perspectives" (McCann, 2009, p.45). In other words, a positive user experience means that users have to enjoy wearing the product despite its functions. Functionality, while important, only contributes to a portion of the user's experience with the product. According to Kim and Shin (2015), the key psychological determinants of smartwatch adoption are perceived usefulness and subcultural appeal. Therefore, emphasis should be placed on both engineering and design to provide a more attainable and unobtrusive user experience. Affective qualities are also influential in determining the adoption of a wearable technology product, because wearables are not just utilitarian tools but items that reflect individual identities and aesthetics. Identity and aesthetics are two important dimensions of fashion; consumers buy not out of 'need' but out of 'desire', specifically the desire to express who they are or wish to be. As Suzanne Lee said in her book *Fashioning the future: tomorrow's wardrobe*: "If

technology can give apparel new abilities in which people can define and express themselves then certainly there will be a market for it" (Lee, Du Preez, & Thornton-Jones, 2005, p.157).

In *A Survey of the Historical Scope and Current Trends of Wearable Technology Applications*, Berglund, Duvall and Dunne (2018) conducted two surveys, one before 2014 and another after this date. They found that before 2014, there was a focus on garment integration. However, more recently the focus has shifted towards accessories and jewellery. This shift in focus is due to technological developments, including the rapid decrease in component size and power consumption of hardware. Also, the developments in garment-integrated technologies are more challenging in relation to manufacture, application development and cultural difference. They note "it seems that earlier applications may have focused more on novel approaches to fashion and lifestyle (such as illuminated clothing) whereas current trends emphasize bringing interactive functionality to jewelry with more traditional aesthetics" (Berglund et al., 2016). This finding indicates that the market is still hesitant in adopting fashion or lifestyle that deviate too far from the current trends and normative aesthetics. With accessories, however, there could be a greater deviation from the norm, because they are less visible and obtrusive when placed on the body (Berglund et al., 2016). The sense of what things 'should' look like is engraved in people's heads and changing this would only occur over time and in small steps. Fashion-change is a great example of this hesitation to deviate. According to Lynch and

Strauss (2007), fashion change can be explained by different theories. The sociological theories "focus on fundamental collective behaviour, and the role of ever-changing fashion in marking group membership and more importantly status and power" (p.9). People dress to conform to a particular group they identify with, but at the same time, they want to feel unique and special as an individual in that group. Hence the preference of familiar designs with a small twist.

In an article on digital jewellery, Miner, Chan and Campbell (2001) specifically point out the importance of fashionable design in pervasive devices, such as smartphones, or digital jewelleries. The difference between smartphones and wearables is that smartphones can be carried in a pocket or a bag and placed independently in relation to the body, while wearables are worn and function on the body, which can affect the wearer's self-image and presentation, and therefore requires more attention to design. "Any technology that asserts itself forces the user to incorporate a technological image into his/her self-image. If it can be integrated fashionably, then the technology itself can be beneficial to the user in an unobtrusive way" (Miner et al., 2001). By unobtrusive, the authors mean a design that is in a recognisable form, a form that the consumers are already familiar with, for example, jewellery. A ring, such as the Motiv Ring (<https://mymotiv.com>) or the Blinq Ring (<https://www.kickstarter.com/projects/904651122/blinq-smart-jewelry-worlds-1st-fine-jewelry-wearab>), vibrates when the user receives a phone call is still a ring; apart from the wearer, anyone who sees it would assume it is an ordinary ring. Compared to a device, that appears foreign and highly technical, strapped to the wearer's hand, the majority of

consumers prefer a more familiar object, like a ring. These unobtrusive designs would draw less unwanted attention and make the wearers more comfortable in adopting wearables that has yet to be seen by the mass market. According to Freudian psychology, unconventional items often indicate non-conformity (Lynch & Strauss, 2007). With a more natural interface and a non-technology aesthetic, wearables would be accepted and adopted much quicker, because one of the major psychological motives behind consumer behaviour is to conform to social standards.

Another way for wearables to be quickly accepted by the consumers is to use materials that are more familiar to the users. Wearable Technology or Wearables are often perceived as a smart/technical device that can be worn on the body as a functional accessory or a kind of lifestyle support. However, the smartness in materials themselves is sometimes overlooked. In Anca Filimon's book *Smart Materials: Integrated Design, Engineering Approaches, and Potential Applications* smart materials are defined as "highly engineered materials that responds intelligently to their environment. [...] Materials transitioned from their premodern role of being subordinate to needs into a means to expand functional performance and open up new formal responses" (Filimon, 2018, p.3). The antibacterial underwear made of nanosilver and wool merino fibres by Organic Basic's is a good example of a smart material (<https://us.organicbasics.com>).

Park, Chung and Jayaraman in their article *Wearables: Fundamentals, Advancements, and a Roadmap for the Future* proposed wearables can be classified using six criteria:

- 1) Single function or multiple functions,
- 2) Invasive or non-invasive to the wearer,
- 3) Active or passive depending on whether a power source

is required,

- 4) Wired or wireless in transmitting data,
- 5) Disposable or reusable, and
- 6) Its field of application.

A smart device, such as the Apple watch, would be a multi-functional, minimally invasive, active, wireless and a reusable wearable for lifestyle support. The smart material used in antibacterial underwear would be a single function, non-invasive, passive, and reusable wearable for everyday use. In this thesis, both types of wearables are examined, but the final step of prototyping focuses mainly on the use of smart materials and their functionalities.

## 2.2 Elements of Fashion Design

The essence of successful fashion design is to creatively harness the zeitgeist or spirit of the time, and translate its influence into unique and marketable merchandise (Ruppert-Stroescu & Hawley, 2014). The creative process for fashion design can function in two ways, leadership creativity and adaptive creativity. Leadership creativity focuses on "divergent, experimental, and insight-based thinking with few restrictions and a heightened awareness of craft and technique to develop products that push the industry into a direction different from the way it is currently trending" (Ruppert-Stroescu & Hawley, 2014, p.22). This kind of creativity can often be found in haute couture and high-priced fashion items, because leadership creativity requires extensive investment in research and development. Adaptive creativity is often defined as focusing on "convergent thinking, analytical and scientific methods that meet the challenge of creating a product with well-established parameters or limitations and imply a heightened awareness of operations, and management, methods and technology" (Ruppert-Stroescu & Hawley, 2014, pp.22-23). This is often seen in designs where the designer borrows from past collections and uses them as inspiration, as well as some lower-

priced items that are mass produced.

Leadership creativity is rarely practiced by mainstream fashion designers because it is innovative, directional and drastically different from existing products and often a full expression of the designer's creativity. Such designs are overly expensive and often not commercially viable. A great example of leadership creativity can be seen at Comme Des Garçons. Rei Kawakubo's designs are astonishing; she always impresses the fashion critics and journalists with her over-the-top creativity. They have been described as 'hugely enjoyable' and 'over-the-top fabulosity' by fashion journalists (Mower, 2018). However, in the consumer market, Comme Des Garçons's main collection fails to be appreciated by the majority of the public. In the article, *The Vast, Mysterious Empire of Comme des Garçons*, author Chavie Lieber comments, "It's (Comme Des Garçons) about being in the know, about being fashion-literate, and being confident enough to appreciate what any sane person would look at and think, 'What on earth?'" (2017). This often is the reason why designers choose to deviate from leadership creativity. The pressure to sell and be profitable leads them into the realm of adaptive creativity.

Adaptive creativity produces products that are readily acceptable and more likely to be commercially successful. One example is the world of fast fashion, where retailers such as Zara and H&M translate popular designs from others into their own price points. This is also a form of adaptive creativity. In the past 10 years, H&M has optimised its adaptive creativity and created many successful collaborations with major fashion designers. Many of the collaborations sold out within minutes, and people were lining up outside the stores waiting for them to open. Hence the popularity of adaptive creativity in mainstream fashion.

In McKelvey and Munslow's (2011) book, *Fashion Design: Process, Innovation and Practice*, the steps most fashion designers go through during their adaptive design process are outlined. First, the designer analyses the brief that outlines what is requested from a client or a project. The second step, research inspiration and research direction, allows the designer to gather information from fashion forecasters, market research and other sources of ideas to assist in their design process. Once this research is done, the designer starts to design and create sketches and samples. These designs are inspired by research but limited by the design brief. In other words, an adaptive creative process.

When analysing a brief, the designer has to identify some key elements, such as: What are you being asked to design? What can you use in your fashion direction? Are there any special considerations? These are all restrictions a designer has to consider during the design process. Once the designer finishes deconstructing the brief, they should have a good idea of what research direction is required. Once the research direction is determined, the designer will start collecting information and materials to help them develop a theme, a texture and/or a style of design. One important source of inspiration is trend forecasting periodicals and agencies. These periodicals and agencies collect and analyse fashion information from runway shows and popular current events to predict what will be on trend in the next season. These publications can further inform the designer's direction in their design process. During the design process, the designer experiments with shape, form, silhouette, and proportion, and considers the aesthetic appeal, as well as fit and comfort.

Another distinguishing feature of the fashion industry is its merchandising process, which involves a leap from the runway to retail. What is seen on the runway rarely reaches the store as is. The majority of designs are altered and adapted for greater public acceptance. The stylists' artistic expressions on the runway serve solely for marketing purposes. A bold visual presentation is often what gives the designer and the brand the exposure they desire. However, when a product reaches the store, its appearance can

change dramatically. The reasons for such alterations include, firstly, that all the runway pieces were designed for models who have a certain physique that average people do not have. Secondly, many outfits seen on the runway are impractical for everyday tasks. Hence the designer and merchandisers are responsible for adapting the designs to the average person. They often borrow elements of a popular style from the runway and incorporate them into a more practical design for the stores.

Marketing and media exposure are very important for any designer. This constant exposure can shift people's views on certain products and designs. A great example is the athleisure trend that went viral in the past decade. Sportswear used to be seen as informal, and it was impolite to wear it in a social situation. However, as more celebrities and KOLs (Key Opinion Leaders) were captured by paparazzi in different social settings wearing sportswear, the exposure and desire of sportswear increased. The sportswear designers started to deviate from traditional sportswear designs, and began combining more fashion and luxury elements into their products; hence the word 'athleisure' started to trend, and sportswear became a socially acceptable outfit in many situations.

## 2.3 Current Wearable Design Approaches

Wearable technology has largely been focused on technical design. The product development process tends to follow an engineering design process, based on HCI (Human Computer Interaction) approaches. It identifies a problem and associates users' needs and develops a product that technically meets these needs. In the article, *Critical Review on Smart Clothing Product Development* (Suh et al., 2010), the authors identified several existing functional apparel product development processes. All of

them start with problem identification, because in a technical product development process, it is crucial to identify a problem and design a product that can solve the identified problem.

In current wearable technology design, the problem is often identified through user analysis. “Designers must gain an in-depth understanding of the needs of the chosen end-user to inform decisions making” (McCann, Hurford, & Martin, 2005). Hence, the decision on whom to choose as the product end-users are very important. McCann further emphasises her view on end-user analysis in the book *Smart Clothes and Wearable Technology* (2009). She suggests an investigation of the lifestyle of the wearers is required to provide the designers with insights into appropriate functionality and true usability (McCann & Bryson, 2011, p. 51). With such emphasis on a user-centred design process, the wearable technology designers’ most important task is to define a user group, and create an end user persona for their products. How do you identify an end user when your product is so revolutionary? Wearables are still in their early stages of development. Most products in development have nothing to

compare to, and market research is almost non-existent. Unlike fashion designers, where sales data can be accessed to support their design direction, and trend forecasting agencies to inform their design aesthetics, wearable technology designers have limited information on what consumers prefer due to the lack of predecessors and consumer data. In the article, *The Future design direction of Smart Clothing development* (Ariyatum et al., 2005), the authors interviewed experts in the field of wearable technology and found that healthcare and sportswear are the two main areas of application focus. Healthcare and sportswear are two areas where functionality is highly valued. The existing healthcare and sportswear consumers are identified as potential end-users to most existing wearables on the market. Their preferences and lifestyles are analysed to inform current wearable technology designs.

After identifying the potential end-users, wearables designers will pinpoint a problem that once solved will potentially increase these end-users’ quality of life. To pinpoint this problem, detailed knowledge of the users’ capacities and limitations, as well as their needs and wishes, is gathered. In Rosenblad-Wallin’s article, *User-Oriented Product Development Applied to Functional Clothing Design* (1985), she describes the user-oriented product development method starting with a user problem or a deficiency experienced by users, then an accurate problem analysis is carried out to formulate relevant user demands for the designer to study. The user demands are then “balanced and assigned priorities in

importance from the standpoint of the use" (Rosenblad-Wallin, 1985, p.281). This problem-solving mindset is common in a product design process, because in product design, usability is one of the crucial elements that determines user acceptance and often market success (van Eijk et al., 2012). Once the wearables designer adopts such a mindset, functionality becomes of utmost importance. Anything that hinders its functionality will be eliminated or redesigned.

Although some wearable technology designers acknowledge the importance of fashionability in their products, they tend to be oriented towards a user-centred, problem-solving approach, because if a wearable technology only appears attractive but lacks functionality, it will not be commercially viable. On the other hand, if functionality dominates fashionability, the end product may become something less desirable for the consumer market. As Apple's Chief of Design, Sir Jonathan Ive once said,

"We're surrounded by anonymous, poorly made objects. It's tempting to think it's because the people who use them don't care — just like the people who make them. But what we've shown is that people do care. It's not just about aesthetics. They care about things that are thoughtfully conceived and well made. We make and sell a very, very large number of (hopefully) beautiful, well-made things. our success is a victory for purity, integrity — for giving a damn." (Arlidge, 2014)

Wearables designers should care about both the functionality of the product and its appearance. The success of Apple products is a great example of seamless integration of fashionability with functionality. The Apple style both in software and hardware attracted a global following since its iPod launch at the beginning of the century. In Seymour and Beloff's article, *Fashionable*

*Technology—The Next Generation of Wearables*, the authors conclude "fashionable wearables must engage the wearer through the mechanisms of fashion. Wearables, objects or garments must become more than mere mediators of perception. They must become communicators of style" (2008, p.139). This issue is the central focus of this thesis.

## 2.4 Current Barriers in the Wearable Design Process

There are many barriers to current wearable technology design and development. Dunne (2010) identifies some key design issues in relation to the commercialisation of wearable technology, such as functionality, manufacture, development practice and also consumer acceptance. The functionality barrier is most prominent in areas, such as sensing, interacting and powering. Most wearables have some kind of a sensor built-in for various purposes. For example, Fitbit's sleep monitoring wristband will sense the wearer's movement during various sleeping stages and determine whether the wearer is sleeping or awake (<https://www.fitbit.com/nz/home>). To enable sensors to work accurately they should be positioned close to the body, or on a particular part of the body. However, this can be a problem because such a placement of sensors can be uncomfortable or distracting. The tradeoff between comfort and data accuracy is a constant struggle for many designers of wearable technology. The same issues also apply to modes of interaction and power a wearable device. The selection of a material for comfort reasons can impact on function. For example, if the wearer wants a light and portable device, they might have to sacrifice longer battery life, as stronger batteries are often heavier and bulkier.

A second barrier is manufacturing. Dunne (2010) says that in the field of wearable technology, the collaboration between designers and companies from dramatically different industries is essential. Such different backgrounds and production systems mean different mindsets and a different design and development process. Garment manufacturers lack the knowledge or systems understanding to work with electronic components, while tech companies have no understanding of working with garments, especially when the garment industry already has an established history and a very well-developed process. It is traditionally resistant to change because the garment industry works on low margins, investments in new machinery and technical skills are too costly.

A third barrier is the barrier of developmental practices. The best example is the expected development time spent on each product and its use cycles. A mechanical watch can be used for years or even for generations, and the design of a mechanical watch took centuries to refine. On the other hand, a cell phone is expected to be replaced every two to three years or even longer, and a new design and interface is available usually once a year. Fashion designers, on the other hand, will design and oversee production of several garment ranges in a year. Consumers are encouraged to refresh and restock every season. The industry is geared towards fast fashion. These differences in development time and use cycle between a garment and an electronic device greatly hinder the collaboration between these two industries. Garments are expected to have a short development time and use cycle, but electronics take longer to develop and are expected to last much longer than a season (Dunne, 2010).

The last barrier, Dunne (2010) identifies the barrier of consumer acceptance. The comfort requirement of a wearable device is far more rigorous than any mobile device. Also, concerns for safety and security are rising. All the personal data collected makes users worry about issues such as identity theft and illegal surveillance. Another consumer acceptance issue is identity and aesthetics. "A worn artifact has a much more intimate impact on the wearer's identity: it becomes in some ways 'part' of the wearer just as clothing does, exerting influence on body image, perceived social status, and societal roles," says Dunne (2010, p.60). In other words, the decision-making process of a wearable device often mirrors that of a garment purchase. However, fashion trends change so rapidly that many wearable device designers cannot keep up. Hence, another reason for the lack of successful wearable devices on the market.

Another important barrier to wearable technology design is the limited focus on accurately identifying target users and their actual needs (Perry et al., 2017). Perry et al.'s (2017) research focusses on the designer-users, namely those who design and also purchase wearable devices. In their opinion, designers' survey and study prospective users who sometimes have never purchased, used or do not have prior knowledge of a wearable technology product. The perception of needs may be very different once prospective users see the actual product. Also, the users surveyed and studied have different backgrounds, and their responses and expectations of such products are different. However, designer-users have the first-hand experience with wearables; these experiences and their feedback are much more informative to the design process than randomly selected survey participants. Perry et al. (2017) identify them as a major consumer group of wearable technology. They suggest their needs, often neglected, should be brought under the spotlight and investigated for the future design of wearable technology devices.

The above-mentioned barriers are areas where many wearable designers are currently struggling, but without a systematic change in both the fashion and technology industries as a whole, no solutions are attainable. The merging of two different fields needs time, courage and investment. This thesis does not propose to resolve all these barriers, but it seeks to investigate the design and development barrier with a fashion design perspective where the study and analysis of consumer behaviour and acceptance is well established.

## 2.4(a) Target Customers

Consumers' motivation and desire to consume changes over time, from conformance to mass culture to expressions of individuality and self-enactment. Psychologist, Abraham Maslow viewed the population as divisible into categories, based on their needs, motivations and levels of self-development. These categories are survivors, believers, thinkers, strivers, achievers, makers, experiencers, and innovators. Their consumption is motivated by three kinds of motivations: ideals motivation, achievement motivation and self-expression motivation (Lynch & Strauss, 2007). Innovators being on the top of the pyramid have access to most resources and innovations. They are sophisticated consumers and always open to new ideas. "Expression of taste and culture in activities and consumption are hallmarks of innovator behavior" (Lynch & Strauss, 2007, p.5). This group of consumers is usually the first ones to adopt a trend or a new technology. On the bottom are the survivors; they are uncomfortable with change and usually have limited impact in the marketplace. They are resistant to trends and new technology. Also on the top tiers of the pyramid are the Experiencers and Makers. Experiencers are motivated by self-expression. "[They] are fashion forward and risk takers, seeking the new and the interesting. Consumption is dictated most by interest in an innovative, leading-edge, cool style. [They] want to stand out in the crowd" (Lynch & Strauss, 2007, p.5). The Makers value function over fashion and prefer value over showiness.

In the fashion world, consumers are also categorised, and the most valuable to designers are the innovators and the early adopters. Similar to Abraham Maslow's theory, the innovators are most cutting-edge. They are risk takers and willing to experience the new and unknown. The Innovators are usually the first to adopt an innovation, and they may even be the innovation creators themselves (i.e. Designer-Users). Although they only consist of a very small part of those who adopt innovations, the Innovators are often the opinion leaders of their social circle and play an important role in diffusing the trend (Kim et al., 2011). The second group of individuals to target is the Early Adopters. This group is characterised as more open-minded with a more favourable attitude towards change. These early adopters often have a higher socioeconomic status and education level. Unlike the Innovators, Early Adopters' acceptance of innovation will lead to more mainstream adoption (Kim et al., 2011).

These two groups of consumers in the fashion industry can also be identified in the wearable technology industry. In Schaar and Ziefle's (2011) research of user-perceived benefits and fears of smart clothing, they conclude that people who have more technical experience (i.e. the Designer-Users/Innovators) are more likely to accept wearables immediately and with higher confidence. In this research, all participants are of high educational standards, conforming with Kim's classification of Early Adopters. Schaar and Ziefle (2011) also find that men are more open to wearable technologies than women, because women are more concerned with safety and social acceptance.

## 2.4(b) Trend Development

Trend forecasting in the fashion industry first emerged after the Second World War, when mass production and retail development became popular. Changes in fashion were documented, analysed and predicted. Since the 1960s, fashion trends have shifted from a single trend that originated from designers and social influencers, and then 'trickled down' to commercial high street products, to multiple trends that are influenced by subculture and focus more on the individual. Consumer aspirations are brand led and lifestyle driven (Lynch & Strauss, 2007). Now with the popularity of the internet, fashion trends are more and more diverse. The fashion bloggers, and KOL's are all developing their own trends. Trend forecasting companies like WGSN (World's Global Style Network) are hugely successful in supporting creative industries. Designers and creators subscribe to their services every year to support their commercial success. Journals, such as Nextlook and Textile View Magazine, analyse the most recent runway shows from all the major fashion capitals and consider current events and fashion trends. From this knowledge, distinctive fashion features are summarised and served to their subscribers to generate ideas for new collections in forthcoming seasons. Information includes colours, materials, surfaces, patterns, silhouettes, styling and other design elements to complete a fashion look.

In the most recent issue of Nextlook, Spring/Summer 2019 trends are predicted by editing and analysing the S/S 2018 designs. The journal identifies six key looks for S/S19: City Heroine, Funfair, Western Mood, Bird Girl, High Touch and Good Vibrations (2018). Trends often emerge from current events, social movements, changing lifestyles and ideas or cultural exchange. For example, in our society today, the talk of gender equality, the millennials starting to dominate the workforce, the fear of supercomputers and the movement towards a more holistic lifestyle are all reflected in the trends. The High Touch inspiration, for example, is said to be in contrast to high-tech and focuses on humans not being the technology. Orsech says:

The theme provides an aesthetic that moves Sportive looks say goodbye to the classic activewear and are contemplative and decelerated. The inspirations move between the areas of yoga and spa; the materials are soft and elastic, the colours are light and pastel, between medical-futuristic sportswear and soft, meditative wellness. (2018, p.134)

The athleisure trend with lightweight, synthetic, and elastic material and soft, pastel colours are said to be still relevant and on trend for S/S19. These trend forecasting journals are essential for the mass-producing retailers. Using this information, companies can narrow down their production and only produce designs that are predicted to be popular.

In the wearable technology design process, trends and forecasts are seldom used (Berglund et al., 2016). Wearables are fairly new to the market, and there are limited information and market research to support trend analysis. Technology development, unlike fashion, can result in each generation being significantly different from previous ones due to rapid technological

innovation. The size of electronic components is one example of technological innovation, because of the constant reduction in size, electronic devices are getting smaller and more compact. In addition, the elements that go into creating wearables are still in the early stages of development; there is little in the way of standards or accepted norms in terms of wearable technology applications, and; there are few established conventions to reject or reinterpret. According to Berglund, Duvall and Dunne's (2016) survey, prior to 2014, the leading categories in wearable technology design were jackets/sweatshirts, gloves, watches, and shirts. Now the trend in wearables has moved towards accessories and jewellery. They say that "earlier applications may have focused more on novel approaches to fashion and lifestyle [...] whereas current trends emphasize bringing interactive functionality to jewelry with more traditional aesthetics" (2016, p.43). After Apple's iWatch became widely adopted, many traditional watch and fashion brands started to manufacture their own smartwatches, for example, Fossil, Tag Heuer, Montblanc and Louis Vuitton (Taylor, 2017). On the other hand, wearable accessories have also become popular, with companies like Fitbit, Jawbone, and Misfit all trying to integrate fashion elements into their products by collaborating with fashion designers and brands. Hence the importance of incorporating fashion design elements in wearable technology design.

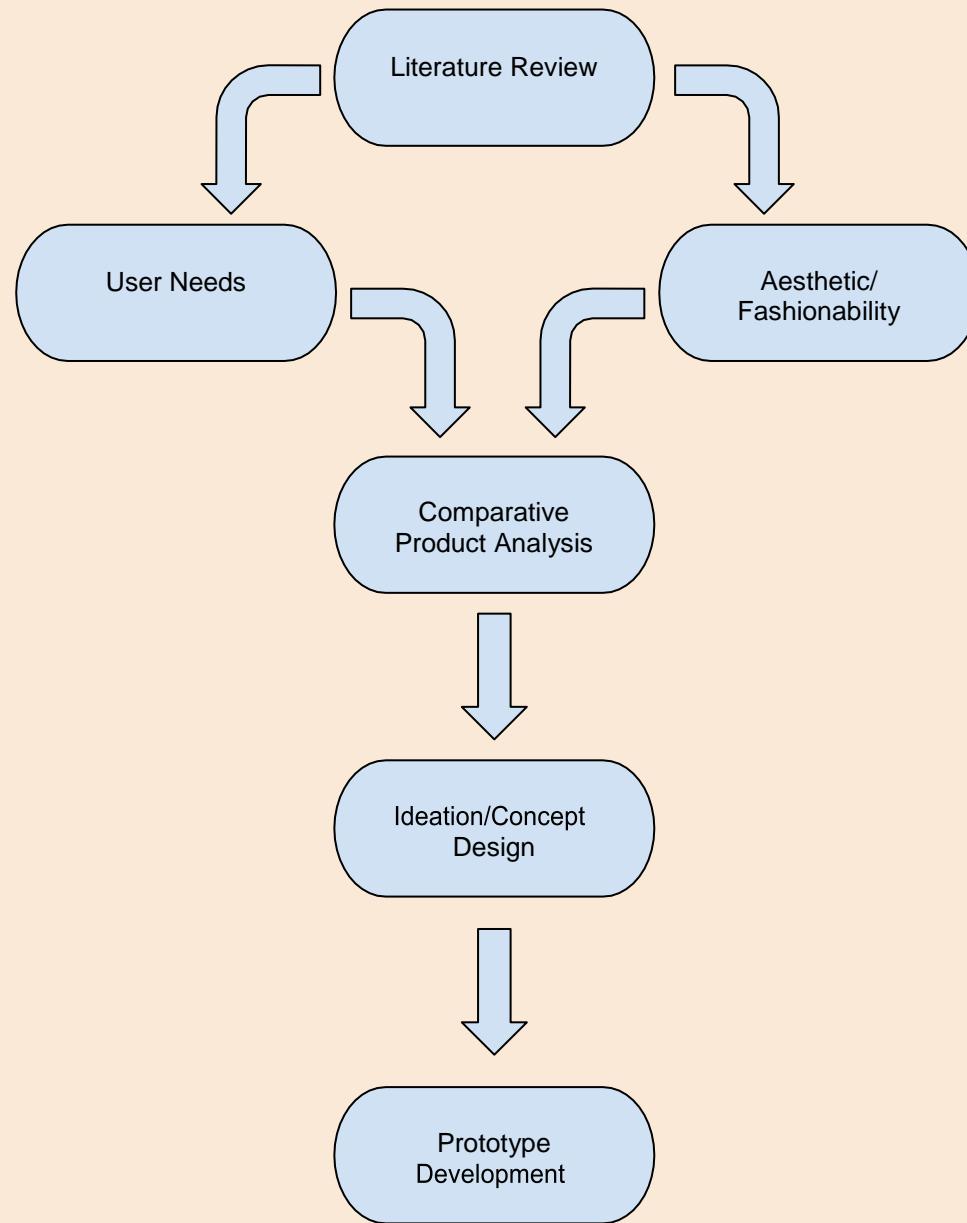


Figure 1. Lin, M. (2018). Research Method [Diagram]

# Chapter 3. Methodology

## 3.1 Methodology

This research has employed a mixed-methods approach, outlined in Figure 1, that includes forms of critical review and comparative analysis, along with research-through-design. As the researcher comes from a fashion marketing background, with limited practical experience in the design of wearable technologies, an inductive approach has been used. Collins (2010, p. 43) recognises that “the strength of an inductive approach lies in understanding the context within which the research takes place and not focusing on a cause-and-effect relationship.” This approach supports a less rigid methodological approach that permits an alternative understanding of what is happening through the research. A theory is then generated from the investigation. The researcher set out to understand and explain the slow acceptance rate of new wearable technologies in the consumer market. The theoretical understanding developed through this research informed the design of a series of concept prototypes, where a process of ideation, inspiration and direction as research was used to explore and articulate potential fashion-led strategies. These concept prototypes were reviewed and two design concepts, using seamless knit technology with the assistance of a senior technician at AUT’s Textile & Design Lab were further developed resulting in two novel design prototypes. This approach has led to the development of a new product concept and a design strategy that could be utilised by wearable technology designer.

This research combines different qualitative methods. The first stage of the process involved a literature review. It provides an overview of research that has been done in wearable technology design and a critical review of selected sources on this topic. From this review, an evaluation of where research is needed emerged. The literature review provided directions for the next stages of the research (Webster & Watson, 2002). This project includes a comparative analysis of a popular existing type of wearable on the Chinese market, air-filtration facewear, and this analysis has informed the following ideation and prototype process. From the research conducted through these stages, a theoretical position was induced. The final stage of this project utilises a research-through-design (RtD) approach that involves the ideation of prototype designs for a particular product category, facewear. As Cross (2006) recognised, research through design is to develop, articulate and communicate design knowledge through people, process and products. The investigation of people’s ability to design, their design behaviours and the nature of design ability are all parts of the research-through-design process. Another part of RtD is “the study of the processes of design, and the development and application of techniques which aid the designer” (Cross, 2006, p.101). Much of RtD revolves around the study of the design ‘language’. Design knowledge also resides in products. “Much everyday design work entails the use of precedents or previous exemplars – not because of laziness by the designer but because the exemplars actually contain knowledge of what the product should be” (Cross, 2006, p.101). To summarise Cross’s view, a good RtD must be reflected on by the practitioner, and re-usable results from that reflection have to be communicated to other practitioners. Fallman (2003) also notes:

Design is a matter of making; it is an attitude to research that involves the researcher in creating and giving form to something not previously there. [...] In design-oriented research, the knowledge that comes from studying the designed artifact in use or from the process of bringing the product into being is the contribution, while the resulting artifact is considered more a means than an end. (Fallman, 2003, pp.225-231)

In this research, the end product is a prototype and has not been manufactured, but through the research and design process, some of the difficulties faced in the wearable technology industry are identified and addressed. Moreover, as Fallman has suggested, the ideation process is a contribution to understanding the topic, in this case, the wearable technology market.

To begin the ideation process of designing a wearable technology device, research and analysis were conducted on the current fashion design processes by comparing approaches described in several key fashion design reference books. Since the fashion design process has already been well developed, most authors present a similar process. Therefore, the authors' backgrounds, as well as their writing styles were evaluated, and a decision was made based on an approach that best fits with the aims of this thesis. Then by comparing a selected fashion design process with the current wearables design process, the researcher narrowed down the specific stages where the two processes could be combined. Details of this integration process are explained in Chapter 5.1 Introduction to Design Development.

After the initial design research process, sketches were developed to further cultivate the possible advantages that the combination of different design processes could bring. In this research, drawing is used as a tool for thinking. Drawings and sketches in design research are ways to externalise ideas already in the designer's head as well as a method for shaping new ideas. When ideas are drawn and actualised on paper, the designer can examine details that are not fully conceptualised in her mind more carefully on paper. Drawings can also be used to explain ideas and knowledge that are elusive and where words are often inefficient in explaining (Theron et al., 2011). Therefore, drawings are an essential part of every design process. The fashion design process utilised in this research can be categorised into stages of brief analysis, inspiration and direction research, and design (McKelvey & Munslow, 2012). The resulting concept prototypes are presented in sketches, and photoshopped images followed by an analysis of the design decisions and reflection on the ideation processes. The sketches and images are limited due to the researcher's lack of experience in design, as the researcher's professional background is in fashion trend analysis, fashion marketing and consumer behaviour.

Through this mixed methods approach, information gathered in each phase helps inform the next stage of the research. In *Mixed Methods Research: Merging Theory with Practice* (2010), Hesse-Biber proposes “a practice of mixed methods that is firmly rooted within a research context with the intention that the method or methods used to foster a richer understanding of the research problem under investigation” (2010, p.11). In this research, the mixed methods used to approach an alternative wearable technology design process fostered an understanding of why wearable technology has been adopted at such a slow rate by the consumer market. The literature review focuses on the design and development of wearable technology and the problems encountered in the adoption of wearable technology. From the literature review, two primary concerns in wearable technology design were noted: misconstrued end-user needs and the lack of fashionability. As mentioned in Chapter 2.4, many existing wearable designers approach their design using knowledge obtained from non-users, which can be misleading. A lack of fashionability observed by fashion critics and the lack of trend analysis in the current wearable technology market all contribute to the slow adoption rate of wearable technology. Reflecting on this observation, the researcher proposes an alternative design approach that could contribute to solving these problems.

The researcher spent some time in China last year, and heard many complaints about air-pollution from locals as well as tourists and expats. She has also experienced serious health issues due to air-pollution during time spent in China, which forced her to personally test out many anti-pollution masks on the market. This started with an online search of most popular and effective masks on Wechat (the number one Chinese messaging and social media

platform) and CCTV-2 (China Central Television Channel 2 - Economy Channel). CCTV is the predominant state television broadcaster in China where most Chinese people get their news from). Then after comparing user feedback and online reviews on Taobao (the biggest e-commerce website in China), the researcher purchased and personally tested 10 different anti-pollution masks. Some of these masks are more technologically sophisticated than others. Their efficacy and wearability also varies dramatically. From this experience, the researcher decided to focus her design research on facewear, especially anti-pollution masks. Is it possible to design a mask that's efficient in filtering harmful particles, and also fashionable to wear without disrupting the wearer's identity and image?

The researcher considered the incorporation of fashion trends analysis into wearable technology design. Trend analysis is a common practice in the fashion design process. Companies such as the World's Global Style Network (WGSN) help businesses stay relevant and find their next growth opportunities (<https://www.wgsn.com/en/>). Trend forecasting publications, such as Textile View Magazine (2018) and Nextlook Trendbook (2018), were used to inform the ideation process. The ideation of designs for anti-air-pollution masks with existing technology as well as upcoming technology forms the latter stages of the project.

In fashion design, trend forecasting is often used to assist fashion designers as inspiration research as well as for other commercial reasons. People want to be ‘in fashion’ or ‘on trend’, to partake in a collective moment to be in step with society and be in touch with the present. To participate in similar themes and ideas that reflect the times, people would experience a sense of belonging (Hemphill & Suk, 2009). Hence the idea of incorporating fashion trends into wearable technology design. This research suggests that if wearable technology is designed following current fashion trends and thus made more fashionable, the consumer acceptance rate may increase and improve the adoption of wearable technology in the consumer market.

To summarise, this research project aims to contribute to improving the understanding of the slow adoption rate of wearable technology in the mass consumer market. The project uses a mixed methods approach. It begins by investigating the current status of wearable technology in the mass consumer market through a literature review. Then a comparative product analysis of existing anti-pollution facewear products on the Chinese market is produced to give insights into some of the existing difficulties experienced with these products in a real-life situation. The third phase of the project involved a research through design approach where the researcher developed wearables' concept prototypes to explore the potential of bringing fashion design processes and trend analysis to wearable technology design. Two mask concepts were then taken further into proof of concept prototypes. This research examines the wearable technology design process from multiple perspectives, such as literal, practical and hypothetical, so future wearable technology designers can learn from this process and consider incorporating elements other than functionality and user experience into their design process.

### 3.2 Detailed Methods in Concept and Prototype Development

Based on information gathered from the research outlined in Chapter 2, the ideation process of this research followed an integrated fashion design process inspired by McKelvey's book *Fashion Design: Process, Innovation and Practice* (2011), Suh et al.'s Critical Review on Smart Clothing Product Development (2010) and McCann and Bryson's *Smart Clothes and Wearable Technology* (2009). In these references, each author has to an extent researched and developed their own design process in fashion design and/or wearables design.

According to McKelvey (2011), the typical fashion design process has been very well developed because of its long history. There are many references on fashion design and its processes, and they are generally similar in concept. However, in the design and development of smart clothes and wearable technology, the design process is still being developed. Suh et al.'s article reviewed many historical design development processes in new product development, apparel product development and functional apparel product development (2010). Historically, in new product development, idea generation is based on problem recognition and opportunity identification. In apparel product development trend analysis takes precedent. Functional apparel product development has taken after new product development in the idea generation stage, but the design and prototype development stages are very similar to that of apparel design with one exception: the information

gathering stage where target consumer's preferences and needs are closely examined (Suh et al., 2010). In recent years a design process that focuses more on end-user needs has prevailed (as discussed in chapter 2.3). McCann proposes a hybrid methodology "to guide the design research and development process of a smart clothing layer system" (McCann, 2009, p.45). The integrated fashion design process used in this thesis first starts with a design brief that presented a concern that is personal to the researcher. This design brief functions partially as a problem recognition process often observed in new product design process. Second, an inspirational search of trend starts to inform the direction of the design, as often seen in apparel product design. Trend research for this thesis is done through reviewing several fashion prediction materials and existing popular products. Fashion prediction material and consultancies are popular among fashion designers because they rely on experts in a variety of fields for their structure, and they have personnel all over the world to help gather intelligence. After trend research is the intelligence gathering process on material and techniques. There are a variety of sources that can aid this intelligence-gathering process, such as street styles, retail feedback and new media data gathering. This research and intelligence gathering process is routine practice in the fashion industry (McKelvey, 2011). However, in the functional apparel or wearables design process, much emphasis is placed on users and resolving a user problem. In this integrated fashion design process, emphasis is placed on both trend/fashionability and user-need/functionality.

Once the intelligence gathering process is done, a balance between the two focus points is needed. How much of the trends observed could be utilised to compliment user needs? How would functionality affect the attractiveness of the product? These two questions are constantly evaluated during the research process. After all the research is done, the actual design process begins. There are many elements to consider during the design development process: shape and form, silhouette, appearance/obtrusiveness, proportion, aesthetics, colour, surface decoration, texture/comfort, movement of the face, construction and functionality. During this process all of the above elements should be tested, worked and reworked. A satisfactory design does not emerge on the first iteration. After the design process, the two-dimensional drawn ideas will be transformed into a three-dimensional prototype for the designer to evaluate on a mannequin. Further decisions are made on details and fit of the design. The final stages of range planning and promotion are commercial considerations based on the client's brand image and philosophy as well as their target market and its preferences (McKelvey, 2011). Within the scope of this masters research, the final stages of range planning and promotion were not considered due to limitations of time and the project focus on the design process.

The design and research process is one of the most important processes in any kind of design. The initial research and ideation process often determines the direction a design collection is going, and it can affect its commercial success. This project aims to develop an alternative design process. Finally, there are time and financial restrictions that have limited this project in terms of the research, ideation and preliminary prototype stages. By utilising an integrated fashion design process on a wearables design, this project aims to encourage an alternative design thinking approach in the world of wearable technology design.

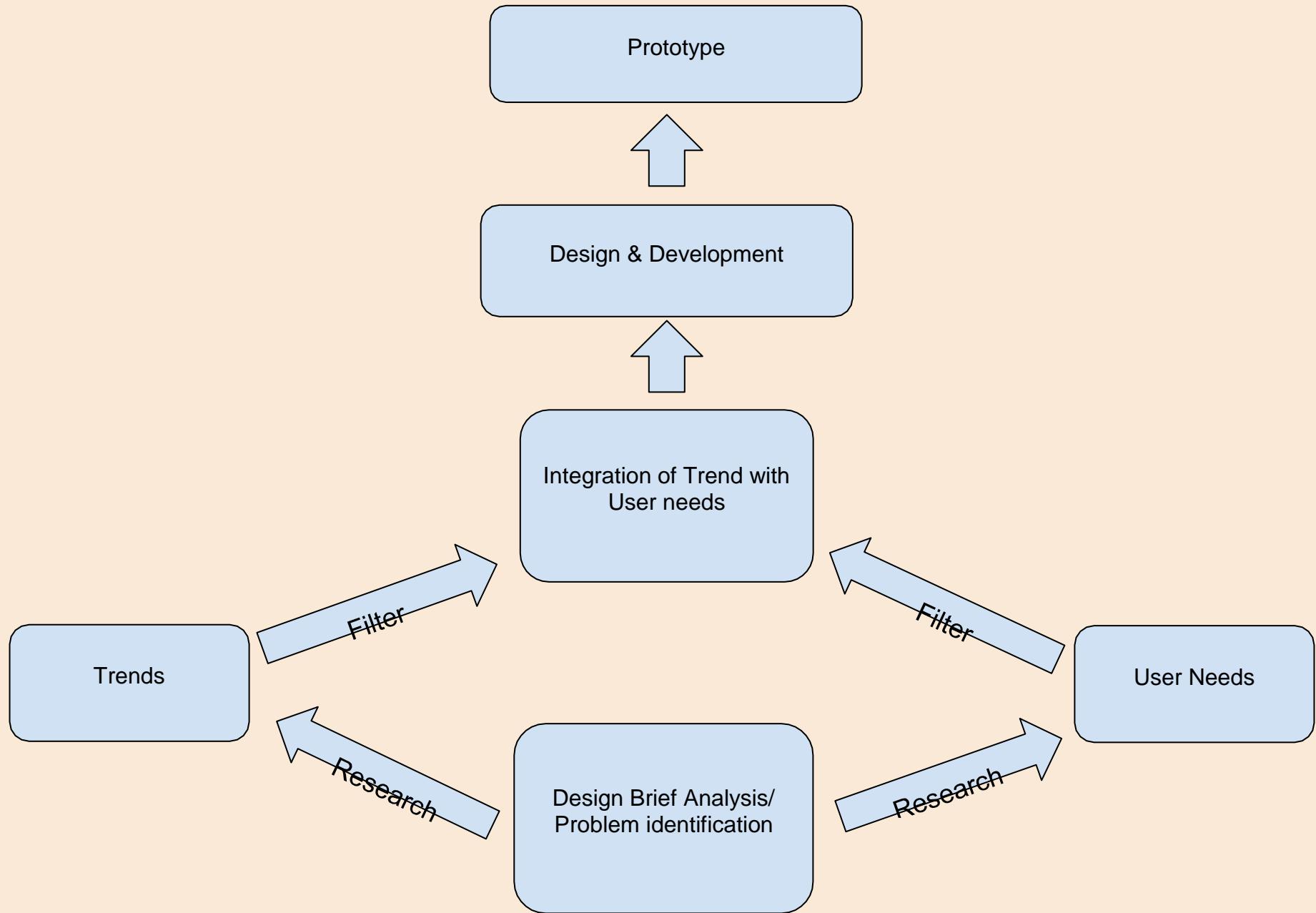


Figure 2. Lin, M. (2018). *Integrated Fashion-Wearables Design Process* [Diagram]

### 3.2(a) Design Brief

A design brief is a document that contains information on the requirements and specifications of a designed product. In practice, it also contains guidelines, such as budget, presentation style and deadlines. In the book, *Fashion Design: Process, Innovation and Practice* (McKelvey & Munsow, 2012). Hilton, a contributing author, details a process to analyse a design brief and how to proceed with the design process. The first approach to the brief analysis is the design approach, a reactive approach looking to identify and solve key problems to create a better product or service. Secondly, the innovation approach, is a proactive approach to change the way user needs are served by products or services, avoiding problems through the innovation (McKelvey & Munsow, 2012). For either approach, research is required. In the fashion design market, research and existing product research is crucial, because fashion is mostly evolutionary, some trends evolve and develop as time passes; however, there are also trends or fads that pop up for a short period of time (McKelvey & Munsow, 2012). By researching popular styles and trends as well as classical trends and styles the designer will be more likely to achieve commercial success. Hence market research agencies such as the World's Global Style Network (WGSN), became popular in providing qualitative research to understand patterns in consumer profiles and purchasing habits. Fashion forecasting companies are also used to provide trend information on colour, silhouette and fabrication (McKelvey & Munsow, 2012).

In the area of wearables design, both market research and product research are limited. Consumer profiles are still vague, and trend forecasting is almost non-existent. The few successful wearable technology devices on the market invested heavily in fashion marketing and the fashionability of their devices, for example, the iWatch. Due to this lack of research material, wearable designers are looking at traditional products and designing with those aesthetics in mind (Miner, Chan & Campbell, 2001). In this thesis, the design brief was drafted by the researcher based on prior research and personal experience. The design brief covered the story behind the product, specific requirements based on the Chinese national standards as well as international standards, and general user preferences gathered from the existing product analysis.

### 3.2(b) Fashion Prediction Materials

As previously discussed, fashion prediction materials pinpoint trends for the future and are often a reflection of current world occurrences. A wearable designer who has sufficient knowledge of current trends means that their design concept is of value to the users. Textile View Magazine is one of the leading trend forecasting publications in the industry. It provides trend forecasting in colors, materials, design and styling for the four upcoming seasons. It also provides street and retail reports, reports on merchandising, consumer behaviour and its influence on fabric and fashion trends. There were five main trends identified for Spring/Summer 2019 Womenswear in its 2018 issue: *Glitch*, *Greener*, *Token*, *Silence*, and *Smile*. *Glitch*, *Greener* and *Token* are interpreted and used in the design development process, because the researcher felt these three trends could be better incorporated into a wearables design. Collaged moodboards were developed using the Textile View Magazine S/S19 women's wear trends as references for design/inspiration research (Refer to Appendix B).

Nextlook Trendbook is another trend forecasting periodical that offers trend analysis in much more detail as seen in Appendix B. Unlike Textile View Magazine, Nextlook Trendbook analyses recent Designer shows in major fashion capitals and compiles detailed photographs of upcoming popular accessories as well as garments, where Textile View Magazine is more generalised and inspirational, Nextlook Trendbook is more factual. In Nextlook Trendbook (2018), editor Gabriele Orsech identified another six inspirations for Spring/Summer 2019. They are City Heroine, Funfair, Western Mood, Birdgirl, High Touch and Good Vibrations. Again, only three of the trends are used as inspiration for the same previously mentioned reasons.

After some exploration, a few upcoming trends are adopted as design inspirations. These trends represent a general direction of where the ideation process will begin. Wearables design trends with technological emphasis are extended and the other trends can also be integrated into the design to encourage more fashion thinking in wearables design. This research adopted and extended two of the specified Spring/Summer19 trends in its prototype designs with user preferences recognised from the comparative product analysis. In the analysis, although its efficacy was doubtful, the simple/clean design and the soft/lightweight material of the Pitta Mask gained great popularity in China. It might be inferred that a popular trend would make wearables more acceptable when it is combined with great user experiences even with limited functionalities. Although current trends are helpful in inspirational research, the time sensitiveness of these trends should also be evaluated alongside other wearables design factors and a development timeline.

## Chapter 4. Comparative Product Analysis

In order to understand consumer facewear preferences, research on existing consumer behaviour and a comparative product analysis were essential to the researcher developing a design criteria that could inform the next stage of design development. According to Nielsen and Ho (2017), during the past thirty years, China has seen a dramatic growth in its economy as one of the main industrial manufacturers of the world. Many factories and power plants are unregulated, and the use of motor vehicles has increased dramatically. A byproduct of this economic growth is air pollution. During the winter months when air pollution is most dangerous, some cities can experience visibility lower than ten metres (Nielsen et al. 2017). As a result of increased air pollution, respiratory issues are common, and the only way people know how to protect themselves is to wear PM2.5 masks (Zuo, 2018). Although many of these masks are deemed ineffective due to their material composition, shape and fit, people still purchase them in bulk as that is their only option (Vedal, 2017).

A television program on anti-pollution mask consumption aired on China Central Television in 2016. The program interviewed randomly selected mask wearers on the street and tested the masks in professional labs. These were valuable information because the interviewees were all current wearers of



Figure 3. Screenshot of CCTV program. From 消费测评: 防霾口罩怎么选? [Consumer analysis: how to pick a mask?]. Retrieved from <https://www.youtube.com/watch?v=cOz9drv0WFk>. Copyright 2016 China Central Television.

the product that this thesis will later design and develop. The feedback was genuinely based on wearer-user needs instead of hypothetical-user needs. Since these users are already incorporating a facewear in their identity, there is less concern for conformity and obtrusiveness in these target customers. Also, the fact that these consumers live in Beijing, China and are mostly young professionals, gave the researcher a better understanding of their lifestyle.

## 4.1 Analysis of Existing Products

In 2016, China Central Television (CCTV) Economy Channel aired a program on respiratory protective devices and their effectiveness to inform consumers on choosing a mask (Yang, 2016). In the program, journalists observed 300 people on the street and identified that only 14% of them wore a mask. Out of these wearers, 33% wore regular surgical masks, 29% wore masks with a valve, 19% wore cotton masks, and 5% wore a trendy celebrity endorsed mask. After interviewing the wearers, journalists found that most people were wearing a mask to protect themselves from PM2.5 particulates; however, the participants had limited knowledge on how well the masks performed. After a search on China's biggest online retailer Taobao, the result confirmed CCTV's observation. Surgical masks are the most popular choice with a sales record of 100,000 units sold every month at a unit price of ¥6.00 per box of 50; the second most popular choice is the cotton mask with around 35,000 units sold per month at ¥20.00 a piece with two disposable filter inserts. The third most popular mask is the trendy celebrity endorsed mask with a sales record of 13,000 per month at a hefty ¥119.00 per pack of 3 price. The CCTV producers took 9 different types of mask (Figure 3) to an independent consumer goods testing company WISENJOY for testing. The top three most popular masks were among the worst performers in the efficacy test. The producers then went to the Council of Standards China's lab for further testing, and the results were similar. The scientists at Council of Standards China

concluded that the better the mask fits the face, the better its filtering effects. Masks that seal tightly on all edges performed best in the lab, such as the 3M 9502 Mask. However, this criteria often results in breathing difficulties and low wearer comfort. Additionally, as part of the CCTV program, a scientist at WISENJOY recommended the E-mask was a resolution for breathing difficulties and wearer discomfort. However, these masks cost around ¥ 300 each. During the program, they conducted an experiment on the street and asked volunteers to try both the regular masks and the E-masks. The feedback was positive; most people agreed the E-mask did not cause breathing problems and were more comfortable. One of the volunteers pointed out that if appearance was not a concern, the E-mask was the best choice in comfort and breathability.

### ***Personal testing of masks***

Personal testing was conducted by the researcher trying on many of the masks available on the market whilst on a leisure trip to China in 2018. This personal investigation of the masks offered a better understanding of the issues of shape, material and fit. There are three common categories of masks on the market: the first is a plain white, disposable, single use mask; the second is a more colourful cotton mask that can be reused multiple times; and a third is the upcoming, high efficiency E-masks. One of the most effective disposable masks, is the 3M mask. This mask is very effective at filtering the harmful PM2.5 particulates in air (PM2.5:

atmospheric particulate matter that has a diameter of less than 2.5 micrometres). They are light in weight and most economical. Another popular brand is the Vogmask; this cotton mask is more costly; however, it is reusable and more fashionable. The E-masks are the most expensive, and marketed as most advanced in filtering harmful particles in the air. The 3M mask, unlike the Vogmask, is designed for single use. It is made of the 3M Advanced Electret Filter Material and it is said to be able to filter 95%-99% of airborne particles (World Air Quality, 2018). In comparison, the Vogmask uses microfiber filtration fabric that can filter 99% of airborne particles (World Air Quality, 2018). E-masks are not yet rated, because they are new to the market and not as widely known and worn.

Whilst I cannot testify to their effectiveness on PM2.5 particle filtering, after trying all three categories of masks, I found overall that they were helpful in relieving the respiratory discomfort I experienced, such as sneezing, and the effects of a sore throat, coughing and sinusitis upon inhaling polluted air. The effectiveness of these masks were tested, documented and published on many platforms, such as Wechat and CCTV. I gathered this information before I decided which masks to purchase and test for my own comparative analysis.

The first category of mask trialled was a single use mask that was said to be most effective in filtering PM2.5 particulates. Most of them only came in limited sizes, although they did offer an adjustable hook to tighten or loosen the straps; they did not fit well on my face, because the masks shape was too rounded and my

face is more oval. The wire on the nose bridge could be bent and adjusted to the size of the nose, but the chin size was not adjustable. The ear straps were too long for me, but when I tightened my strap it got too tight and caused indentations on my face that did not go away for hours after I took off the mask. The material also prevented normal air flow. When I breathed out the mask puffed up and created gaps between my face and the mask. This was undesirable as a filtration system, as air-filtering masks are only effective when they are tightly sealed so that the only way for air to come in and out is through the filters (Vadel, 2017). The other problem was moisture. After wearing the mask for a couple of hours, moisture started building up inside the mask, which created great discomfort. However, this moisture did help my breathing when the air was too dry and irritated my nose and throat. Additionally, I also stopped wearing glasses when I wore these masks because my breath escaped the mask through the gaps around my nose and caused my glasses to fog.

When I was wearing one of these masks in public, I felt self-conscious because only very few people were wearing masks. It seemed that masks were still uncommon as an everyday accessory. The only times people wore masks was when air quality was so bad that visibility had become an issue. Moreover, by wearing a mask on days when air pollution is only ‘high’ and not ‘hazardous’, I became non-conforming which resulted in self-consciousness. Also, the design of these types of disposable masks was so distinct it stood out from any outfit I was wearing,

and this made it difficult for me to incorporate these masks into a coherent self-image.

The second category of mask I tried, was the cotton masks. I bought these masks based on their positive online reviews and recommendation from the World Air Quality Index website. The appearance of these masks were much more appealing. There were multiple colours and patterns to choose from, and it came in different sizes. The shape of the mask was more triangular, which fitted better on my face. I picked a darker pattern and two all black masks because my outfits were mostly dark colours. The Vogmask and the Green Shield Washable PM2.5 mask were made of multiple layers, a filtering layer topped by a colourful fabric. It was much thicker than those single use masks. Some of these masks had a valve, but it seemed ineffective as a device for air circulation. They were all stifling to some degree. However, the cotton masks were more comfortable on the skin, and they could be washed and reused. The problems of moisture and fogging on glasses were the same as the other single use masks. Overall the design of the cotton masks were less intrusive for my personal image. It looked less like a medical necessity and more of a personal expression of style that could be worn to compliment my outfits.

For the third testing I tried two E-masks, the first one was a semi-electronic mask, XD Design Smart Mask. It has an appearance of a regular cotton mask, but the valve was detachable and rechargeable. The electronic component works as a fan to assist wearer's breathing, but the actual filtering was still done through the filter inserts in the cotton mask. This mask was

designed with ear loops as well as a hook-and-loop fastener around the head, because the electronic component is too heavy for the ear loops to hold in place. Although the look of the mask closely resembles a regular cotton mask, the fastening was very uncomfortable and kept sticking to my hair. Unlike the regular cotton mask that is lightweight and easy to put on, this E-mask is too heavy and required a tight fastening to hold in place which was very uncomfortable. The second E-mask I tried on was the Sifyer smart mask with a changeable filter insert. This smart mask is also very heavy and requires the wearer to tighten the neck straps to keep it in place. Although breathing was not a problem, communication became difficult because the material was too thick and heavy. Therefore the wearer has to talk loudly for others to hear.

Finally, I tried on an invisible respirator, Woodyknows Invisible Mask, that fits in the nostrils. It is small, soft and easy to carry around. However, I was only able to wear it for less than two hours, because it was too hard to breathe. Although I did not have to worry about appearances, fit or comfort, like the other masks, the difficulty in breathing gave me a headache and a feeling of anxiety, so I had to remove it right away.

Out of all the masks tested the Pitta mask was the most interesting, because it was one of the more expensive but least effective masks, but is very popular among consumers according to the sales data on the Chinese e-tailer Taobao. One reason could be it was endorsed by many celebrities, and although most of these celebrities were wearing the mask as a disguise, its popularity as

a protective device for air pollution is still on the rise. The mask was marketed as a good filter for micro particulates in the air despite many media outlets proving its ineffectiveness. Out of approximately 60000 reviews on one Taobao Pitta mask seller, the majority of buyers gave it good rating for its breathability, soft material and trendy look ("Dust proof, Breathable,"2019). Comments on its effectiveness in filtering pollution were almost non-existent. This is not a surprise, because efficacy is not readily attestable but breathability, material softness and its appealing look are. Most consumers made the decision to purchase based on its marketing material (i.e. new Japanese technology in filtration and celebrity endorsements) and user reviews. The combination of these gave Pitta mask its popularity and success among consumers.

## 4.2 Design Criteria

This section seeks to qualify the two main concerns identified in Chapter 2 by combining knowledge gained through product analysis with existing national standards. The design criteria were in part based on understandings gained through the user study conducted by the researcher as the user to inform the design development and ideation that is detailed in Chapter 5 with the guidance of the Chinese national standards and New Zealand/Australia standards imposed on facewear design and manufacture.

### #1 Fit & Comfort

The first criteria identified is fit and comfort, because comfort was one of the main user needs recognised in the comparative product analysis. An ill-fitted product can hardly be comfortable, and in the case of pollution protection masks where ill-fitted designs are ineffective in protecting the wearer from air pollution. According to ChinaGB's (The Chinese National Standard Regulation Agency) *Technical Specification of Daily Protective Mask*, the technical design requirements for a daily protective mask are as follows:

1. Basic Requirements:
  - a. Mask shall cover wearer's mouth and nose firmly and safely.
  - b. The material used shall not be irritable, illegal, carcinogenic or anything that violates other national standards regulation.
  - c. Mask shall not contain any sharp edges which could potentially injure the wearer.
  - d. Mask shall be easy to put on and remove and not create unnecessary pressure or pain on the face. Minimal limitation on head movements.
2. Appearance Requirement:
  - a. Mask shall not appear with visible damage, stain or other defects.

In New Zealand and Australia, general standards are similar. According to AS/NZS 1716:2012 Section 2, assembled respirators should be made of safe and durable material that could stand normal use. All parts should be smooth and free from any potential hazard or cause discomfort to the wearer. If a filter is used, it should be readily replaceable with ease. If the fit of a respirator is tested on selected personnel, the manufacturer shall label the respirator accordingly. For respirators with a valve it is specified in section 2.4:

#### 2.4.1 Design

The design of the demand valve of supplied-air respirator shall be such that it is adequately protected against damage and its efficiency is not impaired by any conditions likely to be encountered in normal use. Where the device includes an adjustable reducing valve it shall incorporate a suitable locking device to prevent the adjustment from being altered accidentally.

The assembly shall be protected by a pressure-reducing safety valve or mechanism if the demand valve and associated fittings cannot withstand the full cylinder pressure. Breathing shall be possible at the maximum operating pressure of the pressure safety valve or safety mechanism.

#### 2.4.2 Mode of operation

It shall not be possible to connect a negative pressure demand valve to a positive pressure facepiece or vice versa.

The design and development criteria of comfort and fit are informed by these standards, and when choosing material the first consideration were to fulfill the basic requirement of non-irritating and non-toxic to the wearer. An additional element assessed for this criteria is that the design has to be hazard free, meaning no sharp edges or corners that could injure the wearer.

## #2 Appearance/Fashionability

The second criteria was the appearance of the mask. A significant finding of the personal testing was that the initial appearance of the mask is crucial when it is first introduced to consumers. A product that is obtrusive on the wearer's self-image risks the possibility of being rejected. Hence a wearables designer should have a clear mental model that is of value to the user (Dvorak, 2008). What this means is that when designing a wearable device, the designer should integrate common and relevant world knowledge or experience, instead of solely using knowledge and information that is only available to the designer. For example, the basic desktop metaphor used in the current PC user interface "is based on something most people are familiar with: a desk with folders and documents" (Dvorak, 2008, p.90). This

approach is also backed up by Hemphill and Suk's (2009) theory that people need to feel they belong to a certain group or social class, and by integrating world knowledge, the designer is asserting the wearer of their self-image.

In this thesis, the design ideation process was informed by trends published on well-known trend prediction magazines. The proof of concept and prototype development processes integrated market knowledge gained through online data gathering and personal testing of existing products with the design ideations. Such integration makes the design prototype a stronger proof of concept because it not only takes wearer's conformity desire into consideration, but also inserted a trendy style that could potentially enhance the wearer's self-image.

# Chapter 5. Design Development/ Ideation

## 5.1 Design Development

After initial research on the design direction and inspiration, the process of design development began. The first part of the ideation process was to develop mask design concepts based on concepts from trend books. As previously mentioned, trends are usually a reflection of current events and social changes; therefore, it is easier for the mass market to accept the trend due to reasons stated in conformity theory (Lynch & Strauss, 2007) which were discussed earlier (p.15). Two of the popular fashion trend books were discussed in previous chapters, and three trends were used as inspiration from each trend book in the ideation process. Different filtration systems were considered in each design. Each ideation process started with an analysis of the particular trend used, a moodboard for inspiration, a draft of designs and at the end, a final concept design (for details of concept design development, please refer to Appendix C). Such integration of wearables with upcoming trends could be used to create a marketing flare, but the often short life span of fads puts great pressure on the functionality development timeframe. It would be wise for designers to integrate a more classical trend that has a longer appeal duration.

The second stage was to integrate two design concepts from the ideation process with knowledge gained from the comparative product analysis as well as my personal experiences as a young female professional who lived in China. The first prototype design focused on the shape and colour of the mask, where the jawline was concealed by a darker colour and the shape of the mask to emphasise the wearer's nose and mouth. This design evolved from the City Heroine concept (Appendix C) where a simple and elegant outline and colour was adopted. Female Chinese consumers are known for their obsession with smaller jaws and chins. Hence the increase in popularity of photoshop software and plastic surgery (Rauhala et al., 2018). The need to look a certain way to be considered beautiful was, in turn, an important element in making purchasing decisions, as the review of literature had highlighted the importance of designs to make a connection with the consumers in a widely known and accepted fashion.

The second design was developed from the Glitch concept (Appendix C) and integrated with a widely accepted checkerboard pattern. The intention was to interpret a popular trend together with a more classical fashion element into the design of the wearables, so the design would stand the test of time and still be considered on trend and popular by the time the necessary functionalities were

developed. The literature suggested that the general consumer population is more comfortable with purchasing products they are accustomed to and had a good experience with (Berglund, Duvall and Dunne, 2016). Using this integration of trends could make the mask more acceptable to the consumer because it resembles something popular in mainstream fashion.

## 5.1(a) Concept Design and Development

### **Design Brief**

#### *Project Overview and Background:*

As the research/designer I am personally affected by air pollution every time I visit China. Respiratory issues cause me great discomfort and negatively affect my experience in China. Many of my family still live in China and not being able to enjoy my time spent with them in China is disappointing.

#### *Objective:*

To design a mask that incorporates existing or upcoming filtration systems whilst appealing to the target market's fashion-conscious aesthetic. The design should meet the ChinaGB and International standards requirements and also encompass both the

fashionable and functional features with the extended potential of customisation.

#### *Target Audience:*

Young professionals living in Chinese cities where air pollution is dangerously high with a US AQI of 150 or higher. Many of them are experiencing negative health effects from air pollution.

#### *Key Message:*

This mask has to fit well on the face and be aesthetically pleasing. The mask should not appear to distance the wearer from their surroundings, and it should extend itself to be worn every day in different social situations.

### **Ideation Process**

The six concept designs (documented in Appendix C) started with the above design brief, which outlines the background and objectives of the design process. In these examples, fashion prediction materials, Textile View Magazine and Nextlook Trendbook, were explored to inform the direction of the design concepts. These six designs are referred to as Glitch, Greener, Token, City Heroine, Birdgirl and Funfair. The trends predicted by the periodicals offered insight into what will be popular on the market suggesting possible fashion directions for the following

year. The intention of incorporating these ideas into the design of the wearables was to explore concepts that could inform a fashioned product that appealed to the consumer and therefore would be adopted faster. For these designs, three themes from each of the trend books were used as an initial starting point to develop themed moodboards. Inspiration gathering using moodboards was an important part of the design process; physically and digitally collaging together inspiration aided the design process by informing the design direction and helping to communicate design ideas. Using the moodboards and the existing smart materials and facewear design elements, as well as some of the traditional filtration systems, and new design possibilities were generated.

These design concepts were mockups that were created to explore marketing approaches rather than production prototypes. As previously mentioned in Chapter 2.2, in the fashion world designers often put on catwalk shows for publicity and marketing purposes. Wearables could attempt a similar strategy to create a buzz worthy, marketing material to draw attention to their product that is trendy and like many of the outfits on a catwalk, not always practical to wear in everyday settings. These designs are used to increase consumer interest and create a desire for the product in the market. The next stage of prototyping extended beyond the notion of current trends because of the concern that these trends could change before a wearable product was sufficiently

researched and experimented with. So an approach that considered more established fashion concerns, such as fit and silhouette, along with concepts from the early stage was also used. These included the integration of the glitch trend with a more classic checkered design (p.81), as well as a more current trend, City Heroine, which was explored in the design of the Perfect Contour mask. This followed a more refined and simplistic look that had identified the currently popular Pitta mask.

In bringing these two trends in the prototyping process, there was more confidence that these mask designs would be more appealing to the target market because the design inspirations were already popular on the existing market. The research process then moved on to focus on materials and techniques that could be used to develop these concept prototypes into physical prototypes because, as explained in previous chapters, wearables design has to also meet functional requirements like fit and wearability, production logistics and user needs.

## 5.1(b) Prototype Design

### **Design brief for second stage concept prototypes**

#### *Objective:*

Designing a mask that is appealing to the target market's fashion-conscious aesthetic whilst leaving open the possibility to incorporate existing or upcoming filtration systems. The design should meet basic requirements in the fit and comfort criteria, and also encompass both the fashionable and functional features with the extended potential of customisation.

#### *Target Audience:*

Young Chinese professionals living in cities where air pollution is dangerously high and who are fashion conscious, and has a high awareness of their self-image.

#### *Key Message:*

This mask has to fit well on the face, comfortable to wear and be aesthetically pleasing. The mask should not appear to distance the wearer from their surroundings, and it would be best if it can extend itself to be worn every day in different social situations.

### **Prototype Process**

This section discusses the development of two physical prototypes using a knit process, that were developed to a proof of concept prototype stage in this research. These prototypes drew from knowledge and insights gained from the previous research and concept development as well as the assistance of Mr. Gordon Fraser, senior technician at the Textile and Design Lab. The aims of this phase of the project were based on the project brief elaborated above, with an added emphasis on the wearability, fit and manufacturability of the prototypes.

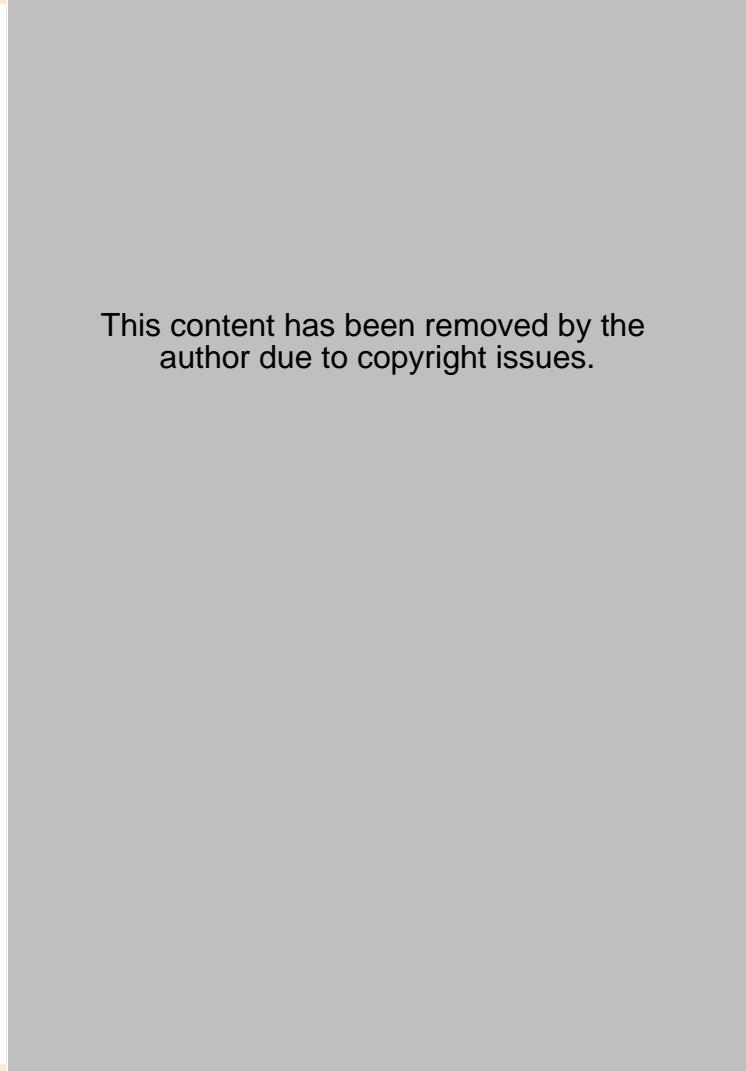
The decision to use knit as the medium and production technology of these prototypes was because firstly, knitting is a textile medium that can be shaped to fit the human body, and is familiar to people in terms of its wearability. Second, the comparative product analysis has concluded that breathability, portability and ease of use were important elements in facewear design. Knit is one of the most experimented and widely used techniques in fashion design. Knitwear is known to be soft in texture, comfortable to wear, dynamic in structure, and can be manipulated and synthesised with many different materials. As Udale mentioned in her book *Fashion Knitwear*, "new forms of textiles are being developed through knit technology. Smart textiles can change their shape, colour or sound in response to changes in the environment or body such as heat, light, pressure, electricity or heartbeat. Knit is good for this as its construction can produce

circuits and communication networks through which information can travel" (Udale, 2014, p.9). Another consideration was the advantage knitting has in production and manufacture. Knitting has many advantages over weaving, such as it is less time consuming and less costly to manufacture (Ray, 2010) due to its ability to be shaped and formed during the knit process. These two aspects of knitting are very attractive in wearables design because it often takes time and money to design and develop its functionalities; a production technique that can counteract these undesirable aspects of wearables design and development could potentially encourage more enthusiasm in wearables design and development.

## #1 The Perfect Contour

### Design Inspiration and Direction

The first design considers the current social phenomenon in China, whereby young Chinese girls desire to look a certain way. Many of the current Chinese made mobile devices incorporate auto adjustments to their cameras, where a face is detected, it would be automatically reshaped into a smaller and pointier one. The exponential growth of the beauty industry in China in recent years has created an aesthetic preference that is distinct to China ("China's Booming Beauty Products Market", 2018). Based on this observation, this mask design would provide a facial shape illusion. Figure 4 is an inspiration for a design that could provide an illusion that the wearer has a more desirable facial structure. Figure 5, shows how the design was adapted by altering the colour of the front shield so the jawline is disguised. Further iterations that considered contouring more structural facial features of the face other than just the jawline (refer to Figures 5 and 6) were also explored.



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*Figure 4. Sleep No More Mask. From Medium. Retrieved From <https://medium.com/@mulligan/the-sleep-no-more-primer-baf0d9c3a0fd>. Copyright 2018 by Medium. Blank Female Face. Adapted From Halloween Costume.com. Retrieved From <http://www.halloweencostume.com/female-blank-mask.html>. Copyright 2018 by Halloween Costume.com.*

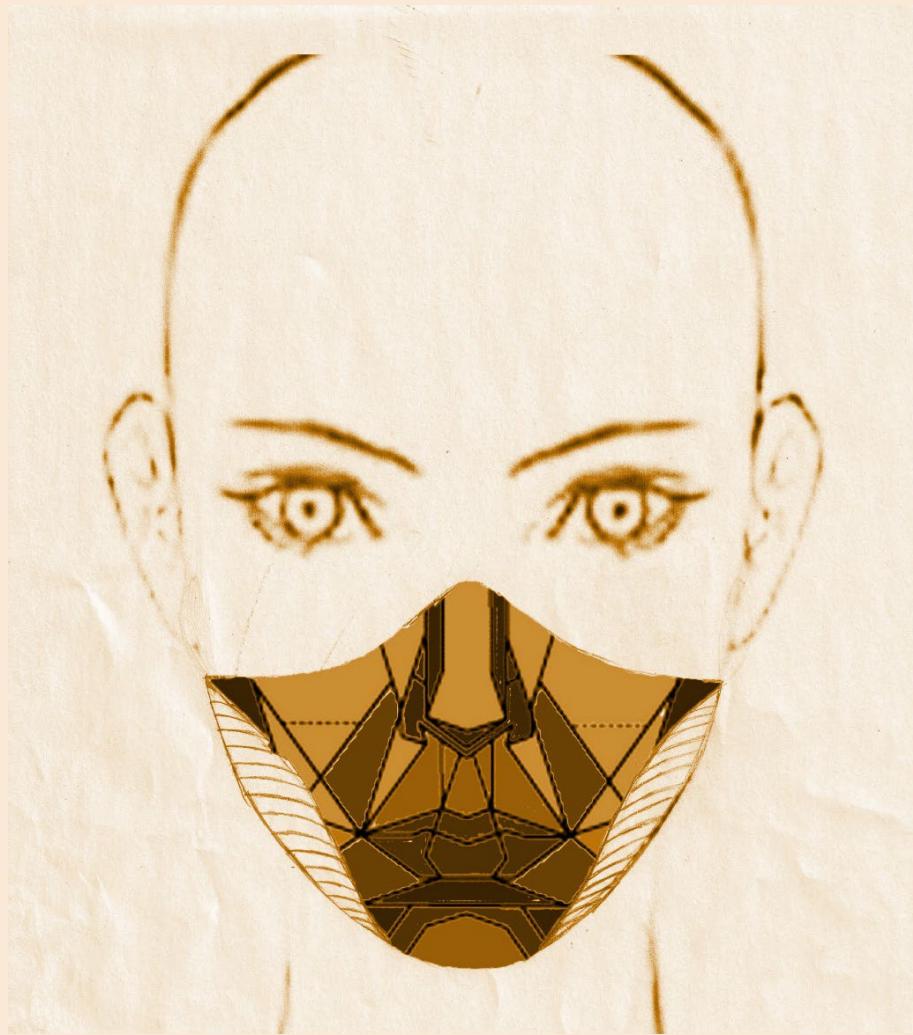


Figure 5. Perfect Contour Variation A

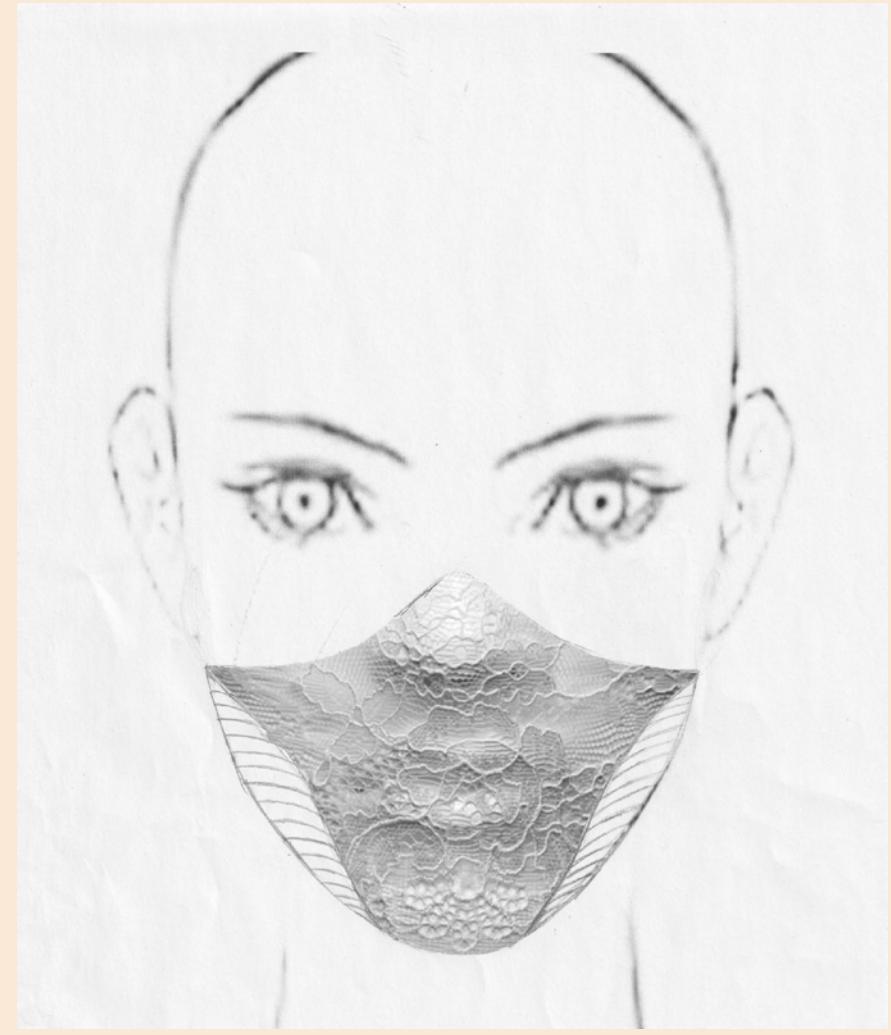


Figure 6. Perfect Contour Variation B

In Figures 5 and 6, the design of the mask incorporates sides that are made of filtering materials, which have a darker colour to the rest of the mask; and creating an illusion that the wearer's face is smaller than it actually is. Figure 6 shows further development of the design by making the nose and mouth part more fitted to the actual human face with contours of perfect facial features. This will resolve fit problems and greatly increase the mask's efficacy. The filtering sides are fabricated into a gill-like system for air filtration. The gills could be designed so air would only travel in one direction, out of the mask with a little pressure which would be created when the wearer exhales. All the other sides of the mask would be sealed to the face by fitting perfectly to the wearer's facial structure to prevent unfiltered air getting into the mask which would make this mask most effective in air-pollution filtering. This design will eliminate the previously mentioned problem of glasses fogging from the wearer's breath (p.46) but still trap the warmth inside the mask, for the mask is usually worn during the winter months when pollution is most hazardous. The centre of the mask would be shaped in a way to resemble a preferred nose and mouth contour, as in Figure 6. This contouring of the mask would give an illusion that the wearer has a perfect profile. This mask design would also be customisable, as the contouring part of the mask would be able to be moulded into whatever nose and mouth shape the customer desires. This would allow for more individuality and personalisation in the masks, an aspect the literature review highlighted as important. Wearable products must be able to incorporate individuality like other fashion

products on the market. Figures 5 and 6 show the customised masks' potential pattern and colour.

The prototyping process started with a general shape modelled after the most popular Pitta Mask. As Cross (2006) recognised, in design, precedence has valuable knowledge often used for future designs and developments. The Pitta mask was designed so the part covering the face and the ear loops are in one piece. This minimalist design made the mask look fitted and fashionable. The size and measurements were taken from two sources, an article called "The Korean American Woman's Face: Anthropometric Measurements and Quantitative Analysis of Facial Aesthetics" (Choe, Sclafani, Litner, Yu, & Romo, 2004) and the ancient Chinese golden ratio (Zhang, Chen & Xu, 2016). This was done to create a mask that could be molded into a 'Perfect' face shape.

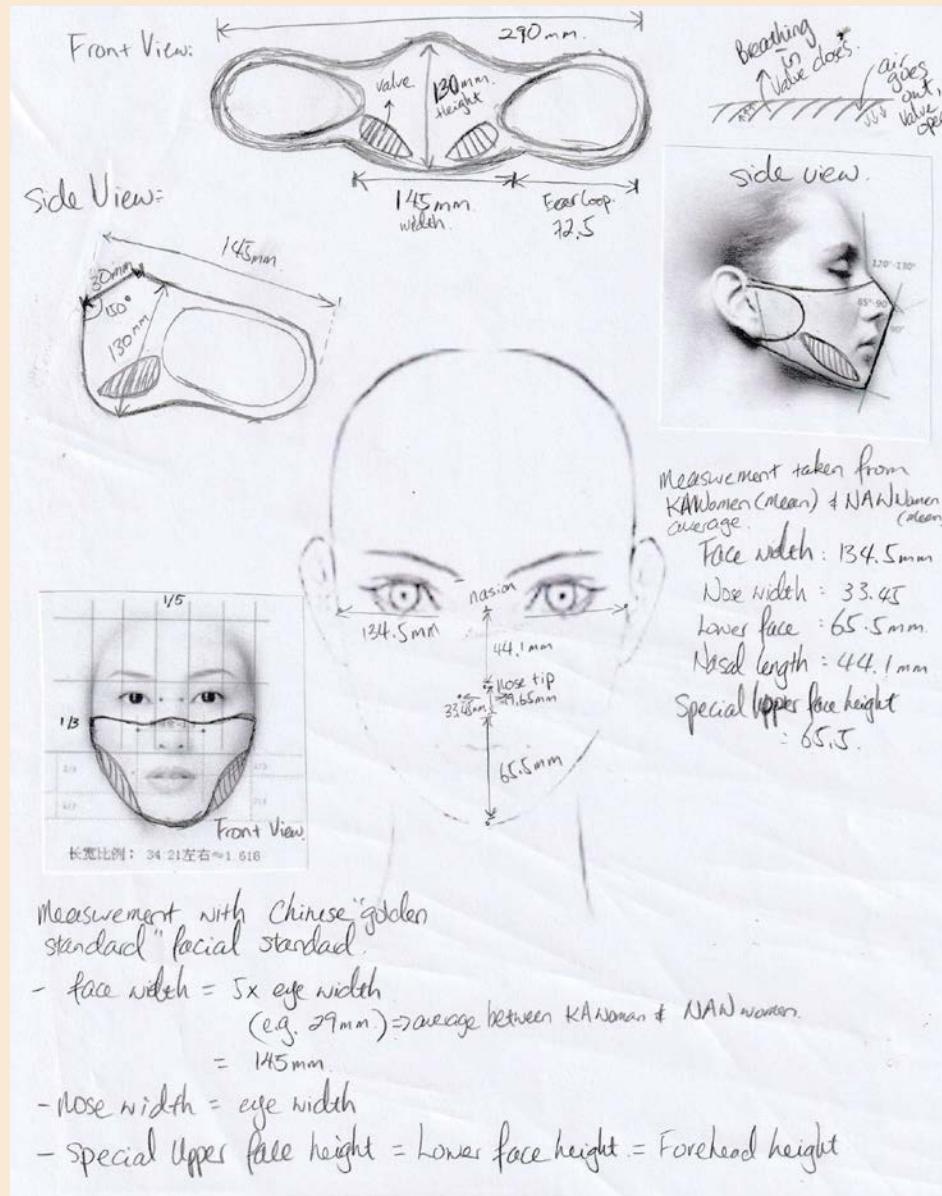


Figure 7. The Perfect Contour Prototype design draft.

When choosing material, comfort was the first priority. In consultation with the technician, I decided to develop this mask with mixed merino yarn because it is soft, lightweight and breathable. At the Textile and Design Lab, the Shima Seiki SIG intarsia knitting machine can knit a variety of patterns with different techniques. Different patterns have different elasticity and thickness. After sampling, five different knitting techniques (Figure 8 - Figure 12); we decided to use Rib Knit for the face and All Knit for the ear loops. Rib Knit (Figure 12) created one of the more elastic structures. The fabric it created was thinner and more breathable. The ear loops needed a thicker structure to hold the mask in place; therefore, we used an All Knit technique. The All Knit structure (Figure 8) used more needle beds compared to the Rib Knit and therefore created a tightly knitted fabric that can create a stronger and less flexible structure.



Figure 8. All Knit Swatch.



Figure 9. Interlock Knit Swatch.



Figure 10. Tubular Knit Swatch.

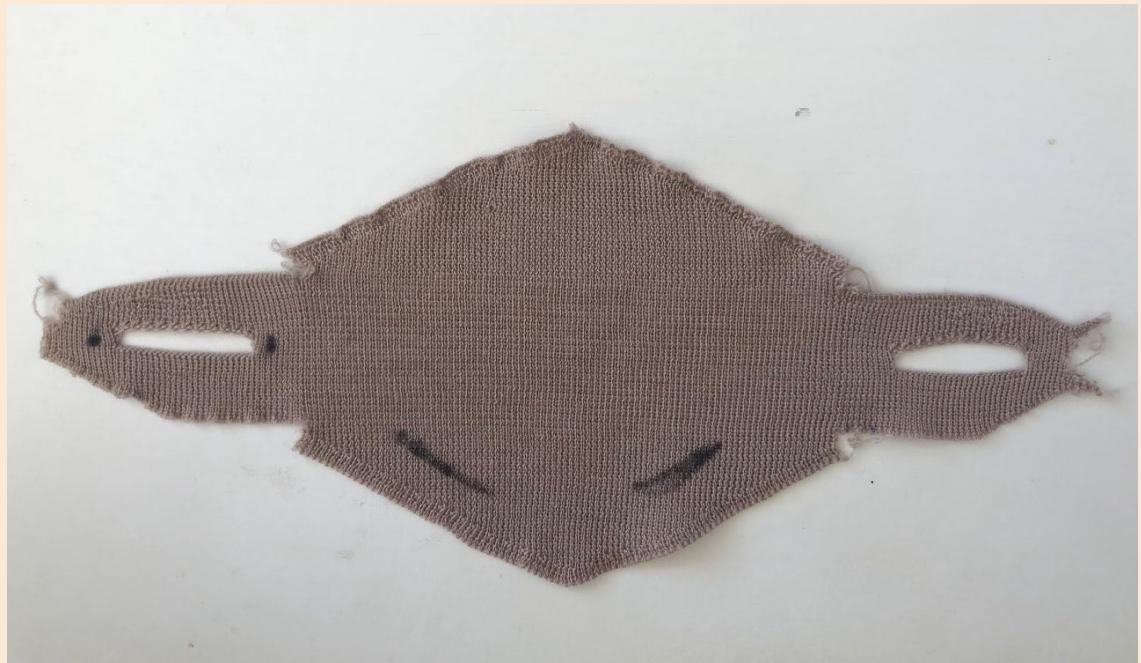


Figure 11. Plain Knit Swatch.



Figure 12. Rib Knit Swatch.

The first prototype had a general shape, and although the elasticity in the knitting pattern created a nice fit on the face, the chin and the nose area still needed to hug the face better, as seen in Figure 13. The earloop openings were too small to fit the ears, and the valve openings were hard to put in at the angle I requested because the knitting machine knits horizontally, and having it knit openings at an angle was difficult so the angle was restricted at a certain degree.



*Figure 13. Prototype Draft I*



Figure 14. Prototype Draft I Testing (Side View).



Figure 15. Prototype Draft I Testing (Front View).

The second prototype draft had valve openings added, and the earloop openings widened. However, we were unable to knit the valve openings slits parallel to the edges due to limitations in the knitting machine. In Figure 16 when the slits were added, the mask fitted the chin better. The gap in Figure 14 disappeared, and the slits created more space for the chin. The knit structure was flexible and elastic enough to hug the chin and jawline perfectly so we would not need to worry about decreased functionality due to air escaping through the jawline edges of the mask. Now the concern lays on the top edges of the mask where the nose and cheekbones are.



*Figure 16. Prototype Draft II.*



Figure 17. Prototype Draft II Testing (Side View).



Figure 18. Prototype Draft II Testing (Front View).

In the third prototype the valve openings were much bigger for two reasons; first, to create an illusion of a smaller chin, second, to assist in breathing. Although the knit fabric was very breathable, it could potentially become less so if we were to add a layer of filtering fibre to the mask to advance its function. In Figure 18 the contour of the chin looked an average size; however, when the large slits, where the valve would be, were added the chin appeared much narrower in Figure 19. The illusion of a smaller face and pointier chin was created.



*Figure 19. Prototype Draft III Testing (Front View).*

In order for the nose and chin area to be more fitted, a decision was made to try a different yarn, called Pemotex. Pemotex is made of 100% polyester, and when heat is applied to the yarn it shrinks and becomes stiff. When using heat on Pemotex yarn one can mould the fabric into different shapes. Once the yarn has stiffened it cannot be reversed. As shown in Figure 22, the Pemotex yarn became tight and stiff after being heat treated. The gaps commonly seen in a knitted fabric disappeared and a slightly see through fabric turned completely opaque. A first attempt to mould the fabric was done on a mannequin with a steam iron. This test showed that steaming the Pemotex could achieve a general shape of the mannequin's nose but did not show much of the detail (see Figure 21). In subsequent tests, a hairdryer and a hair straightening iron were both used. These worked on the Pemotex, but because these heating devices targeted a large area it was difficult to localise the heat. Additionally, the temperature these required were too high to mould it while it is on the wearer's face.



*Figure 20. Prototype Draft III Testing (Side View).*



Figure 21. Pemotex Testing on Mannequin.



Figure 22. Pemotex After Heat Treatment.

The results of these initial trials indicated the yarn could be successful in forming the mask to a detailed shape of the face; however, the amount of heat required to activate the Pemotex yarn could not be achieved on an actual face. Therefore, a decision was made to take a silicone mould of my face and use this to create a plaster cast of my face (refer to Figure 23). This could then be used to experiment with different heat sources to achieve the most detailed face shape possible.



*Figure 23. Plaster Face Cast.*

In Figure 26, 27 and 28, a fabric steamer was used to test the shrinkage of the Pemotex yarn while the fabric was on the new cast of my face. While the steamer worked well, it was unclear if the process only required heat or heat in the form of steam. In order to find out, the Pemotex fabric was then tested using a hairdryer on the cast of my face. It worked almost instantly. The mask shrunk and moulded to the face cast and the texture changed from regular knitted yarn texture to a more solid and less flexible structure.



*Figure 24. Prototype Draft IV (with Pemotex).*



*Figure 25.* Prototype Draft IV before Heat Treatment on Face Cast.



*Figure 26.* Prototype Draft IV after Heat Treatment on Face Cast.



*Figure 27.* Prototype Draft IV after Heat Treatment.



*Figure 28.* Prototype Draft IV after Heat Treatment II.

Figure 29 is a comparison of the Pemotex mask before and after heat treatment. The size of the mask shrank by almost 40% and although the mask can be somewhat manipulated into the desired shape to fit the face mould perfectly, due to the lack of control in the heat application process, the mask has to be shaped as a whole. Work on creating a larger mask that would shrink down to a wearable size could be one way of addressing this issue, or if we were only to shape the edges to fit the face seamlessly but leave the centre of the mask soft and flexible as it was before heat treatment, we would need a heat source that can be localised to a small area.



*Figure 29. Prototype Draft IV before and after Heat Treatment.*



*Figure 30.* Prototype Draft IV after Heat Treatment Testing  
(Side View).



*Figure 31.* Prototype Draft IV after Heat Treatment  
Testing (Front View).

After testing Pemotex with different heat sources I decided to test it with a glue gun, because a glue gun has a localised point where heat is emitted. The swatches worked very well with the glue gun. When the glue dripped onto the Pemotex swatch, it shrank right away, and it only shrank around the glue leaving the rest of the swatch as it was (see Figure 32). Compared to the hairdryer the glue gun worked much more slowly and took a longer time to action the fabric, but it did provide a more precise shaping of the mask.



*Figure 32. Pemotex Swatch Tested with Glue Gun.*



*Figure 33.* Prototype Draft IV before Glue Gun Heat Treatment (Side View).



*Figure 34.* Prototype Draft IV after Glue Gun Heat Treatment (Side View).

In Figure 34, the mask took a more detailed shaped after heat was applied to the mask using a glue gun. The glue gun was only used along the edges to shrink the yarns, so they fitted the face better. The top edge of the mask that sits on the nose and cheekbones has clearly shrunken.

After testing different heat sources on this design, two concerns were noticed. First, the plastic smell of Pemotex was very strong, and since the mask is designed to be worn on the face the strong smell could be intolerable to some people. Second, the changed texture and flexibility of the fabric after heat treatment made the mask less comfortable to wear. Pemotex lost its advantage as a yarn that is soft, flexible and breathable. To resolve these problems, we decided to mix Pemotex with regular yarn as seen in Figure 35, so the texture became much softer.



Figure 35. Merino & Pemotex Mixed Swatch.

When I tried to apply heat to the mixed yarn fabric with a hair dryer it worked very well, and it did not shrink as much as it would when only Pemotex was used. However, the glue gun did not work as well on this mixed fabric, which means other ways of heat application (such as a more focused hot air blower) would have to be experimented with, if localised manipulation is desired.

This design integrated the City Heroine trend with a more appealing form from the existing facewear market. The combination of the two created a design that fulfils the criteria listed in section 4.2. Although actual market response to the product was not obtained, the possibility of it being accepted by the consumers is high because many of the existing consumer concerns have been addressed. One problem with this design is the heat application process. The high temperature required to activate the yarn cannot be used on the human skin; therefore, the mask had to be treated on a cast. This factor could limit the customisability of shape and form the mask can take. On the upside, the successful integration of regular yarn with Pemotex could indicate that other yarn would also integrate well with Pemotex. For future development, it could be beneficial to mix silver infused antibacterial yarn with Pemotex. This could enhance the bacterial resistance function of the mask. The anti-pollution efficacy of the mask could be explored with other yarn mixtures (including nanofibre yarns and filters) and different knitting techniques.

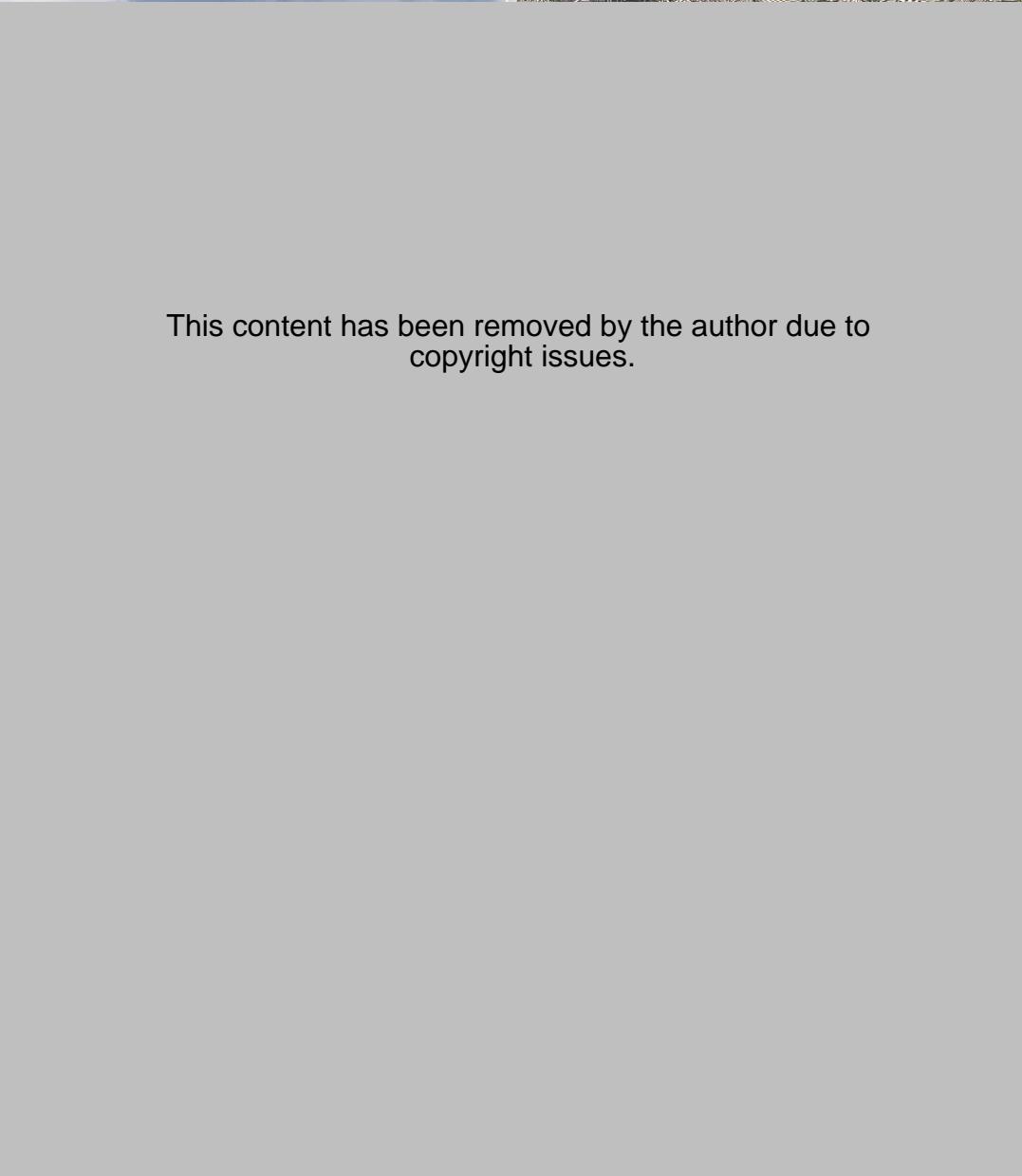


Figure 36. Merino & Pemotex Mixed swatch before and after heat treatment.

## #2 The Popular Print

### Design Inspiration and Direction

The second design incorporates the same narrowed shape at the chin to create an illusion of the face being smaller than it is. The ideation of this design started with inspiration derived from the classic checkerboard pattern. There are many variations of the checkered pattern, such as gingham, plaid and tartan. They are all gridlike patterns with different band and stripe organisations, based on the warp and weft of woven textiles. Many of these patterns have existed for thousands of years, and they are still popular in the fashion world now (Adams, 2018). Major brands such as Burberry and Louis Vuitton are known for their plaid and checkered patterns. These patterns are perhaps one of the most widely recognisable and iconic patterns used by the fashion industry globally. A moodboard was created as an initial design starting point (refer to Figure 37).



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copyright issues.

Figure 37. Popular Print Moodboard Counter Clockwise: Check-Mate. From Vogue Italia. Retrieved From <https://www.yellowtrace.com.au/check-mate-tim-walker-for-vogue-italia/>. Copyright 2016 by Vogue Italia. Cute Checkered Background. From Freepix. Retrieved From [https://www.freepik.com/free-vector/cute-checkered-background\\_813732.htm](https://www.freepik.com/free-vector/cute-checkered-background_813732.htm). Copyright 2018 by Freepix. Grid Mask. From Aliexpress. Retrieved From <https://www.aliexpress.com/item/WosporT-Hunting-Paintball-Accessories-Tactical-CS-Protective-Grid-Mask-Necessary-Half-Lower-Face-Steel-Mesh-Wire/32585803310.html>. Copyright 2018 by Aliexpress. Checkered Optical Illusion Vector. From Can Stockphoto. Retrieved From <https://www.canstockphoto.com/checkered-optical-illusion-20694473.html>. Copyright 2018 by Can Stock Photo. Checkered Fashion. From Livejournal. Retrieved From <https://omonatheydidnt.livejournal.com/13122024.html>. Copyright 2018 by Livejournal. Papa. From Moziru. Retrieved From [http://moziru.com/explore/Drawn%20pattern%20grid/#go\\_post\\_1986\\_drawn-pattern-grid-1.jpg](http://moziru.com/explore/Drawn%20pattern%20grid/#go_post_1986_drawn-pattern-grid-1.jpg). Copyright 2018 by Moziru.

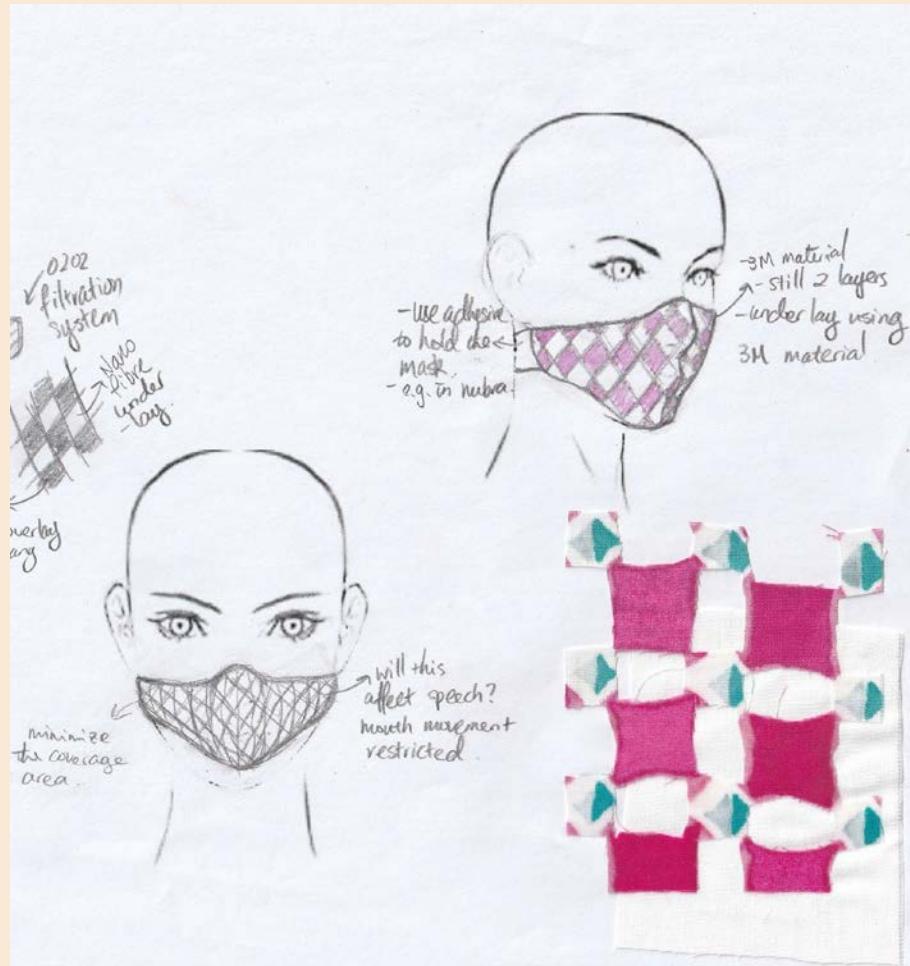


Figure 38. Popular Print Design Draft.

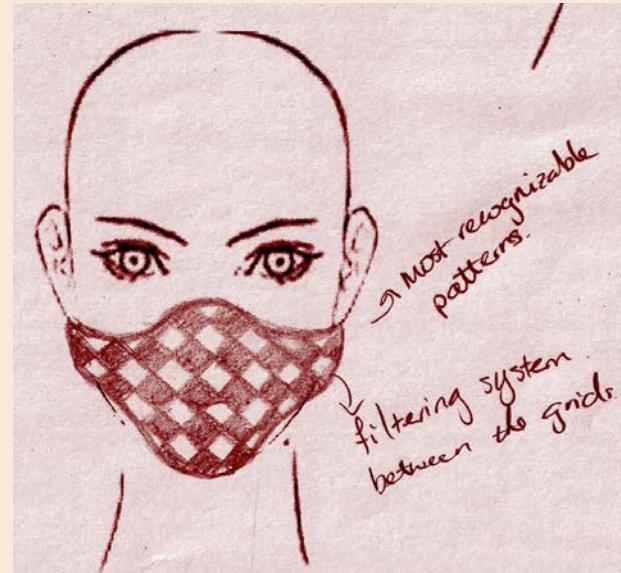


Figure 39. Popular Print Design Final

The research and literature on wearables design suggested fashion is often evolutionary instead of revolutionary and that it was important to design with ideas familiar to the user. Therefore, it was important that the new designs did not deviate too far from what people are familiar with and what people could connect with. The checkered pattern can be distorted to create an illusion of a human face with desired features, for example, a smaller chin or a bigger nose. This design fulfils the user's need to have a visual illusion of a smaller face, the functional need for filtering air pollution and the aesthetic requirement to look and appear fashion forward. Figure 38 illustrates a sketched side view with the 3M filtering fibre. The 3M filtering fibre has an adhesive wing on each side of the mask to keep the mask on the face. The adhesive wings are commonly used in strapless bras. They are reusable and can easily be cleaned with warm water. This was incorporated into the design as my personal user experience whilst testing the existing market products, highlighting that the existing ear straps negatively affected the fit of the masks. The Green Shield mask was either too tight or too loose, and this greatly affected my experience while wearing the mask. With adhesives, the wearers are free to adjust the mask; however, they want it; it can be more flexible.



*Figure 40. Popular Print Prototype Draft I.*

When prototyping this mask, it was decided to keep the general shape designed for The Perfect contour mask but add the pattern and insert a pocket in the mask. A Tubular knit technique was used for the face and the All Knit structure used for the ear loops. The Tubular technique would create a pocket in the mask where a filtering material could be inserted to increase its efficacy. The Tubular structure knits much closer together, therefore has much less elasticity compared to the Rib knit. It became much thicker because it has two layers. The mask was still knitted in mixed merino yarn in one piece, although it was thicker and heavier, it was still breathable and comfortable on the skin. The negative experiences with ear straps were not a problem with knitted masks because the yarn was very soft. Since a knitted mask can be easily stretched to fit different faces, the ear loops were only used to keep the mask on the wearer's face, not to seal off the edges, so the mask is more tailored to the face.



Figure 41. Popular Print Prototype Structure Testing.

After the first draft we started to add the checkered print to the mask, as well as Pemotex yarn with the merino yarn. There was an opening created on the side of the mask for filtering inserts (Figure 43). With the tubular knit, the mask is thicker and less elastic. The edges are looser and it became harder to make the mask fit my face. The glue gun as heat source would not work as efficiently on such a thick layer of fabric.



Figure 42. Popular Print Prototype Draft II.



Figure 43. Popular Print Prototype Pocket Testing.



*Figure 44.* Popular Print Prototype Draft II Testing (Side View)

Since a glue gun could not be used on the prototype we decided to test it on a mannequin with an industrial steam iron. The front of the mask stiffened after heat treatment, the sides as well as the ear loops were still soft. Although the mask was stiff compared to a regular knitted fabric, it is still foldable and can be easily put in the pocket without the shape being distorted.



*Figure 45. Popular Print Prototype Draft III on Mannequin After Heat treatment (Side View).*



Figure 46. Popular Print Prototype Draft III on Mannequin After Heat treatment (Front View).



Figure 47. Popular Print Prototype Draft III After Heat treatment.



*Figure 48.* Popular Print Prototype Draft III After Heat Treatment Testing (Side View).



*Figure 49.* Popular Print Prototype Draft III After Heat Treatment Testing (Front View).

The mask that was heat treated on the mannequin did not fit my face as well as I thought it would be. Although the chin and jaw lines were very well covered, the nose and cheek part of the mask were still unflattering. It could be assumed that this design might not be best mixed with Pemotex, because it was already thicker and bulkier, and if another layer of filtering material was inserted the mask would be even thicker and harder to fit the face.

Again this mask was designed with an integration of the Glitch trend (Appendix C) and a popular print pattern that was inspired by the classical checkered design. The shape and form of the mask was inspired by the product analysis in Chapter 4.1. The appearance of the mask is quite appealing, and the possibility of customisation of the mask with different colour yarns could also be a selling point. The downside of this mask is its difficulty in being heat treated to fit the face due to its thickness. For future development, it might be worthwhile to experiment with different knitting techniques and yarns to achieve a shape or form that is lighter and easily manipulated. Finally, with the possibility of inserting a filtering material into the mask, the functionality aspect of this design should be easily achievable.

# Chapter 6. Summary and Conclusion

## 6.1 Summary

This research addresses the potential of integrating fashion design elements and methods into wearables design to help accelerate the adoption of wearables in the mainstream consumer market. From the literature review, several barriers to wearables design are identified, two of them are further investigated, because they are crucial in the wearables design process. The first issue is the difficulty in identifying target consumers and the usefulness of market research in an emerging field, such as wearables. Existing market research is limited and seems to capture demography that is non-essential to wearables design and development (i.e. surveys of non-users). Therefore, a careful selection of research participants and target markets is crucial in the design and development of wearable technology (Chap.2.4(a)). Wearables are often created to assist or enhance the wearer's life, so a wearer lifestyle analysis should also be investigated.

The second problem this research looks at is the lack of fashion awareness and aesthetics in wearables' design. Apart from the lack of collaboration between designers and technologists recognised in this research (Chap.2.3), another reason that wearables lack in aesthetics is that there are limited references to

guide wearables design directions. Hence the focus of this thesis on the incorporation of fashion design process in wearables design. Fashion is an industry with a history of consumer success, and the fashion design process is very well developed. This project has adopted elements of the fashion design process into wearables design. The researcher identified elements in fashion design that could potentially be adopted in wearables design, such as inspiration research and trend analysis. Trend analysis is used as a basis for research and design inspiration and direction. The reason for this is that integrating existing aesthetic preferences with wearable technology would make wearables appear more conformable to existing social standards. Thus, trend research and analysis become meaningful. By integrating existing design concepts into the design of a wearable air filtration system, the researcher gained a clearer direction to begin the design process.

In the design process, many elements were considered, such as form, material, colour and comfort. These design elements are essential in fashion design as well as wearables design. The researcher used trend books as guides to begin the design process, and as inspiration when making a decision on the above design elements. The concepts were drawn on paper to assist the researcher in evaluating their aesthetic value and developing further designs. Following the design process was the prototyping process where the elements considered were tested using a variety of yarns and different digital knitting techniques. Active materials were also integrated and considered during the prototyping process to evaluate their functionality, comfort level and wearability. Through this

design and prototype process, it was shown that it is possible to integrate fashion elements with user needs in wearables design and that elements of the fashion design process can be utilised in the design process of wearables.

## 6.2 Limitations

This research could be valuable for wearable technology designers who come from a technical background, where functionality and problem-solving approaches are heavily ingrained. Also, it provides some insights for designers and companies struggling to actualise wearable technology in the consumer market. However, there are some limitations to this masters research. The market for wearable technologies is an emerging market, and there is limited research published in the field (Chap.2.1). While this project drew on literature, product analysis, research through design and prototyping, the conclusions could only be deduced rather than proven. For example, due to time limitations, there was no market testing and no user feedback collected on the prototypes generated through this research to inform a fuller analysis and evaluation. In addition, user feedback on mask shape and fit was not fully ascertained with wearers other than the researcher. While personal commentary on the design and prototypes gives some critical insight, it is recognised that the design and prototype evaluation is limited and it could only be deduced that if a product captures the existing popular design and user needs elements, it would be more attractive for consumers. Further research involving professional fashion designers and

follow up user evaluations would address some of these issues. Other limitations of the project include a limited evaluation of other wearables products other than facewear and limited research into other wearables companies and their design development processes. This information is usually confidential to companies and not accessible by the public.

It would be useful for future research to develop case studies of companies on their design processes. Due to the commercial nature of most wearables R&D, designers in this field are hesitant in sharing too much information. However, the researcher is hopeful that as open-sourcing becomes more popular in wearables development, research would be made easier and more accessible. It would also be useful for future research to collaborate with experienced fashion designers and wearables designers simultaneously to test the value of different design approaches. Serving as a medium between the two fields, research to integrate these two design approaches would further encourage cross-industry collaboration and accelerate the adoption of wearable technology.

### 6.3 Conclusion

This project attempts to answer the question: Can the integration of fashion design elements, smartness in materials and wearables design elements lead to an alternative design approach that would benefit the adoption of future wearables? After a literature review on current wearables design processes and fashion design processes, and an actual attempt for designing and prototyping wearables using the integrated fashion-wearables design approach, it can be concluded that such an approach is beneficial to the adoption of future wearables in two ways. First, the selection of market research participants should be based on past experience with wearables, and such research should be more focused on user lifestyle. This will help designers to better understand what motivates users to consume, and differentiate those who are experiencers and those who are survivors. It would be beneficial to survey those who are more willing to experiment with new trends and to deviate from the norm than those who are uncomfortable with change. Secondly, incorporating existing popular fashion elements and trends in the design direction could encourage the consumer to adopt because consumers are more willing to purchase a product that conforms with their self-image, and wearables that project the wearer's identity and image are more likely to be adopted. Unlike portable devices, such as cellphones and laptops, wearables are more intrusive on the wearer's identity. Therefore, a design that does not conform with their self-image could make the wearer feel uncomfortable within their environment or their social class, which in turn would lead to a low adoption rate in the consumer market.

This research has given me a better understanding of consumer behaviour in both wearable technology and fashion. After working in the fashion industry for several years, I felt confused and tired, seeing fashion going in circles. Wearables are a new area in fashion development, and I am interested in seeing

where they will go. The way fashion could evolve with the help of technology, and how wearables could develop with the integration of fashion are exciting areas that this research has considered and investigated.

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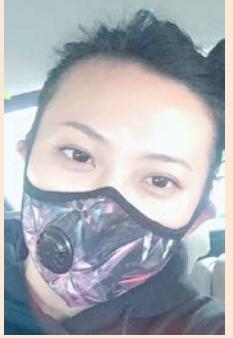
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## Appendices

### Appendix A: Existing Product Analysis Table.

Image/s	Brand	Price	Shape/Design	Technology/ Material	User Experiences
	Miniso Surgical Mask	-¥ 10 per pack of 10  -One size fits all	-A flat rectangle with two ear straps.	-Polypropylene sheet.	-Lightweight, easy to wear and breathable.  -Unattractive appearance.

	Green Shield M95 Mask	<ul style="list-style-type: none"> <li>-¥ 60 per Box of 10</li> <li>-One size fits all</li> </ul>	<ul style="list-style-type: none"> <li>-A round shape folded in the middle.</li> <li>-With breathing valve</li> <li>-Plain white with ear straps; lightweight</li> </ul>	<ul style="list-style-type: none"> <li>-Ag. coated cotton with microfilter systems.</li> </ul>	<ul style="list-style-type: none"> <li>-Ill-fitted</li> <li>-Uncomfortable while breathing</li> <li>-Unattractive appearance.</li> </ul>
  	Dettol Protect + Haze Protection KN95 PM2.5 Filter Adult Mask	<ul style="list-style-type: none"> <li>-¥ 99.90 per Box of 6</li> <li>-Size M</li> </ul>	<ul style="list-style-type: none"> <li>-A hexagon shaped mask with breathing valve</li> <li>-Can be folded in the middle</li> <li>-Plain white with ear straps; lightweight.</li> </ul>	<ul style="list-style-type: none"> <li>-Seven layers of polypropylene nonwoven fabric.</li> </ul>	<ul style="list-style-type: none"> <li>-The ear straps were too tight, and left marks on my face.</li> <li>-Hard to Breath</li> <li>-Moisture buildup inside the mask.</li> </ul>

	Vogmask	-¥ 198/each -Size M	-A triangular shape that resembles the lower face -Colourful patterns & a soft texture	-Four layers of activated carbon filter clothes.	-Thick, would get hot in the summer -Better fit and comfort level -Same breathing problem -Better look
 	Pitta Mask	-¥ 35 per Box of 3 -One Size Fits All	-A rounded one piece shaped to fit the lower half of the face. -Very lightweight and soft. -Can easily fit into a purse or pocket. -Can be folded in all directions	-A new polyurethane material.	-Easy to wear -Popular among celebrities. -Trendy -Not too tight on the face -No problem breathing -More like an accessory than a necessity.

	<p><b>Green Shield Washable PM2.5 Mask</b></p>	<ul style="list-style-type: none"> <li>- ¥ 30/each with 4 disposable filter paper.</li> <li>-One Size Fits All</li> </ul>	<ul style="list-style-type: none"> <li>-A hexagon shaped mask with a nose padding wire</li> <li>-Ear straps are adjustable</li> <li>-Can be folded in the middle.</li> <li>-No valve, reusable/washable outer layer. Only need to change the filter paper.</li> </ul>	<ul style="list-style-type: none"> <li>-A regular cotton mask with Ag. coated cotton microfilter inserts.</li> </ul>	<ul style="list-style-type: none"> <li>-The nose padding and wire make the mask fit better without having to tighten ear straps too much.</li> <li>-Breathing was ok, due to ample space between the mask and the nose.</li> <li>-Moisture buildup inside the mask.</li> <li>-Makeup gets smudged on the mask.</li> <li>-Better appearance.</li> </ul>
	<p><b>LIFAAir</b></p>	<ul style="list-style-type: none"> <li>- ¥ 29.8/each</li> <li>-One Size Fits All</li> </ul>	<ul style="list-style-type: none"> <li>-A round shape design to cover the nose and mouth with valve.</li> <li>-A structure that cannot be folded.</li> <li>-Ample space for breathing; adjustable ear straps.</li> <li>-A thin stretchy fabric sealing the edges for comfort</li> <li>-Reusable not washable</li> </ul>	<ul style="list-style-type: none"> <li>-A top layer of nonwoven fabric.</li> <li>-A second layer of Electrostatic Cotton.</li> <li>-A third layer of antibacterial fabric.</li> </ul>	<ul style="list-style-type: none"> <li>-Very comfortable to wear.</li> <li>-Minimal breathing problem.</li> <li>-No problem with glasses.</li> <li>-Cannot be easily stored in pockets or purses.</li> <li>-Takes up space due to its non-flexible structure.</li> <li>-Minimal makeup smudges.</li> <li>-Looks odd.</li> </ul>

 	<p><b>XD Design PM2.5 Smart Mask</b></p> <ul style="list-style-type: none"> <li>- ¥ 150/each with 2 filters</li> <li>-One Size Fits All</li> </ul>	<ul style="list-style-type: none"> <li>-One piece, round design for the outer layer of the mask with ear loops.</li> <li>-Removable/ rechargeable attachment filter.</li> <li>-Inner layer has a nose pad and a white filter pad inside.</li> <li>-Can be folded in the middle.</li> </ul>	<ul style="list-style-type: none"> <li>-Filter made of four layers: nonwoven fabric + heat sealing cotton + microfilter + nonwoven fabric.</li> <li>-A removable/rechargeable fan for ease of breath.</li> </ul>	<ul style="list-style-type: none"> <li>-Mask is too big for me.</li> <li>-Attachment can only be used for about 2 hours.</li> <li>-The mask looks very big and chunky.</li> <li>-No breathing problem, nor moisture problem.</li> <li>-Cannot avoid makeup smudges.</li> <li>-Bulky looking.</li> </ul>
	<p><b>Sifyer Smart Mask</b></p> <ul style="list-style-type: none"> <li>- ¥ 290/each with 2 filters.</li> <li>-One Size Fits All</li> </ul>	<ul style="list-style-type: none"> <li>-A diamond shaped plastic cover on the nose and mouth.</li> <li>-Silicone edges on the mask.</li> <li>-Neck/head straps.</li> <li>-Reusable/ rechargeable.</li> </ul>	<ul style="list-style-type: none"> <li>-Electronic fan pulling air through a filter pad.</li> <li>-Filter pad has four layers (antibacterial fabric + activated carbon fabric + High Efficiency Particulate Absorber fabric + Nonwoven fabric) and is changeable.</li> </ul>	<ul style="list-style-type: none"> <li>-Very heavy and hard to keep in place.</li> <li>-The neck/head straps messed up my hair, and difficult to put on and remove.</li> <li>-Communication was a problem. It was difficult for others to hear what you are saying.</li> <li>-No breathing problem.</li> <li>-Silicon edges were soft but due to its weight, I had to tighten the straps to keep it in on my face, which in turn left</li> </ul>

 					<p>heavy marks on my face.</p> <p>-Looks odd.</p>
 	<p>WoodyKnows Invisible Mask</p>	<ul style="list-style-type: none"> <li>-¥ 33/each with 2 filters</li> <li>-Size S</li> </ul>	<ul style="list-style-type: none"> <li>-Two small, round, pea sized nostril inserts with filtering paper inside.</li> <li>-Only the wearer knows he/she is wearing a mask.</li> </ul>	<ul style="list-style-type: none"> <li>-Two layers of filter: Electrostatic Cotton and Activated Carbon filter fabric.</li> </ul>	<ul style="list-style-type: none"> <li>-Extremely hard to breathe.</li> </ul>

Note: All prices are in RMB. Photographs taken by Melissa Lin.

## Appendix B: Trend Analysis

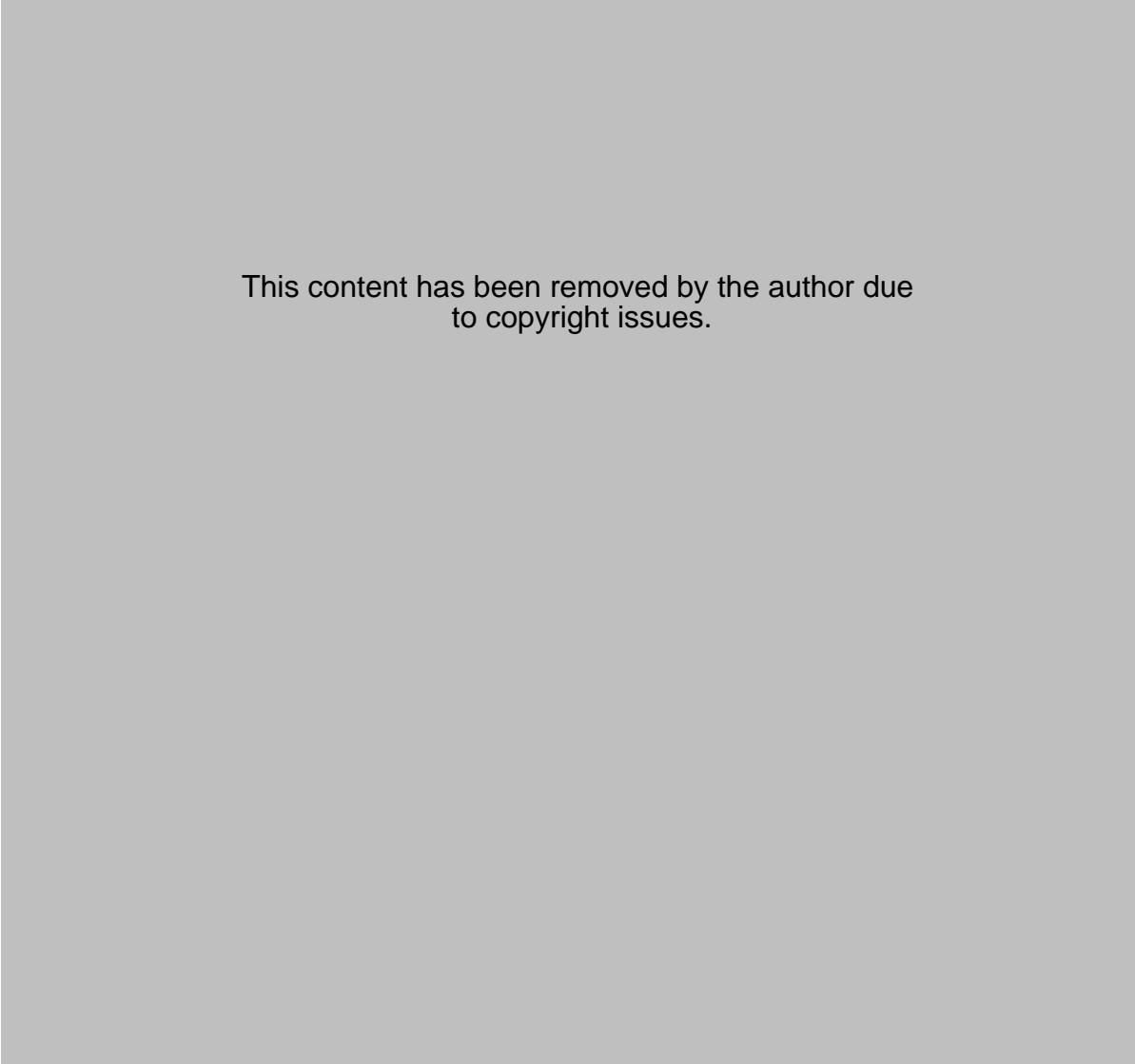
### Textile View Magazine s/s19

1. Glitch - "Innovative new ideas harness fast-moving technology, taking us to places beyond what we considered possible. Multi-sensory, immersive experiences shift and move, challenging our perception and transporting us to the other worlds" (Reca Group, 2018, p.91). Glitch is a word originated from the 1960s. It was defined as a sudden surge of current, a malfunction; something that is temporarily broken ("Glitch", 2018). This trend can be interpreted as a reflection of the rapid growth of technology in the past decade. Many are challenged and disoriented by these technological advancements. The hectic and illusional feelings are mirrored in this trend. Wearable technology being a technological advancement can best illustrate this trend.

2. Greener - "Mindful of our wellbeing and the threats to our environment, there is even more energy being directed towards seeking intelligent solutions for our planet" (Reca Group, 2018, p.92). This is a response to the environmental movement, a call for awareness of global warming. Among other issues, America's talk about withdrawal from the Paris climate agreement pushed the issue of global warming into the spotlight again (Worland, 2018). Hence the trend towards being green and environmentally conscious. There is also the issue of sustainability in the fashion industry. One of the biggest concerns of wearable technology is its

inability to be recycled. This raises questions like: How can technology be greener and more sustainable? If we were to develop wearables, would it potentially contribute to many more environmental issues?

3. Token - "A memory, a keepsake: a heartfelt fragment of a treasured past. Artisanal pieces with a story behind them, delicate, embellished and unapologetically feminine" (Reca Group, 2018, p.95). This reminiscence of the past could be understood as a reflection of the desire for a peaceful world without all the violence (Gavin, 2018). A modern motif in vintage tapestry, the juxtaposition of a sporty garment with the finest embellishment can also be a contemplation of the current state of the world where war and famine exist alongside lives of luxury and dissipation. The advancement of internet leads to new social styles and often more complicated relationships among people. Token possibly symbolises the idea of a simpler life in the past.



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to copyright issues.

Figure 50. S/S19 Women's Wear Trends Collage. Adapted From *Textile View Magazine* (2018). Copyright 2018 by Textile View Magazine.

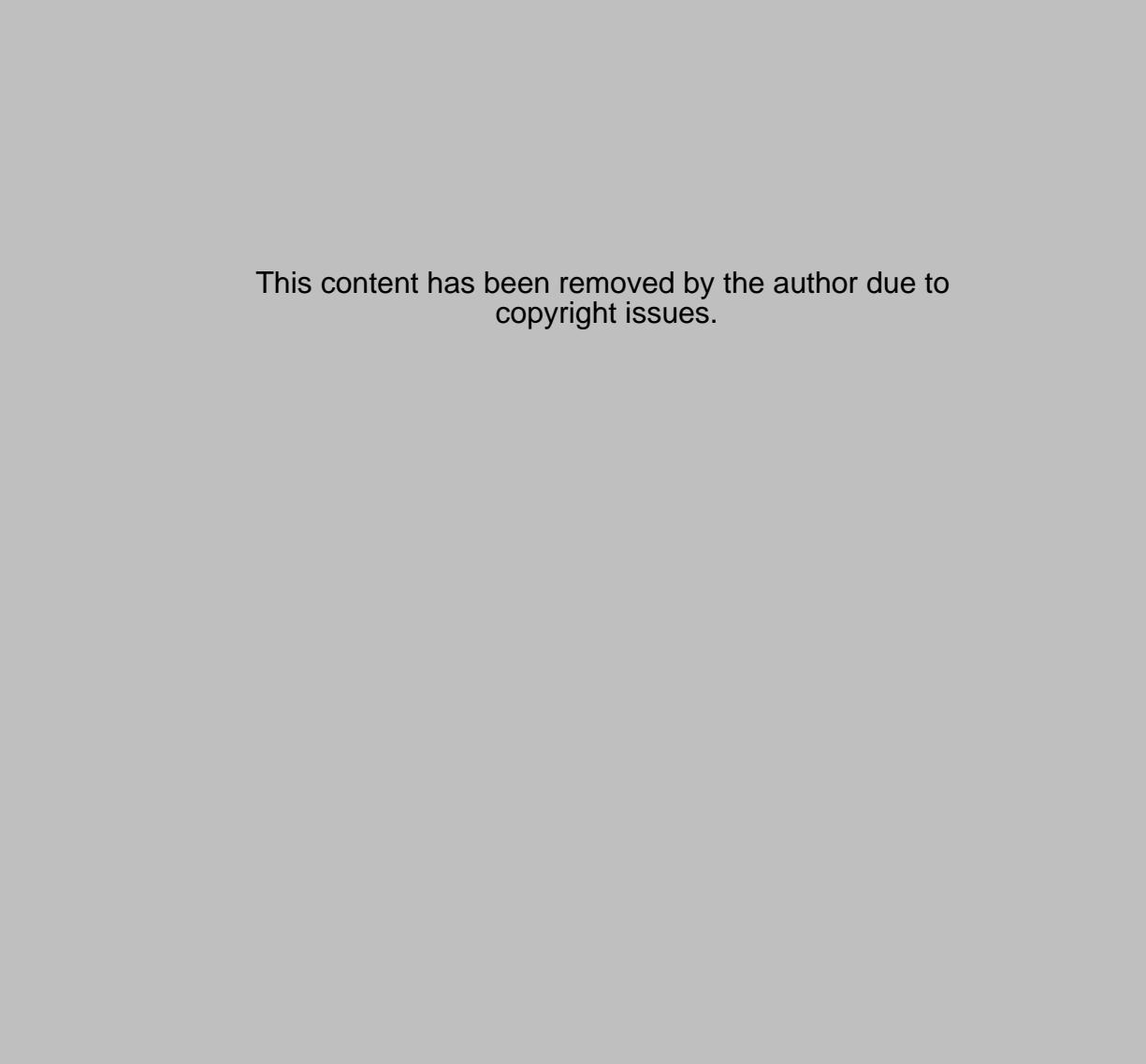
## Next look Trendbook s/s19

1. *City Heroine* is a fashionable metropolitan look, that is formal and luxurious combined with casual shapes and practical details. (Orsech, 2018, p.6) This metropolitan look is inspired by the feminist movements that have gained momentum in recent years; for example, the Women's March. More and more people are joining and supporting women's rights and equality, and although wearable technology has been said to best target male consumers, female users are growing rapidly and by making wearable technology more fashionable is possibly the best way to target female consumers.

2. *Funfair* entails patterns with comic, game and fairytale references; it is loud, extravagant and fun (Orsech, 2018). This look is one of the easiest to incorporate into wearables. The over-the-top enthusiasm is reflected in wild colours and patterns. As with much existing wearable technology, the designs are everything but modest. The use of colourful lights and fantastic shapes all speaks to this trend.

3. *Bird Girls* are romantic and nostalgic. This feminine look encompasses lace, floral and silk but this season the "delicate pastels are set to black and thus create a hard, yet fresh looking contrast" (Orsech, 2018, p.102). This look can be a variation of *Token* in Textile View Magazine (2018), a reminder of the carefree

and idyllic times. A new take on modern women, tender but daring. This combination of soft and hard best represent the current state of wearable technology where incorporation of electronic components into a textile is a real struggle.



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copyright issues.

*Figure 51.* S/S19 Women's Wear Trends Collage. Adapted From *Nextlook Trendbook* (2018). Copyright 2018 by Nextlook Trendbook.

## Appendix C: Designs Informed by Fashion Trends

### Design Brief

#### *Project Overview and Background:*

As the research/designer I am personally affected by air pollution every time I visited China. The respiratory issues caused me great discomfort and negatively affected my experience in China. Many of my family still live in China and not be able to enjoy my time spend with them in China is very disappointing.

#### *Objective:*

Design a mask that incorporates existing or upcoming filtration systems whilst appealing to the target market's fashion-conscious aesthetic. The design should meet the ChinaGB requirements and also encompass both the fashionable and functional features with the extended potential of customisation.

#### *Target Audience:*

Young Chinese consumers living in cities where air pollution is dangerously high. Many of them are experiencing negative health effects from air pollution.

#### *Key Message:*

The trend books should be utilised to determine the design direction. The mask should not appear to distance the wearer from their surroundings, and it should extend itself to be able to be worn every day in different social situations.

### Design Inspiration and Direction

One of the trends identified by the Textile View Magazine for Womenswear Spring/Summer 2019 is *Glitch*. It is described by the Textile View Magazine as a concept where “Innovative new ideas harness fast moving technology, taking us to places beyond what we considered possible. Multi-sensory, immersive experiences shift and move, challenging our perception and transporting us to other worlds” (Reca Group, 2018). This trend is physically characterised by visual disturbance, colour shifting, transparency and a high shine surface.

Using this concept as inspiration, the first mask design incorporates the characteristics of visual disturbance, colour shifting and a high shine surface. It uses a distorted pattern of colour shift fabricated from shiny material that reflects a different colour at every different angle. The mask is also decorated with crystals that can reflect light and add to the shine of the mask. The 3M filtering material is placed underneath the colourful material that serves as a veil over the filtering material. It is intended that wearing this mask will be seen as a fashion statement rather than that of only a health requirement. It has two magnetic earrings that help hold the mask in place. The ear hooks are made of silicone for comfort. The magnetic earrings are attached to the end of the silicone ear hook for stability.

## Glitch

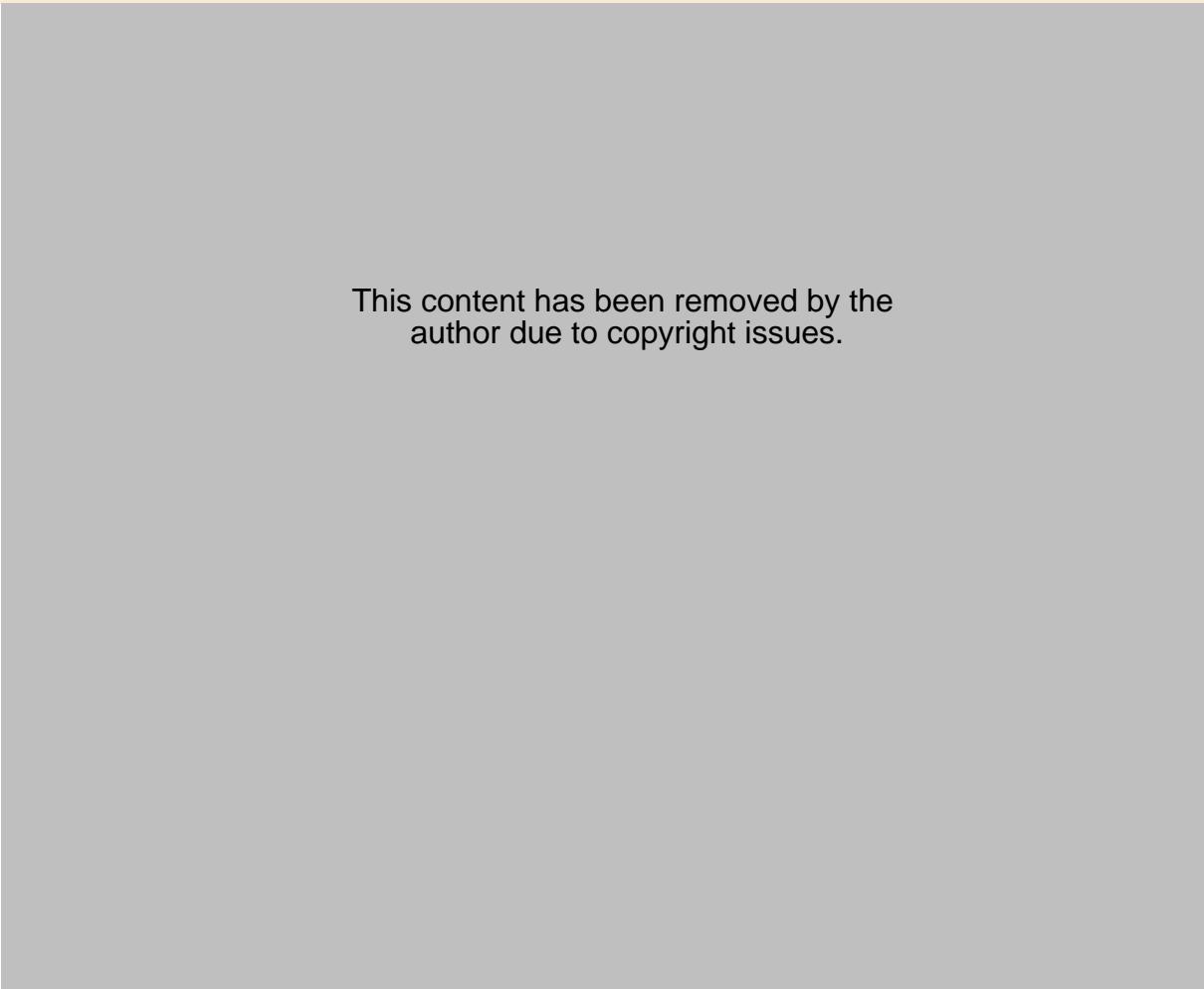


Figure 52. Glitch Moodboard Counter Clockwise:

Vector. From 123RF. Retrieved From [https://www.123rf.com/photo\\_51848419\\_stock-vector-vector-vibrant-violet-pink-blue-colours-modern-abstract-digital-vertical-stripes-glitch-graphic-design.html](https://www.123rf.com/photo_51848419_stock-vector-vector-vibrant-violet-pink-blue-colours-modern-abstract-digital-vertical-stripes-glitch-graphic-design.html). Reprinted with permission. Iridescent Faceless Bust. From Future Gallery. Retrieved From <https://futuregallery.org/jon-rafman/>. Copyright 2018 by Future Gallery. Iridescent Faceless Bust. From Door of Perception. Retrieved From <http://doorofperception.com/2015/06/jon-rafman-new-age-demanded/>. Copyright 2018 by Door of Perception. BLINX2. From Flickr. Retrieved From <https://www.flickr.com/photos/r00s/5981939039/in/photostream/>. Reprinted with Permission. Glitch\_Heart. From Imgur. Retrieved From <https://imgur.com/8jJh9wy>. Copyright 2018 by Imgur. GUNEE Homme. From Pandagunda. Retrieved From <http://www.pandagunda.com/guneehomme>. Copyright 2018 by Pandagunda.

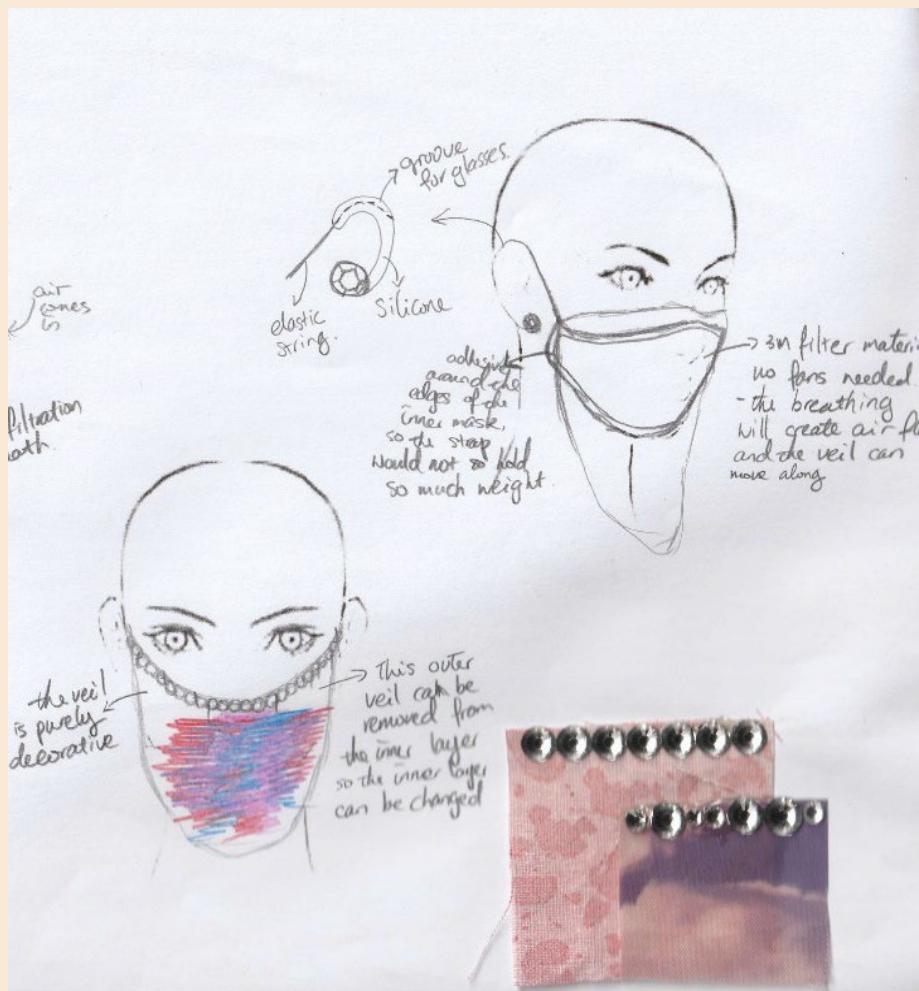


Figure 53. Glitch Concept Design Draft.

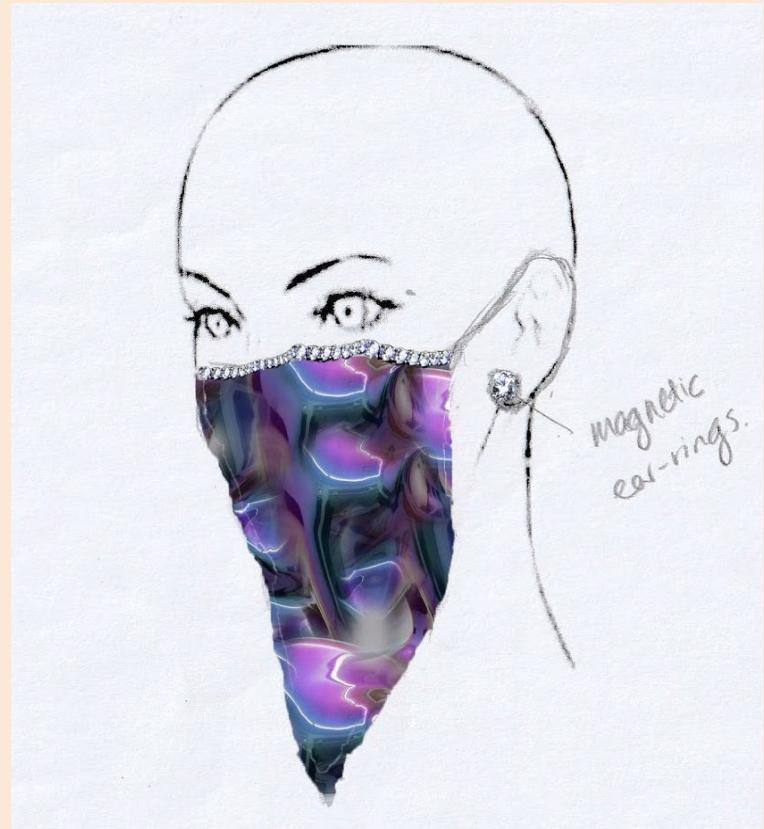


Figure 54. Glitch Concept Design Final.

Using a type of veil to cover up the filtering material is one option to make a plain face mask appear more interesting. The design enables the veil to be changeable and customisable according to the wearer's preference. This will increase the desire to wear the mask as it can be treated as an accessory that is additive and can complete an outfit rather than detract from it. In turn, this resolves the problem of the wearers being self-conscious when wearing something that is obtrusive on their self-image. The decision to use a silicone ear hook instead of the elastic bands in traditional masks is because silicone is more comfortable on the skin. However, this design could be problematic for people who wear glasses. One option is to add a groove into the ear hooks for glasses so that the mask and the glasses will click together. These ear hooks can also serve to secure the glasses and the mask, so the wearer would not need to worry about either one failing. This design has extended the *Glitch* trend in colour and silhouette selection. A computer glitch sometimes exhibits itself in a blue screen or a rainbow colour flash; in this design, a scale of similar colours are used for each mask. For example, a mask with a purple hue will use a mixture of lilac, lavender, violet, plum and mulberry; a mask with a red hue can be a mixture of auburn, burgundy, cardinal and maroon. The form and style of the mask were designed with the wearer's comfort and functionality in mind. The appearance follows popular trends and is likely to be readily accepted by consumers.



Figure 55. Glitch Concept Design prototype.

I created a prototype and used it in a photoshoot. The Glitch mask was obviously present, but it did not take away the viewer's attention. The overall vibe of the outfit or the photo was not overshadowed by the mask. Figure 54 and Figure 55 were shot under a natural light. Again the mask's colours and material did not seem to dominate the image nor did it look intrusive. The colours were soft and reflective as is the dress. It could also be induced that a consumer who owns outfits that complement the Glitch mask would have no problem accepting this design, because it would enrich her self-image instead of derail it.



Figure 56. Glitch Concept Prototype Editorial I.



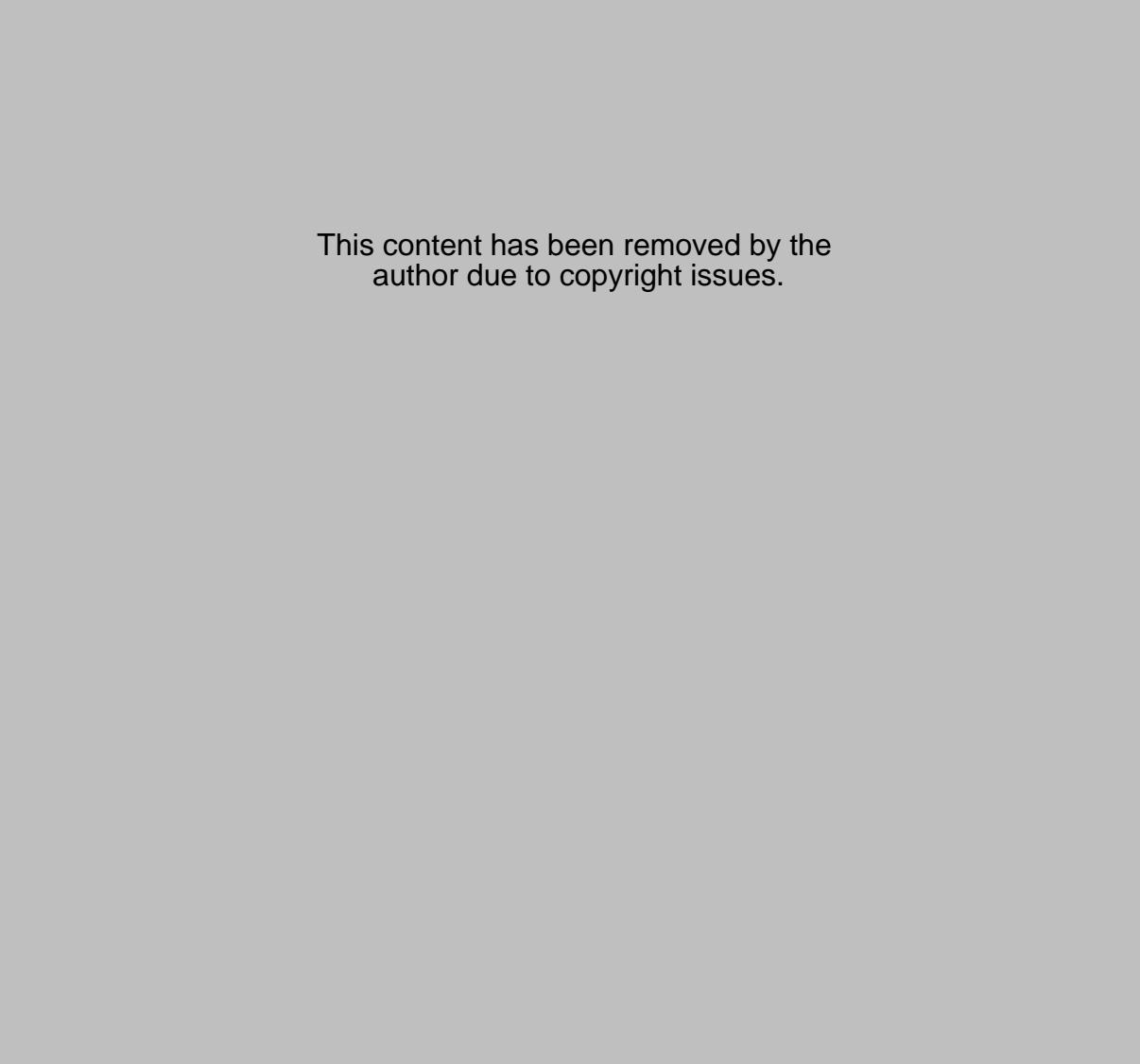
Figure 57. Glitch Concept Prototype Editorial II.

### Design Inspiration and Direction

The second design is inspired by the *Greener* theme from the Textile View Magazine (2018). *Greener* in the fashion idiom means being sustainable and regenerative, and focusing on wellbeing and community. The inspiration comes from nature and the art of embodying the human with nature. Giuseppe Arcimboldo's paintings of portraits in his collection Four Seasons are what first inspired this design. The notion of nature being part of us, and us resembling nature inspired by my designs.

Using this theme as inspiration, the mask is designed using leaves and algae. The mask is covered with algae and plants, such as the Boston Fern and Spider Plant. These plants are said to be natural air purifiers. Using plants as part of the design plays into the idea of sustainability and regeneration. By wearing this mask, the wearer is creating a social statement. Promoting an awareness of the importance of sustainability and environmental consciousness.

Greener



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Figure 58. Greener Moodboard Counter Clockwise:

Flower Beard. From Bored Panda. Retrieved From <https://www.boredpanda.com/flower-beards-trend/>. Copyright 2018 by Ashley Thalman. Spring. From Crystal Bridges Museum of American Art. Retrieved From <https://crystalbridges.org/blog/the-four-seasons-philip-haas-interprets-giuseppe-arcimboldo/>. Copyright 2017 by Crystal Bridges Museum of American Art. Flower Beard. From Blogspot. Retrieved From <http://josephscissorhands.blogspot.co.nz/2014/04/flower-beards-facial-foliage.html>. Copyright 2018 by Joseph Scissorhands. Spring. From Johannes Stötter. Retrieved From <http://www.johannesstoetterart.com/seasons-gallery/>. Copyright 2018 by Johannes Stötter. Montreal Botanical Garden. From Meme. Retrieved From <https://me.me/i/h-montreal-botanical-garden-quebec-canada-3378547>. Copyright 2018 by Meme.

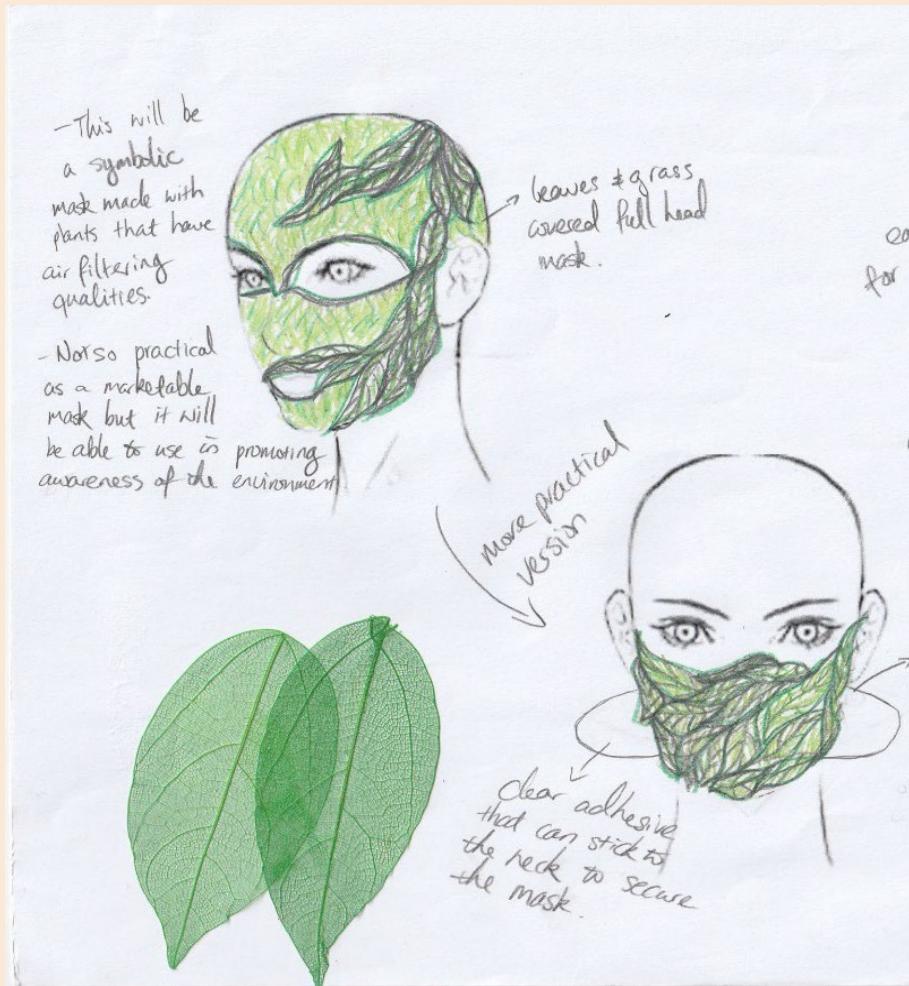


Figure 59. Greener Concept Design Draft.



Figure 60. Greener Concept Design Final.

This will be an exhibition piece only, because wearing a plant facewear is not realistic and such a design would only be a promotional tactic. There are two versions of this mask; one is more of a showpiece covering the whole face with only the mouth and eyes visible, the second one is more practical. The second design can incorporate the 3M filtering materials. If the 3M filtering fibre is used, the filtering material should be folded and coloured into a plant or leaf shape and colour. On each side, a clear adhesive wing is attached to the wearer's neck to secure the mask on the face or elastic bands to hook on the ears. The material should be biodegradable and/or reusable. This design targets those who are health conscious as well as environmentally considerate. By wearing this mask the environmentalists can make a bold statement to advance their cause; on the other hand, the mask can seamlessly integrate into any floral print outfits. This not only strengthens the wearer's self-image, but also promotes a good cause.



Figure 61. Greener Concept Prototype.

In these two pictures, I choose to wear a more colourful outfit that was further incorporated with the background. As I mentioned earlier, this mask is perfect for environmental enthusiasts and those who are health conscious. It is possible that these people prefer spending time in nature and/or around plants. Thus Greener mask perfectly camouflaged their appearances in nature. Also, the rise in popularity of floral prints also gave Greener mask a reason to shine with those who adopted the floral trend.



Figure 62. Glitch Concept Prototype Editorial I.

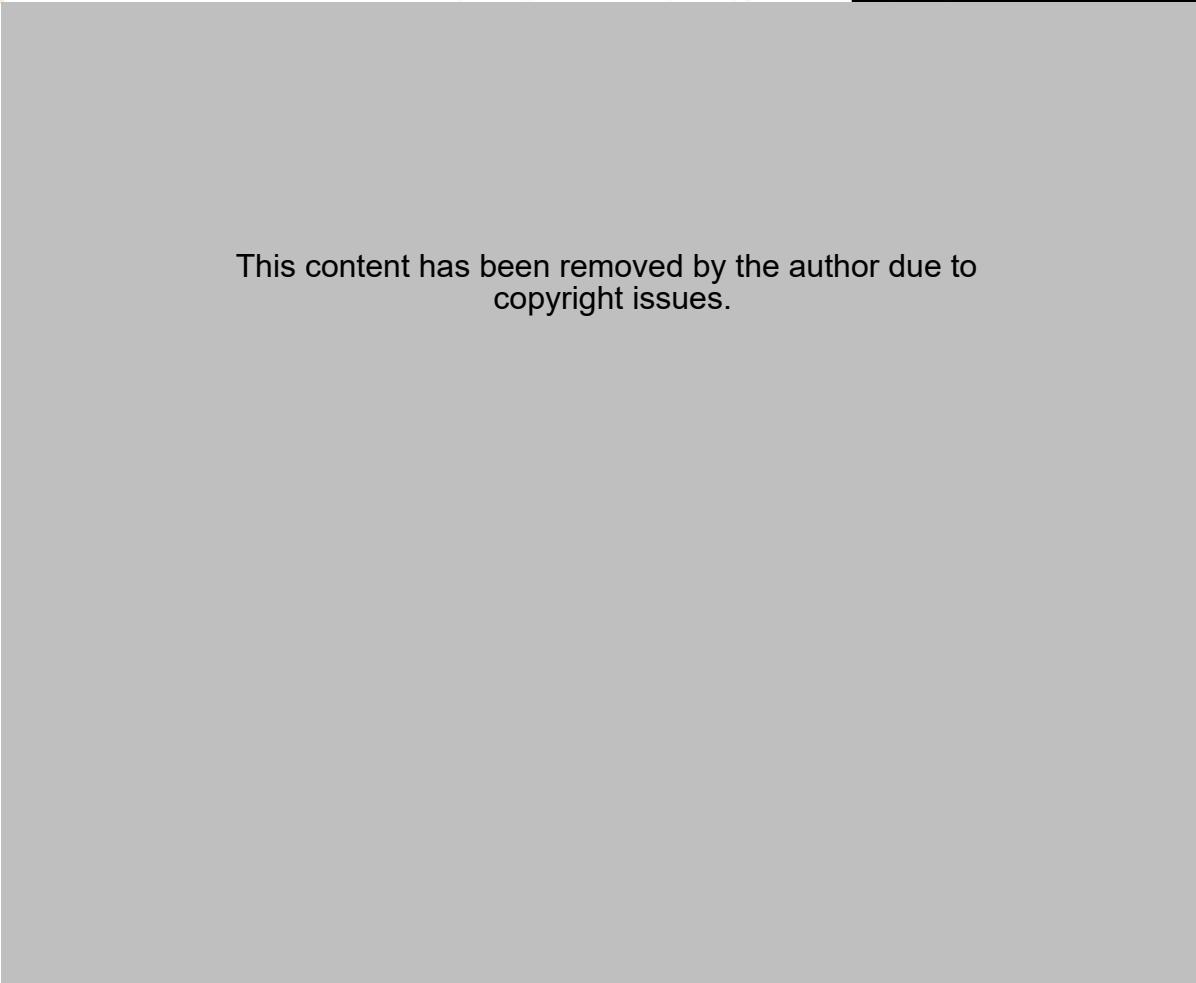


Figure 63. Greener Concept Prototype Editorial II.

### Design Inspiration and Direction

The third design is inspired by *Token*, “a memory, a keepsake: a heartfelt fragment of a treasured past. Artisanal pieces with a story behind them, delicate, embellished and unapologetically feminine” (Reca Group, 2018). My inspiration came from traditional art works from different cultures. Artefacts and paintings carry some history, because these are tokens of memory, a reflection of culture identity and they are reminiscent of the past.

## Token



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copyright issues.

Figure 64. Token Moodboard Counter Clockwise:

Chinese Opera Mask. From Pinterest. Retrieved From [http://static5.depositphotos.com/1002772/524/i/950/depositphotos\\_5247731-Chinese-opera-mask.jpg](http://static5.depositphotos.com/1002772/524/i/950/depositphotos_5247731-Chinese-opera-mask.jpg). Copyright 2018 by Depositphotos. Graphic Yin Yang symbol made of sakura flowers. From Colorbox. Retrieved From <https://www.colourbox.com/vector/yin-yang-made-of-sakura-vector-23655252>. Copyright 2018 by Colorbox. Mask from Manaus. From Dreamstime. Retrieved From <https://www.dreamstime.com/stock-photo-mask-manaus-brazil-made-fish-scales-seeds-piranha-teeths-image54447148>. Copyright 2018 by Dreamstime. Chinese Winged Orbs. From Pinterest. Retrieved From <https://www.pinterest.nz/pin/234116880608578977/>. Copyright 2018 by Pinterest. Deluxe Phantom Filigree Mask - Antique White. From Simply Masquerade. Retrieved From [https://www.simplymasquerade.co.uk/masqueradeshop/prod\\_152311-Deluxe-Phantom-Filigree-Mask-Antique-White.html](https://www.simplymasquerade.co.uk/masqueradeshop/prod_152311-Deluxe-Phantom-Filigree-Mask-Antique-White.html). Copyright 2018 by Simply Masquerade. Chinese Traditional Folk Art Paper. From Shutterstock. Retrieved From <https://www.shutterstock.com/image-photo/chinese-traditional-folk-art-paper-21466777>. Copyright 2018 by Shutterstock.

In Figure 63, two different ideas were first drafted, a Chinese Opera mask inspired design and an Asian traditional floral drawing inspired design. These inspirations are all pieces of a treasured past in Chinese culture. For the first design, the traditional Chinese floral drawing is used, because the target audiences are Chinese. A design that speaks to the targeting market's culture and art could be accepted much quicker. The chrysanthemum leaves are rearranged on the face from the initial design sketches and are placed in a way so that an asymmetrical shape is created for a more fluid look. One side is higher under the eye and the other drops away in a soft curve. Chrysanthemum is commonly seen in traditional Chinese floral drawings. This is because chrysanthemum blossoms are believed to resemble wealth and immortality in Chinese Art (Welch, 2013). The red colour is most popular during Chinese New Year (which is celebrated in one of the pollution-heavy winter months, January or February) when wearing red represents prosperity and happiness. These artisanal pieces are incorporated into the design to call for a new appreciation for traditional Chinese art. What also adds to the femininity is the fishnet texture added to the mask in Figure 64, where filtration takes place. Behind the fishnet is the 3M filtering material. This design appears more fashion-forward than technologically advanced, and can be quickly accepted as a fashion item. Again considering the appearance of the mask, it is

important that consumers can establish a connection with the design. A wearable technology that incorporates cultural references into its design allows those who are not ready to accept a technological self-image to try and adopt a piece of wearables that looks culturally appropriate.

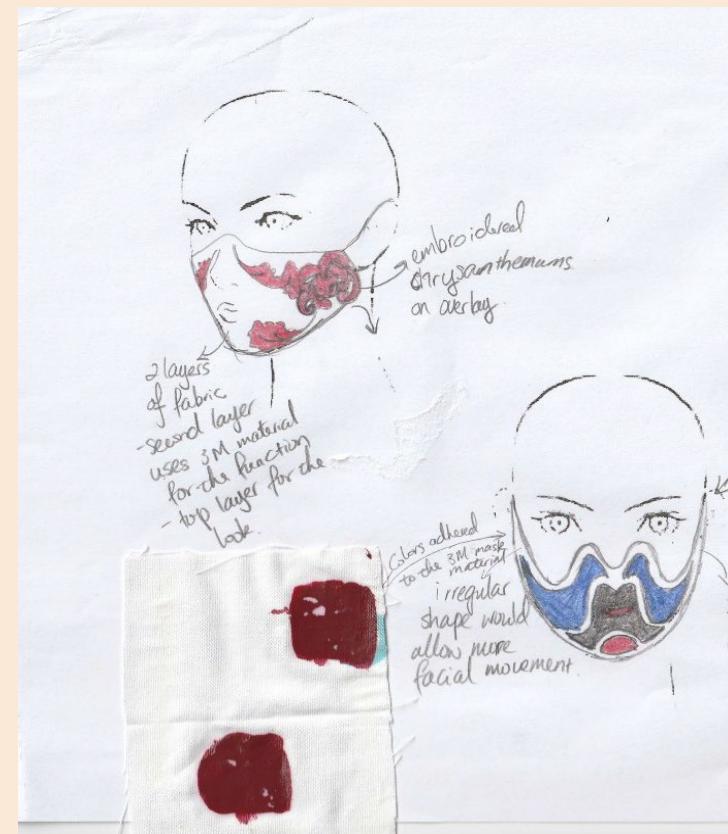


Figure 65. Token Concept Design Draft.

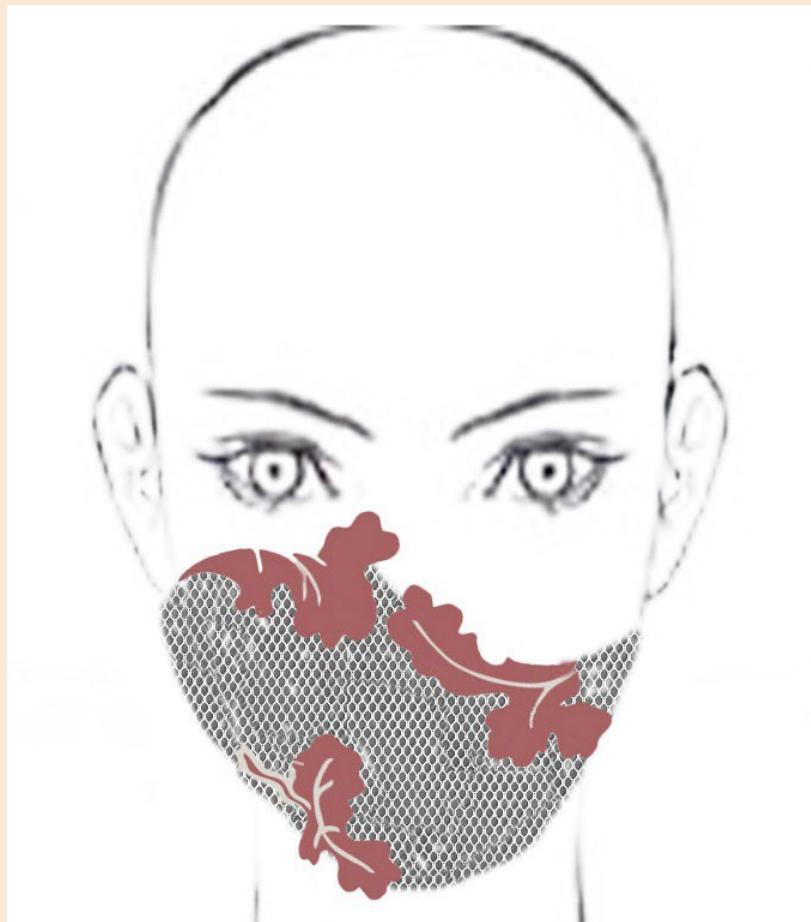


Figure 66. Token Concept Design Final.



Figure 67. Token Concept Prototype.

The token mask was prototyped with red and white lace. The softness of the material goes well with the fluidness of the design. These set of pictures were taken with an outfit that has some cultural elements. The red chryanthumun echos with the red cocktail dress, and the green corset perfectly underpins the theme. Although the prototype looked exaggerated and covered the majority of the face, but its colour, design and material seemed to hold it back from overwhelming the look as a whole. A look like this will surely strike a conversation at a cocktail party.



*Figure 68. Token Concept Prototype Editorial I.*

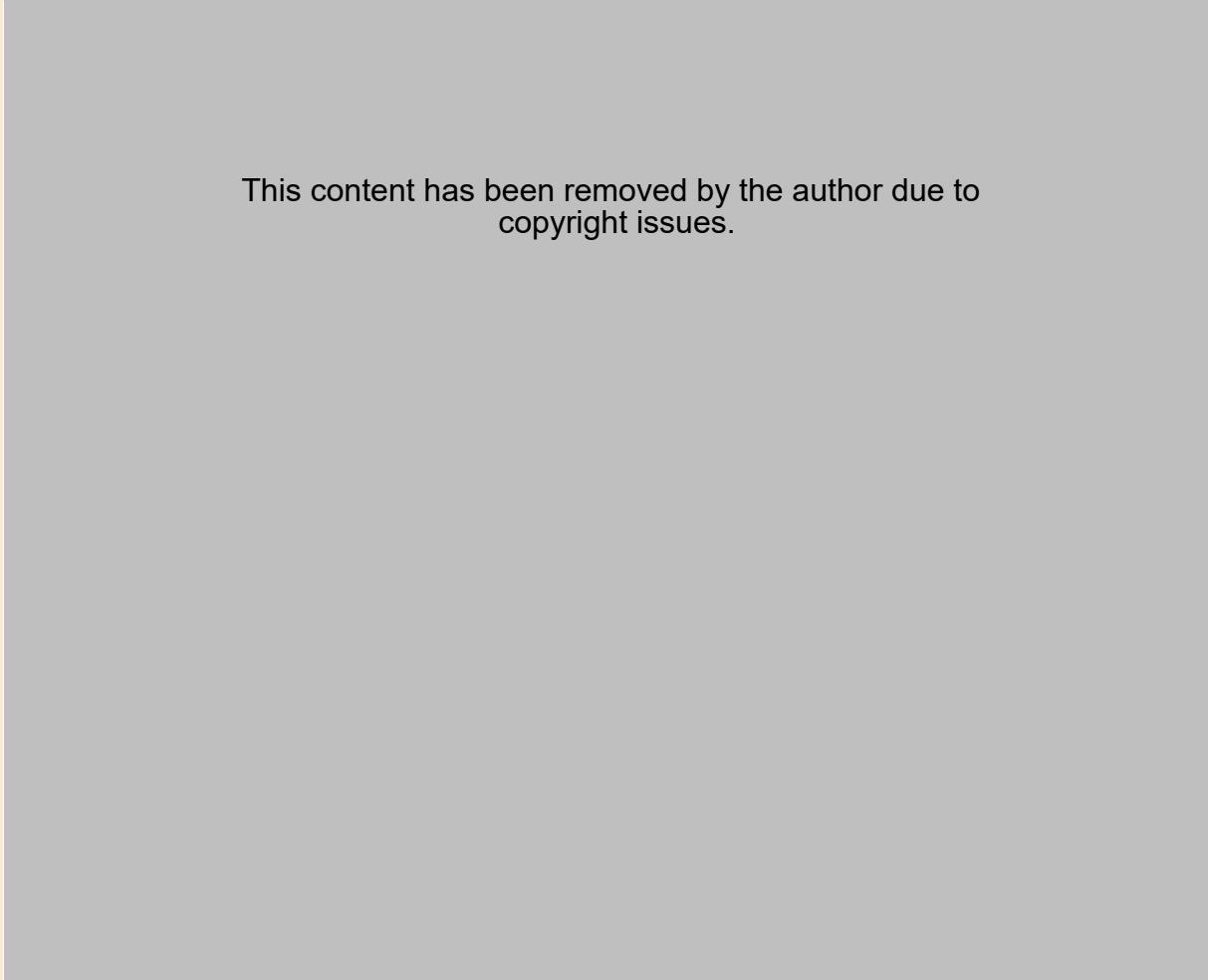


*Figure 69. Token Concept Prototype Editorial II.*

### Design Inspiration and Direction

The next three designs are inspired by themes from the Nextlook Trendbook (2018). First is the *City Heroine* inspiration, where luxurious styles and materials are combined with casual shapes and practical details. The inspiration came from high fashion editorials, jewellery and interior designs. The combination of precious metals and minimalist shapes best illustrates the *City Heroine* style.

## City Heroine



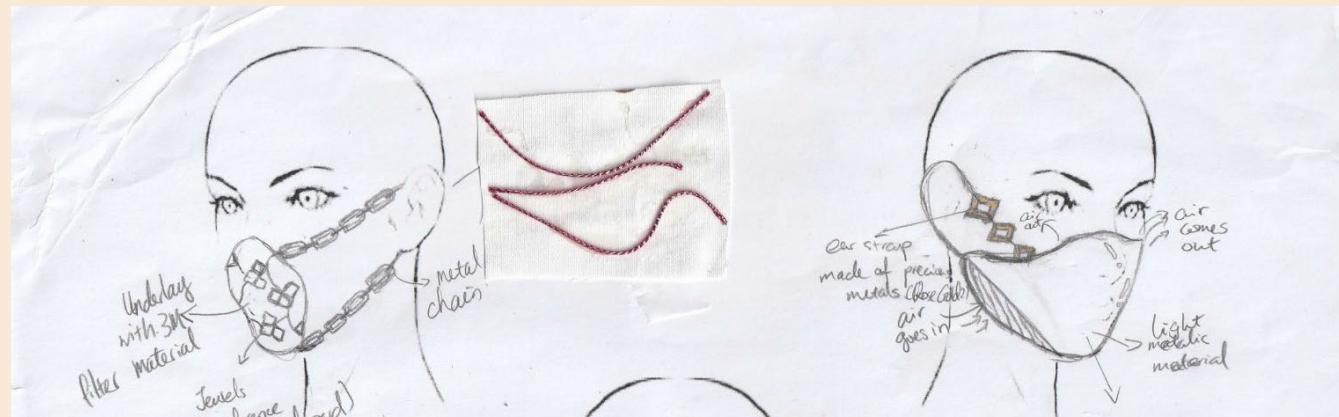
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copyright issues.

*Figure 70.* City Heroine Moodboard Counter Clockwise:

Cover Up. From Live Journal. Retrieved From <https://noirfacade.livejournal.com/1030123.html>. Copyright 2018 by Vogue Korea. Look of the Day. From Fashion Style Guru. Retrieved From <https://fashionstyleguru.wordpress.com/2013/10/23/look-of-the-day/>. Copyright 2018 by Wordpress. Sarah Jessica Parker. From Vogue. Retrieved From <https://www.vogue.com/article/sarah-jessica-parker-makers-episode>. Copyright 2018 by Vogue. Lindsay Headpieces. From Pinterest. Retrieved From <https://i.pinimg.com/originals/d2/58/bf/d258bfae8f7aae463c719b7347d831d5.jpg>. Copyright 2018 by Steven Turner. Masquerade Mask. From Beyond Masquerade. Retrieved From <https://beyondmasquerade.com/masquerade-mask-luxurious-wall-decor-mask-gold-blue-m31083/>. Copyright 2018 by Beyond Masquerade. 25 Minimalist Bathroom Design Ideas. From Maison Valentina. Retrieved From <http://maisonvalentina.net/blog/minimalist-bathroom-design-ideas/>. Copyright 2018 by Maison Valentina.

In Figure 69, different combinations of material and style are experimented with. Both an electronic filtration system and a traditional filtering material are idealised and incorporated into the designs. However, with the combination of precious metals and the electronic filtration system, the mask could become too heavy to wear. With the wearer's comfort in mind, a simpler design is engaged. The final illustration in Figure 70 uses a minimalist approach which barely covers the nose and mouth. The edges of the mask have adhesives applied to them so the mask can stay on the wearer's face, and the ear straps are made of silver chains, which are more for decorative purposes than actually holding the

mask in place. This design is one that should be easily adopted by consumers as it has a simple and elegant appearance. In addition, the colours are mostly neutral. The white and silver colour combination is on trend and can easily be matched to numerous outfit choices. Having such low-risk design elements, this mask can be styled with almost any outfit for its unobtrusiveness. This should advance the objective of encouraging frequent mask wearing.



*Figure 71. City Heroine Concept Design Draft.*

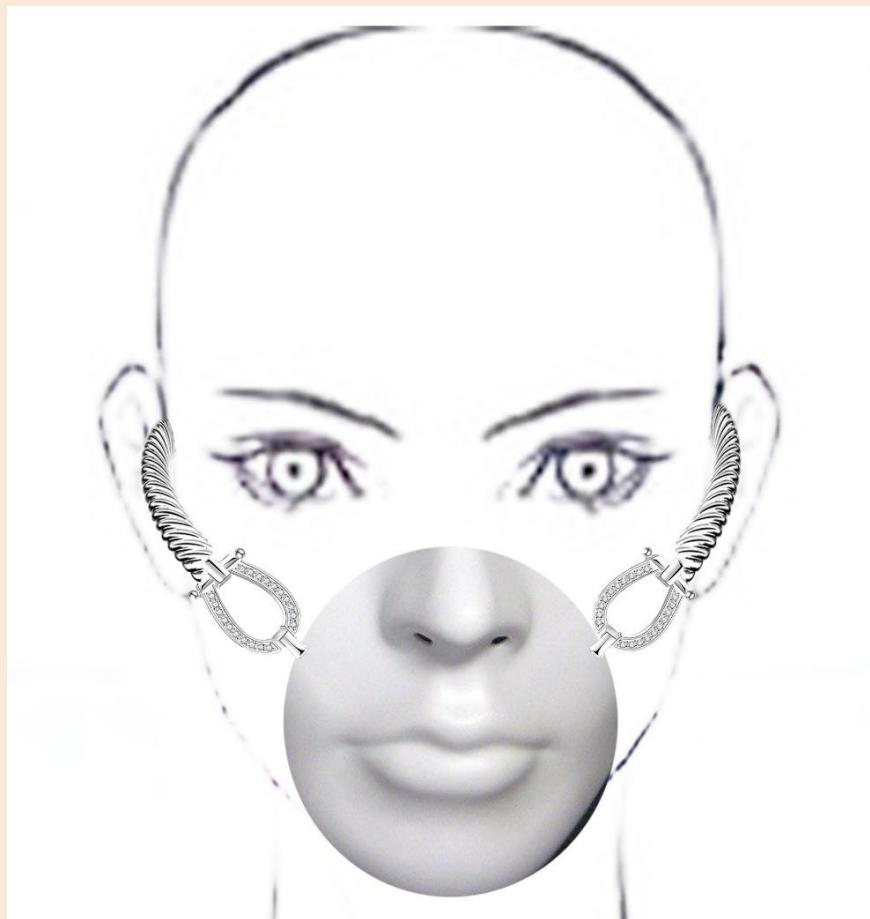


Figure 72. City Heroine Concept Design Final.



Figure 73. City Heroine Concept Prototype.

In this set of pictures, I styled the mask with another outfit that is popular and common in the workplace, a blue stripe button down shirt. The minimalist design of the City Heroine mask looks sharp. The crisp white oval covered the nose and the mouth, nothing more and nothing less; comparable to a smart business lady, determined and concise.



*Figure 74. City Heroine Concept Prototype Editorial I.*

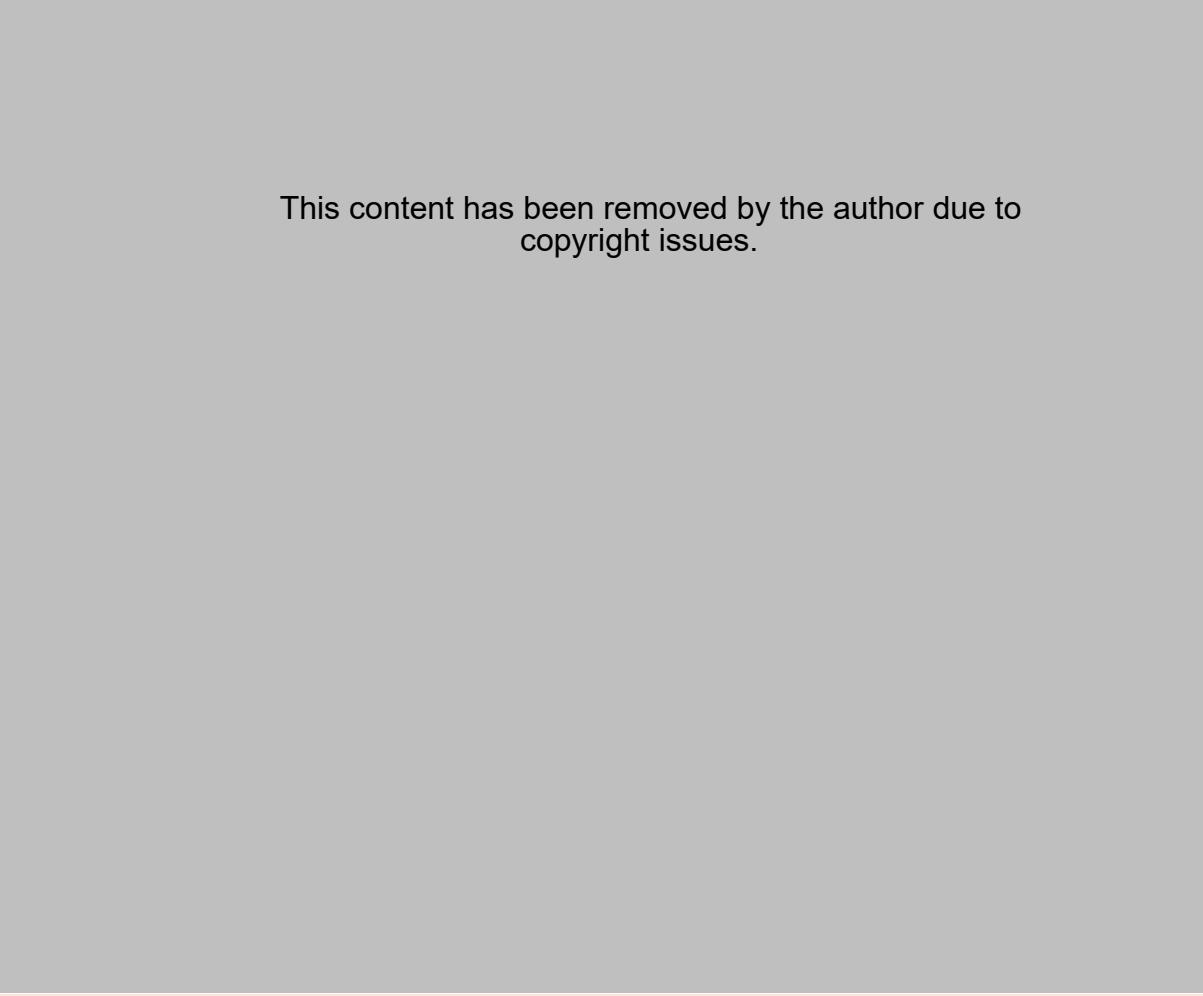


*Figure 75. City Heroine Concept Prototype Editorial II.*

### Design Inspiration and Direction

Next is the *Birdgirl* inspired design. This theme is femininity with a twist, millefleurs and lace on dark backdrops to create a hard visual contrast. Materials are often transparent and flowing accompanied with heavy embroidery (Orsech, 2018). This inspiration has a mythical twist, so the moodboard contains images of fairy-like models against a dark backdrop, and elements of soft and hard are intertwined.

## Birdgirl



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copyright issues.

Figure 76. Birdgirl Moodboard Counter Clockwise:

Flower Angel. From Instagram. Retrieved From <https://www.instagram.com/p/BNtlzrtD71C/?taken-by=jodilakin>. Copyright 2018 by Bella Kotak. City of Angels. From Pinterest. Retrieved From <https://www.pinterest.nz/pin/515873332302611850/>. Copyright 2018 by Kim Sang Gon. Floral Headpiece. From Pinterest. Retrieved From <https://i.pinimg.com/originals/f0/c1/35/f0c135b2874f37d3162e25f4fbba9964.jpg>. Copyright 2018 by Paolo Roversi. Bird. From Pinterest. Retrieved From <https://i.pinimg.com/originals/56/77/5e/56775e34613d6aa76fb81b6bc4b02abc.jpg>. Copyright 2018 by Ng youngjoo. Enchanted Worlds. From Bella Kotak . Retrieved From <https://www.bellakotak.com/Enchanted-Worlds>. Copyright 2018 by Bella Kotak. White Crow's Garden. From Pinterest. Retrieved From <https://www.pinterest.nz/pin/60517188724025585/>. Copyright 2018 by Ainigmati Studio.

Figure 75 shows the experimental designs with different elements defined in the trend, such as the combination of lace and a feather-shaped electronic filtration system. This design combines the softness of lace with the hard, plastic material required for electronic filtration system. The second design in Figure 75 incorporates oriental embroidery on both sides of the mask, and the shape of the mask is more rounded and soft to create a look that is more feminine. The colours used in this design are also light-hearted and youthful. Moreover, the sketch in Figure 76 is a combination of lace and embroidery, but with 3M filtration material for a lighter weight. The flowers next to each side of the face are made of feathers that hide the ear straps. I chose this design to move forward into the final *Birdgirl* mask design, which appears semi-transparent in the middle where white lace is used. The sides have flower embroidery and floral shaped feathers. As suggested by the trend book, a colour combination of blue and black was used to create a hard contrast to the materials used. This design is targeting those who are soft at heart but also want to look daring. It can complement a style that is both soft and strong. The colour contrast makes it fitting for both a lace floral dress style and a black pantsuit style without looking misplaced.

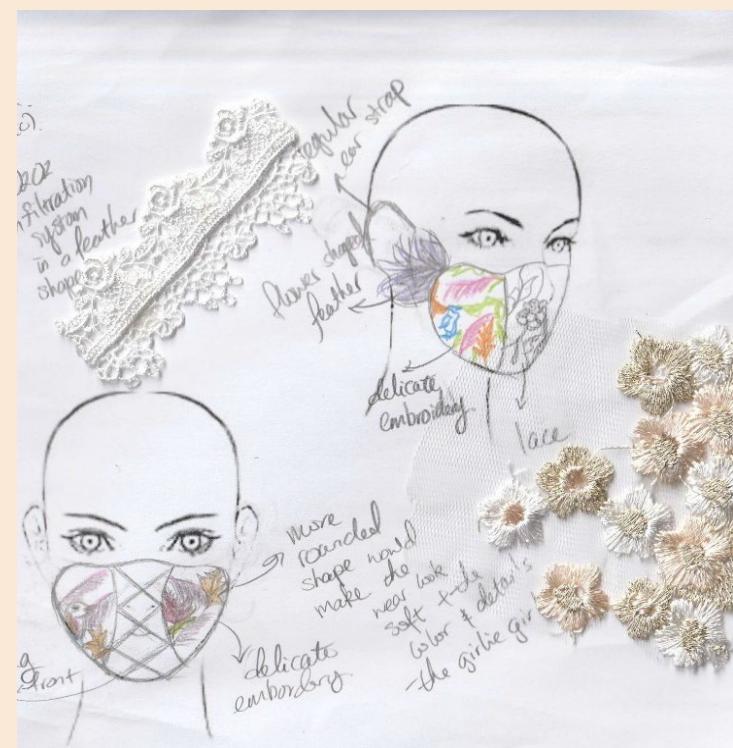


Figure 77. Birdgirl Concept Design Draft.

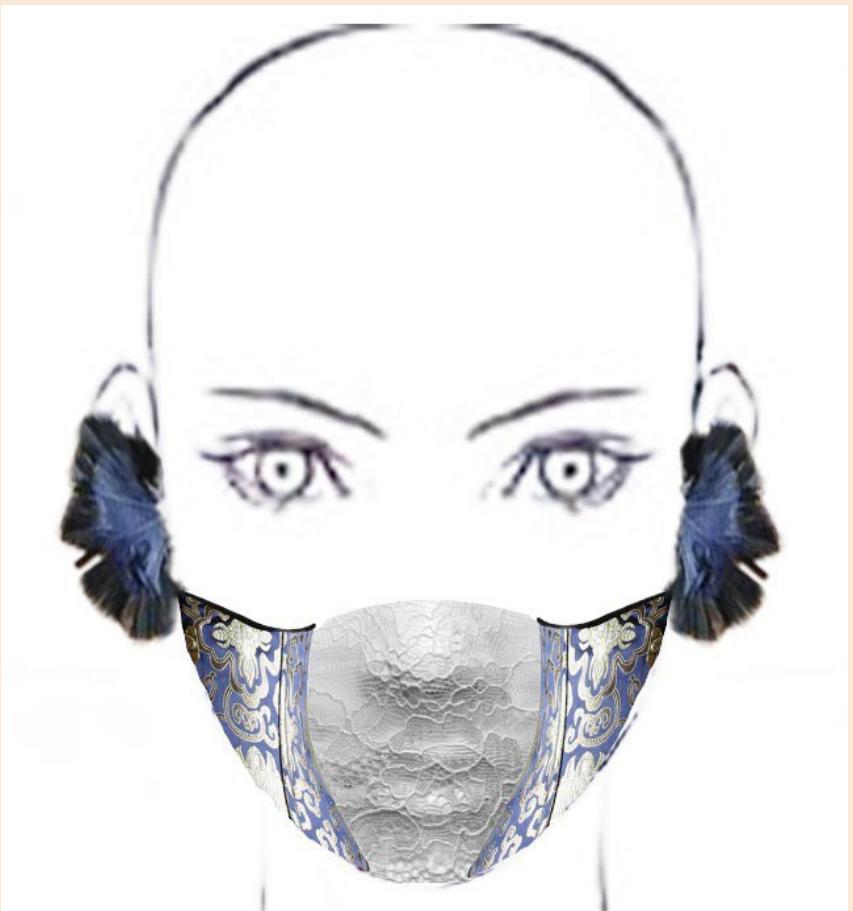


Figure 78. Birdgirl Concept Design Final.



Figure 79. Birdgirl Concept Prototype.

In this Birdgirl Prototype, dark purple lace was combined with soft neutral floral embroidery and white feather. The dark purple design on the side not only serves as a contrast in the design, as mentioned in the design inspiration, it also created an illusion of a narrower face. The Birdgirl mask, with its feathers gives a gentle vibe to the overall look. In this set of pictures, the general vibe of the pictures and outfits is more free-spirited with a sensuous temperament. As the Birdgirl theme promotes a fairy-like, spiritual design with a strong and determined undertone. The Birdgirl mask has a strong structure and the dark contrast colour, but it also has the fluid edges and a feminine overlay. The lace dress and kimono flowing in the wind and the feathers on the mask flutters, such should be the image of a fairytale.



Figure 80. Birdgirl Concept Prototype Editorial I.



Figure 81. Birdgirl Concept Prototype Editorial II.

### Design Inspiration and Direction

The final design explored the *Funfair* theme. Orsech says:

Those who love colour and patterns, will find fashion to their hearts content. Cocooning and kidification present themselves at their peak-escapism has never been more beautiful than now! Comic, game, manga and fairytale inspirations can be found as print or embroidery. The range is completed by animal motifs and scribbles. The yearning for childhood memories and seemingly better days is presented expressively, loud and extravagant; for the fun and games in fashion and solace in everyday life. (2018, p.38)

## Funfair

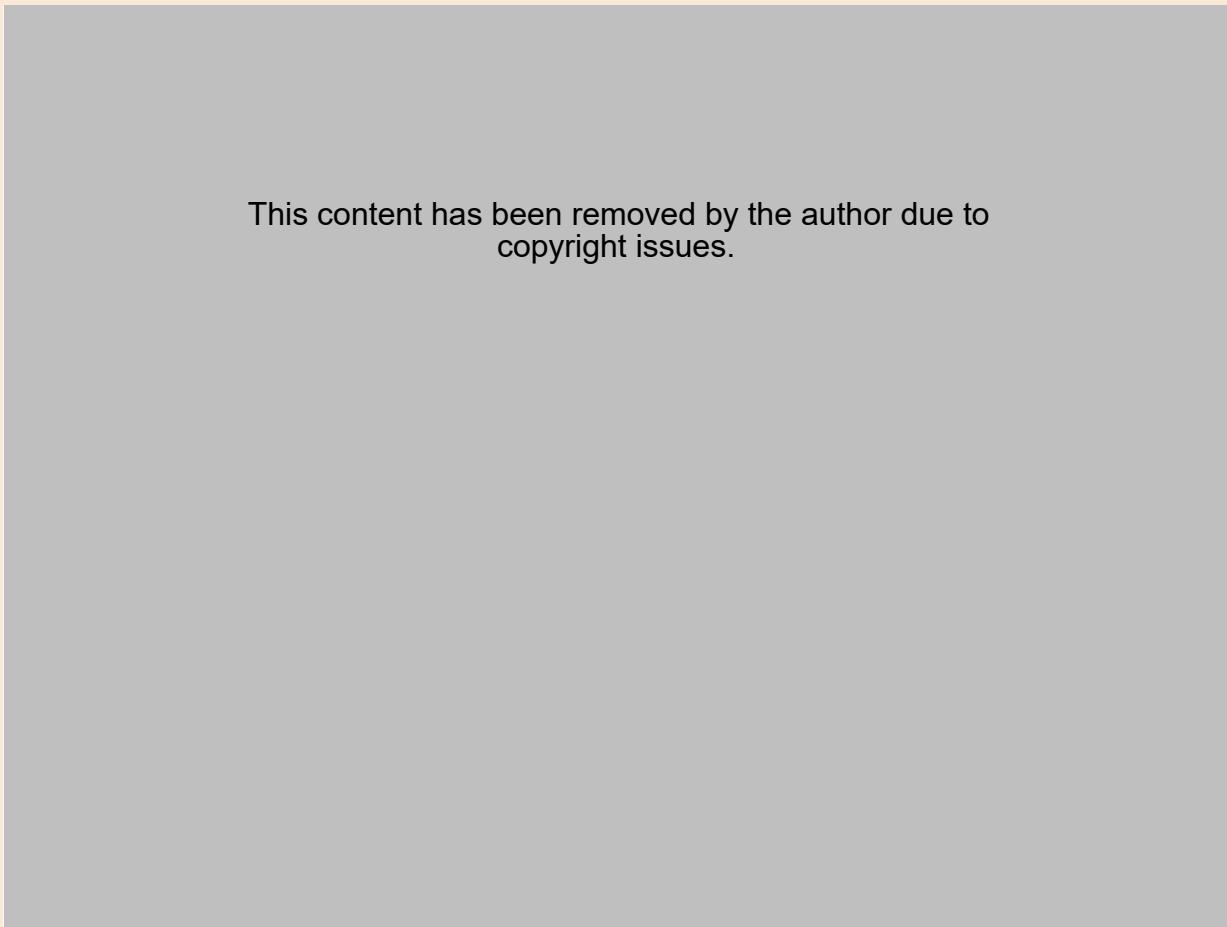


Figure 82. Funfair Moodboard Counter Clockwise:

Dog Mask. From Clipart Library. Retrieved From <http://clipart-library.com/clipart/1038842.htm>. Reprinted with Permission. Cartoon Art Wallpaper. From Wallpaper Gallery. Retrieved From <https://wallpaper-gallery.net/single/cartoon-art-wallpaper-22.html>. Copyright 2018 by Wallpaper Gallery. Pip & Pop. From NN Contemporary Art Northampton. Retrieved From <http://www.nncontemporaryart.org/>. Copyright 2018 by NN Contemporary Art Northampton. Carnival Queen. From Valeria Kogan Photography. Retrieved From <http://www.valeriakoganphotography.com/portfolio/fashion-photography/carnival-queen/>. Copyright 2018 by Valeria Kogan Photography. Trash Animal. From Street Art Today. Retrieved From <http://streetart.today/2017/11/29/7-best-murals-of-the-month-november-2017/>. Copyright 2018 by Street Art Today. Marilyn Monroe 2013. From Flickr. Retrieved From <https://www.flickr.com/photos/kaneda99/9117829522/>. Copyright 2018 by Alessandro Pautasso. Abstract colours Vector Art Wallpaper. From All Wallpaper. Retrieved From <https://www.allwallpaper.in/abstract-colours-vector-art-wallpaper-2686.html>. Copyright 2018 by All Wall Paper.

This theme is colourful, fun, childlike and passionate. The drafts are designed with a playful mind. The use of bold colours and Mickey Mouse inspired shapes all plays into the idea of fun and passion. Figure 81 shows the design sketched with the 3M filtering material. In the final design in Figure 82, I borrowed the speech bubble idea from cartoons and combined it with glittering colours. The word 'ARGH!!' is used to grab maximum attention, because that is what being a child is about. Being childish is often seen as being loud and attention seeking. This design explores these characteristics with its shape and colours. This theme can easily be incorporated into a smart mask, because it would not seem out of place even with the most outrageous technologies due to its extravagant nature. A wearer who embodies this style is probably not too concerned with the incorporation of unfamiliar forms and technology into their already eye-catching self-image.

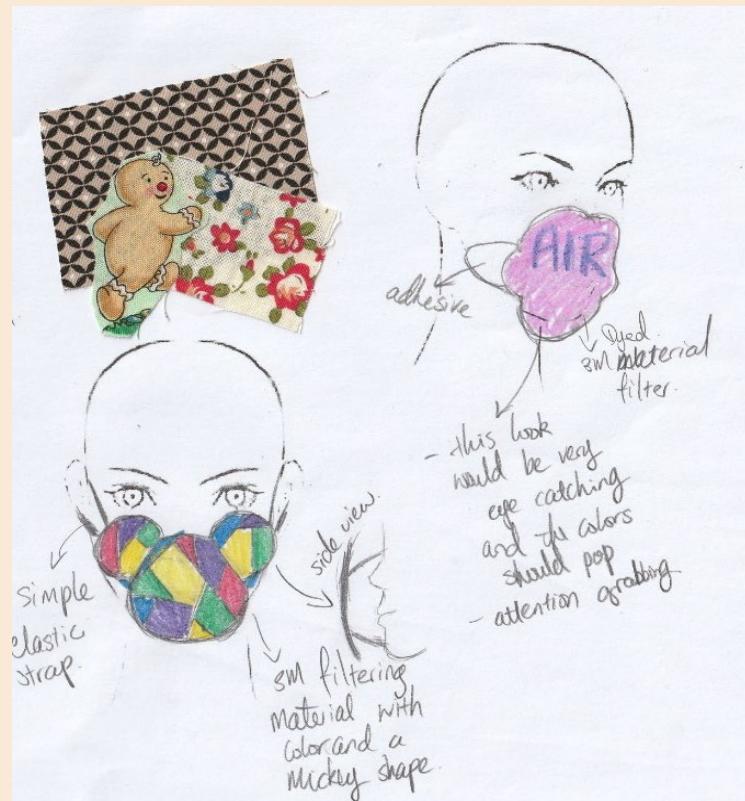


Figure 83. Funfair Concept Design Draft.



Figure 84. Funfair Concept Design Final.



Figure 85. Funfair Concept Prototype.

It is assumed that a smart respirator would look less obtrusive when the wearer's image is also exaggerated and fashion forward. The next set of pictures exhibits a childlike spirit with colourful, loud style. The oversized, neon coloured skirt and comical glasses, all speaks to a fun-loving audience. The Funfair mask combined with these style choices brings a smile to the viewer's face. The lightheartedness infatuated the wearer's self-image. Although the mask was designed to grab maximum attention, but when it is situated in an environment where it belongs, the attention was evenly distributed to the whole image rather than a spotlight of attention.



Figure 86. Funfair Concept Prototype Editorial I.



Figure 87. Funfair Concept Prototype Editorial II.