

Making Sustainable Garments the Societal Standard: Smartphone Projection Jewelry for Adaptable Fashion

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Figure 1: *Liquid Crystal prototype*

Abstract

Incorporating a dynamic accessory for adaptable fashion into the consumer aesthetic lexicon—personal wardrobe, taste, trends—benefits consumers on two highly impactful strata: the overarching health of the consumer’s natural environment, and the consumer’s personal finances. As such, widespread adoption of adaptable fashion accessories should be an objective of the broad industry of fashion, and perhaps more importantly, the tastemakers. The supply of adaptable fashion accessories must be met accordingly with demand in order to realize the wide range of benefits. Making adaptable and sustainable fashion the societal standard is contingent on the qualities of the accessory’s form factor. It must become an extension of what consumers will always do—use garments and jewelry as a curatorial tool for communicating physical appearance and personal identity. This paper intends to justify and propose an original methodology for developing an adaptable upper body jewelry system that fashion-oriented consumers are likely to embrace. The approach described in this paper includes an ornamental system of upper body chains, custom fabricated to enclose a magnifying glass angled towards the user’s body. The system functions like a projector when the user attaches their smartphone to the necklace, enabling projection of dynamic visuals onto the wearer’s shirt. An accompanying mobile application allows the user to select a variety of visual clips to display on their garment. The described jewelry technology marries principles of adaptive design and sustainability by ascribing the digital fluidity and immediacy we have come to crave to a comparatively static—yet essential—medium: clothing.

Keywords: dynamic garments, smart jewelry, wearable display, flexible display, 3-D printed wearables, animated textiles

1 Introduction

Meaningful advances in the field of wearable technology have predominantly occurred in niche areas outside of the consumer sphere. Funding for such research tends towards the military and health industries with emphasis on the development of utilitarian applications: health monitoring and biometric sensing, time management, security concerns, and so forth [2]. These practical uses, though noble, align very little with the characteristics that are likely to make wearable tech ubiquitous and mainstream: personal context and connection.

Incorporating a dynamic accessory for adaptable fashion into the consumer aesthetic lexicon—personal wardrobe, taste, trends—benefits consumers on two highly impactful strata: the overarching health of the consumer’s natural environment, and the consumer’s personal finances. As such, widespread adoption of adaptable fashion accessories should be an objective of the broad industry of fashion, and perhaps more importantly, the tastemakers.

The supply of adaptable fashion accessories must be met accordingly with demand in order to realize the wide range of benefits. Making adaptable and sustainable fashion the societal standard is contingent on the qualities of the accessory’s form factor. It must become an extension of what consumers will always do—use garments and jewelry as a curatorial tool for communicating physical appearance and personal identity.

The societal and cultural norm of internet connectivity has impacted the way consumers perceive and evaluate products. The degree of online access to precedents and visuals of top tier fashion is such that not even elite couture can remain original for long. Contemporary consumers have seen it all and the drive to stay on trend makes preference for a certain visual style or trend relatively ephemeral.

Although the coupling of portable devices and online information have primed consumers for adoption of wearable tech, there is an unreconciled difference between what consumers want and what wearable technology currently promises. Inability to identify with a product's use is enough to keep the highly practical strain of wearable tech out of mainstream consumer culture [2].

On the other hand, "reactive fashion" as a "second skin" provides value that is likely to engender widespread consumer adoption of wearable technology: the notion of changing skin, identity, and cultural context. "The killer application for wearable computing is to convey personal identity information. This is called fashion and it is mostly visual." [2].

Furthermore, "From our random sample survey an overwhelming majority, 98%, of women were in favor of fashion products and accessories that can dynamically be changed via a smartphone app to match their desired outfit ensemble. Their condition was that it should not look, feel, weigh, or smell like a technology brick roped to the side of a fashion product as that would defeat the whole purpose." [6].

Contemporary consumers have seen it all and the drive to stay on trend makes preference for a certain visual style or trend relatively ephemeral. Too often this leads to waste from irrational consumption of clothing items, and a significant carbon footprint. However, when spontaneously changing a garment's appearance is tantamount to changing a television channel, the weekly installment of bleeding edge trends from "fast fashion" become less compelling to consumers. *Quality over quantity. One device that does it all.* A technology aesthetic is firmly rooted in our collective unconscious as an accepted visual form.

The proposed adaptable fashion accessory is a modular upper body jewelry piece designed to physically interface with the user's smartphone by locking into the corresponding smartphone case. The smartphone display works with an embedded magnifying glass to form user-controlled projections on the user's upper body.

In the same way consumers ordinarily update the liquid crystal display of a smartphone screen by launching different media, this accessory system lets consumers update the appearance of their garment on command. Deploying this accessory in the consumer marketplace is the critical first step for recalibrating industry and societal standards for sustainability and environmental consciousness.

This paper intends to justify and propose an original methodology for developing an adaptable upper body jewelry system that fashion-oriented consumers are likely to embrace. The approach described in this paper includes an ornamental system of upper body chains, custom fabricated to enclose a magnifying glass angled towards the user's body. The system functions like a projector when the user attaches their smartphone to the necklace, enabling projection of dynamic visuals onto the wearer's shirt. An

accompanying mobile application allows the user to select a variety of visual clips to display on their garment.

The described jewelry technology marries principles of adaptive design and sustainability by ascribing the digital fluidity and immediacy we have come to crave to a comparatively static—yet essential—medium: clothing

2 The Empirical Impact of Fashion

2.1 Unsustainable Production Processes

The apparel and textile industries stand among the most environmentally detrimental of all modern industries: negative environmental and social repercussions directly result from each phase of their product life cycles [7]. Specifically, the production processes for apparel and textiles are associated with carbon emissions and expedited climate change, depleted air quality from industrial pollution, accumulation of hazardous waste, and excessive expenditure of natural resources [2].

Regardless of the quality standard and price point of an apparel brand, under common production methodologies textile and garment production requires the same amount of finite resources [2]. The manufacture of popular synthetic fabrics like polyester requires significant amounts of crude oil, affecting both climate change and human health: the subsequent chemical emissions include volatile organic compounds, particulate matter, and hydrogen chloride, all of which contribute to respiratory disease [3].



Figure 2: Cotton, the most pesticide-dependent crop

Environmental consequences also stem from the manufacture of natural fabrics such as cotton, one of the most popular and versatile fibers used in clothing manufacture. The cotton crop alone accounts for one fourth of the total pesticides used by the United States—the biggest player in cotton distribution in the world [3]. In fact, it is the United States' cotton crop that formed an impetus for a globalized fashion industry, and ultimately, the phenomenon of fast fashion [3].

2.2 Fast Fashion

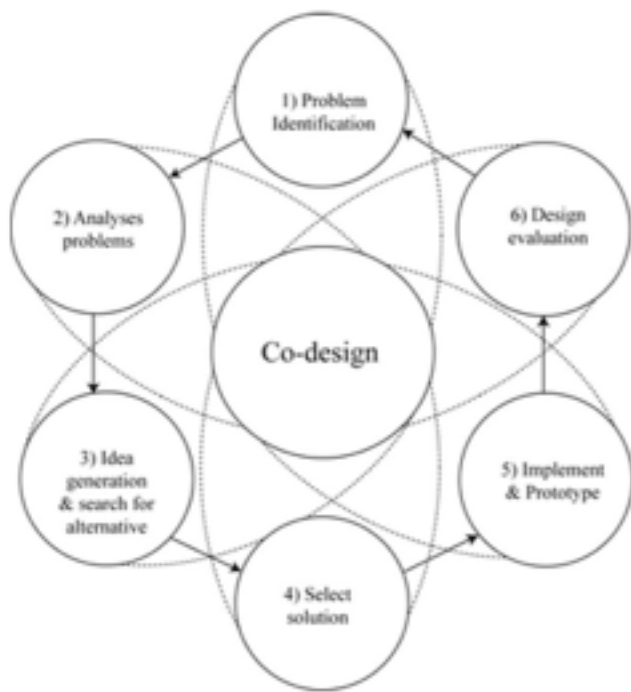


Figure 3: Co-design framework

The globalization of the fashion industry dramatically changed the way society approached clothing consumption, especially in America. The traditional model for the fashion industry has evolved into one of “fast fashion”, characterized by excessive accumulation of clothing, higher rates of discard, disproportionately low rates of utilization of existing garment inventories of personal garments, expedited fashion and trend cycles, and lack of interest in wearing garments throughout their functional lifecycle [2].

According to a 2005 study on a similar topic, “each year Americans purchase approximately 1 billion garments made in China, the equivalent of four pieces of clothing for every U.S. citizen.” [3]. These figures are not particularly shocking taken at face value; however, “once bought, an estimated 21% of annual clothing purchases stay in the home, increasing the stocks of clothing and other textiles held by consumers...The report calls this stockpiling an increase in the ‘national wardrobe,’ which is considered to represent a potentially large quantity of latent waste that will eventually enter the solid waste stream.” [3].

According to data from the EPA, Americans throw away more than 68 pounds of clothing material per year [3]. This consumptive behavior is not limited to the United States— the fast fashion market makes up about one-fifth of the entire clothing market in the UK [7].

In general both the production and consumption of apparel has steadily increased since the Industrial Revolution, and the majority of existing research on the topic has centered on the production side of the chain [7]. Taken together, these figures urge definitive research about consumer motivations for participating in the economic cycle of fast fashion.

Stage 1: Initial exploration of work (Problem identification & analyses)
 > Designers meet users
 > Exploration of problems
 > Observation, examine, analyses

Stage 2: Discovery process (Ideation & Select)
 > Designer and users generate new ideas and heavily interaction
 > Employ various techniques (storyboarding, toolkit and games)
 > Clarifies users goals and values
 > Stakeholders agree on desired outcome of the project

Stage 3: Prototyping (Implement & Evaluation)
 > Designers and users shape technological artifacts
 > Prototyping on sits and in lab
 > Mock-ups

Research suggests that the cycle of fast fashion encourages excessive consumption: consumers now tire of their clothing after wearing them a few times, and subsequently dispose of them prematurely. When there is almost no price barrier, there is a greater chance that consumers will purchase something they never ultimately wear, and also begin to shop to fill emotional or psychological needs. Material culture and the drive to accumulate as much as possible is a benchmark of Western culture [2]— from this perspective, it can be deduced that consumers engage in fast fashion to keep their personal wardrobe up to date in hopes of impressing those around them. Such behaviors reinforce the large-volume production and mass supplier approach of the fast fashion market.

This is further confirmed by an examination of this industrial model: “the shortening of the design process in recent years, a reduction in initial retail prices of fashion items and a decline in the residual value of fashion, all of which serve to counter the development of sustainable fashion and textile consumption.” [7]. It has become increasingly clear that a systemic change within the fashion industry is essential to progress towards a feasible sustainable industry.

2.3 Disrupting the Cycle

Making a change to the firmly rooted problem of the fast fashion industry requires adjustments to not only the production end of the cycle, but also consumption: “there can be no doubt that consumer behavior has a significant influence on the environmental impact of clothing.” [7]. Said differently, many of the environmental issues we face can be considered a design problem about the way society regards material goods, how they are constructed, and eventually used.

There is a body of existing theory for reimagining the industry model to move towards sustainable production and consumption. The concept of co-design is one such example that proposes a

participatory model of fashion design that attempts to engage consumers earlier in the fashion cycle. This approach allows consumers to act as co-partners in the design process in hopes of increasing their feeling of investment in the item and driving sustainable consumption [7].

Co-design by this definition is not prevalent in the fashion industry— when it is seen it comes towards the end of the design process through mass-customization [7].

The concept of adaptable design presents a more viable approach to remediating the fast fashion industry. There are two established theories of adaptability: design adaptability and product adaptability. “Design adaptability refers to the adaptability in the design of a product, so that the design can be adapted to produce another product. Applying product adaptability creates a product that can be changed by the user in a usually reversible and simple procedure to achieve different functions or usages.” [2].

The core of the adaptable design concept is to provide consumers with the ability to adapt to emerging requirements and maintain (or tweak) use of a material item regardless of circumstantial changes.

3 Product Adaptability in the Context of Garments

3.1 Product Adaptability Principles

Product adaptability in particular is a possible design solution for creating a sustainable synergy between consumers and the fashion industry and change the way consumers consider garment acquisition. Applying principles of product adaptability in the context of garments would remove the need for consumers to purchase something new every time they craved a change in what they had [2]. Instead, the modern concept of an “update” would be made possible within garments, a previously static medium.

By nature product adaptability can assume many forms. Often product adaptability is characterized by enabling the user to replace different functional parts of an item, or upgrade existing parts [2] “By using platform or modular designs, the products have removable or exchangeable parts, which allow for adaptation as well as upgradeability. Upgradeability can reduce waste by allowing the consumers to replace the part that is worn out rather than the whole item.” [2].

These concepts are commonly exemplified in product families outside of garments— practically any digital or analog item with multi-functionality. Two proven products include a bicycle U-lock that triples as a carrier and a splashguard, as well as the 2003 Ford Freestyle FX car that can convert between an SUV and pickup truck with user-friendly agility [2]. These examples were proven to extend utility and lifespan by incorporating versatility and ease of use into the design concepts; however, there are fewer such examples in the realm of mainstream apparel.

A prototype built as part of a recent study offers a strong prototype of a shoe-based flexible and wearable display, and a precedent for adaptable garments. This prototype incorporated a battery-powered electronic paper display, Arduino microcomputer, Bluetooth chip, and custom Android mobile application to prove their concept. incorporated a mobile application as the driver of

user input. The Arduino was subtly embedded within the high heel shoe, enabling it to receive input information from the user’s smartphone application. Users were able to send commands to the shoe’s microcomputer component for processing against the pre-loaded images and patterns, ultimately triggering the user’s choice to display on the shoe’s electronic paper display [6].



Figure 4: *Flexible wearable display prototype*

The developers of this prototype acknowledged the logistical and spatial concerns associated with their development process, particularly in regard to finding the optimum placement for the electronics. This is a probable cause of the absence of adaptable apparel items in the mainstream market. Incorporating adaptable design principles into garment development paradoxically solves a design challenge while presenting another: the challenge of adding tremendous functionality to a traditional garment while maintaining a strong aesthetic.

3.2 Second Skin and Reactive Fashion

Soft electronic garments have become a burgeoning offshoot of computer wearables that promise a future of adaptable garments. “Work is being done by artists and designers in the area of reactive clothes: ‘second skins’ that can adapt to the environment and the individual. Fashion, health, and telecommunication industries are also pursuing the vision of clothing that can express aspects of people’s personalities, needs, and desires or augment social dynamics through the use and display of aggregate social information.” [5].

Such advancements are likened to second skin because they are more ergonomically placed on the wearer than traditional wearable computing components. Bringing these parts in closer contact with the skin makes incorporating new technologies into everyday life a more intuitive feat. In fact, using garments as the primary location for on-body computing is often more feasible— and more wearable— than more structurally rigid accessories like shoes. “In order for the wearable computer to be more wearable, it needs to be knit onto the body and conductive yarns need to replace wires.” [5].

Reactive fashion, though technically wearable computing, subscribes to a different set of design principles that illustrate the conceptual transition from desktop computing technology to a framework suitable for the body. “Materials need to change, functionality needs to evolve past the point where wires hang along the user’s body, and the computer housing (the clothing) needs to be more attractive. Most importantly, the wearable

computer needs to be less fragile. Users who wear such a thing should be able to do so without the fear of hurting their wearable.” [5].

3.3 The Base Garment Concept

The Base Garment Concept describes a reactive fashion garment that coincides with the principles of adaptive design. The concept of a base garment effectively removes any need for similar garments of the same color and invites even further creativity: “since the garment could display *any* pattern, the creative options for textiles designers open up, including patterns that actually animate.” [4].

The base garment is purchased with a default color of black and invisible functionality for the wearer to select the garment’s color. The user choice could be made through either a garment component (e.g. pocket or button) or a wireless accessory (e.g. brooch, necklace, earrings). The possibility of incorporating the functionality into software for mobile phones is also acknowledged [4].



Figure 5: E-ink garment concept prototyped using projection mapping [9]

As described, *The Base Garment Concept* would offer broader technological capabilities than the proposed technology for the dynamic garment display. Although useful, functionalities like generating power from the body, transmission of information over the skin, and emitting and receiving information from nearby devices, introduce unnecessary complexities like health concerns resulting from close user proximity to radiation [4]. In turn, the viability of the base garment concept is jeopardized due to its complex and multi-purpose nature.

This suggests that complex and multi-purpose functionalities, while favored in highly practical and utilitarian ubiquitous computing, may not be appropriate for innovation in the realm of reactive fashion and second skin wearable technologies.

The technology proposed in the sections that follow attempts to provide value similar to that of the base garment, but in a manner that simplifies the physical configuration and functionality of the device.

5 Appealing to Fashion-Oriented Consumers

5.1 Harnessing Consumer Support

The premise of the wearable computing vision is that people and computers will continue to integrate to the point that we will wear technology just as we do clothing, in hopes of “facilitating context-dependent interactions with the world and people in it.” [1]. However, this vision is arguably far off from fruition. Regardless of the power and value offered by wearable computers, they are too often forsaken due to feeling unwearable. “Their various components are made of hard plastic, metal, and silicon. They are heavy and angular. Their weight is uncomfortable for extended use and the advantages of wearing such devices are not clear to a majority of people.” [1].

When the use cases for wearable technology are unclear to consumers garnering their support is unlikely. To do so, the product must align to adding economic, social, hedonic, and in some cases, altruistic value [11]. When concerns about the efficacy of a product in any sense are not easily quelled,

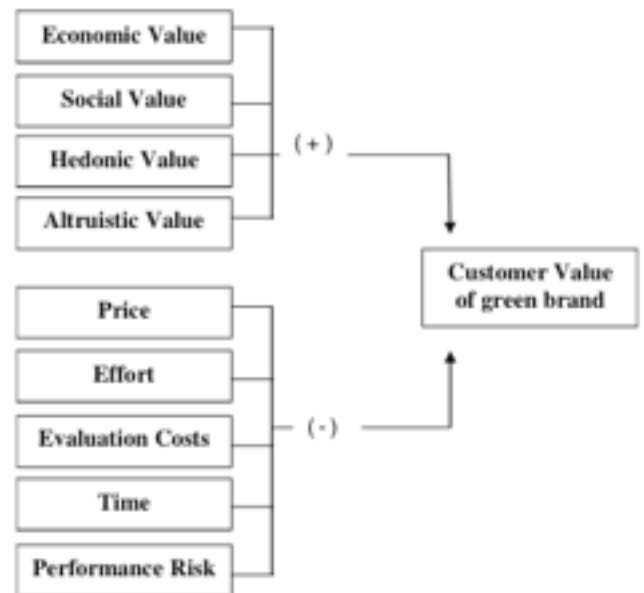


Figure 6: Consumer motivation models

consumers will not buy [11]. In other words, if a consumer must spend longer than a few moments evaluating a new or unfamiliar product based on criteria like “is this accessory socially acceptable?” or “what would owning this product say about me?”, they are unlikely to make a purchasing decision.

To create consumer buy-in for wearable technology, the products

most strive to align to the values consumers seek from their non-technological counterparts. “Mihaly Csikszentmihalyi writes that physical artifacts help us objectify the self in three ways. They can be viewed as symbols of personal power, symbols of the continuity of the self through time, and symbols of the permanence of relationships that define the individual in a social framework. Similarly, the idea of costuming is thousands of years old and is effectively used to hide, reveal, and distort the self that we present to the world. We use clothing to express a lot of things: social class, religion, and overt labeling through labels with the associated lifestyle promised by advertising.” [1].

Despite the ongoing developments in highly utilitarian wearable technologies, the potential for innovation within traditional fashion is clear. The killer application for wearable computing is to convey personal identity information. This is called fashion and it is mostly visual.” [1]. In fact, clothing can be considered one of the first forms of wearable technologies, and one of the most integrated and personal embodiments that “functions as protection, disguise, and interface to the world.” [1].

Merging textiles with the maturing fields of software, display, and sensing technologies can produce fabrics and garment materials that look and feel natural despite their high tech capabilities [4]. As a result of the pairing between digital innovation and textiles, the interactions between body and garment are at a juncture for setting new precedents. Increasingly there is strong consumer interest in computer wearables and electronic textiles. “There is strong consumer interest in computer wearables and electronic textiles. In the last few years, technology itself has become quite a fashionable thing and emerging technologies in particular are becoming fashionable lifestyle accessories.” [1].

Consumer acceptance of technology for adaptable fashion is a reasonable next step in the ongoing expansion of our technological lexicon. “We carry growing amounts of attractive portable computing and personalized digital devices on our bodies. We increasingly believe in the idea of being wired and connected with others and in the idea of monitoring ourselves and others. At the same time, a technology aesthetic is infiltrating our cultural language and visual style. We know what technology can do for us and we want more of it, in a ubiquitous and seamless way.” [1]. In light of this, consumers are more open than ever to alternative applications for technology, and perhaps new forms altogether.

Even with this readiness for technological advancements there is value in assimilating to traditional form factors. “Wearable technology in the form of wearable computing displays, etc. will need to not only add extra technological value to the user. It will need to strategically or seamlessly blend in to current form factors or augment them in ways that shed unnecessary steps from the procedures of how things are conventionally done while adding desirable value proposition and comfort.” [6]

A survey conducted in conjunction with the afore-mentioned wearable shoe display prototype yielded encouraging results: “From our random sample survey an overwhelming majority, 98%, of women were in favor of fashion products and accessories that can dynamically be changed via a smartphone app to match their desired outfit ensemble. Their condition was that it should not look, feel, weigh or smell like a technology brick roped to the side of a fashion product as that would defeat the whole purpose.” [6]

First generation technologies for adaptable fashion should

particularly adhere to these ideas, attempting to invisibly incorporate any technology into a conventional form factor such that its appearance is outwardly indistinguishable from its analog counterparts.

5.2 Consumer Field Research

An online questionnaire was distributed to the target demographic in a casual and natural manner to assess consumer preferences for engaging in the proposed trend of adaptable fashion. The following survey questions were refined over the course of several weeks before being used for field research, producing a total sample size of 15 respondents considered within the target demographic bracket for the described technology.

- (1) How often do you feel that you “have nothing to wear.”
- (2) “I only buy new clothes when the old ones wear out.” (How much do you relate to this sentiment?)
- (3) How important is garment-related sustainability to you? (e.g., buying from green companies, only buying what you need, etc.)
- (4) Do you communicate your stance on issues (global, political, environmental) through your clothing? (e.g., t-shirts for a specific cause, eco-friendly symbols, etc.)
- (5) Are you interested in the idea of wearing a garment that changes appearance on command? (e.g., color)
- (6) Do you like to wear statement jewelry?
- (7) Are you likely to wear a visually adaptable garment?
- (8) How likely are you to wear a statement necklace that turns your shirt into a display screen?
- (9) Please describe an instance when you would like to wear a shirt with a changeable screen-like display.
- (10) Is it likely that your clothing purchases would decrease if you had an adaptable garment you could update for many occasions?
- (11) How important is the aesthetic quality of a wearable technology?
- (12) You are most inclined to buy wearable tech products for:
 - A) health (e.g., sensors, monitoring)
 - B) utilitarian purposes (e.g., navigation, timekeeping)
 - C) novel augmentation (e.g., Google Glass, jewelry for message alerts)
 - D) other

One third of the respondents indicated that they relate to the sentiment of having nothing to wear, thereby confirming that at least one third of the sample qualifies as members of the target demographic; only one respondent noted that he or she only purchases new clothes when existing clothes are worn out.

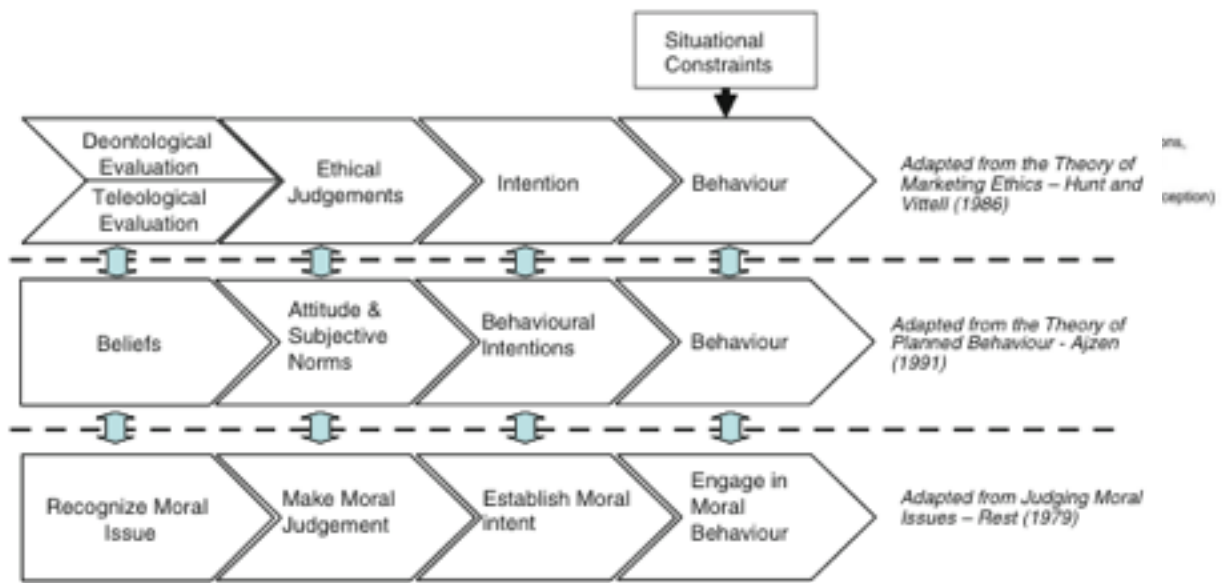


Figure 7: Models of ethical consumption

One third of the respondents noted that garment-related sustainability is not important to them. It stands to reason that two thirds of the respondents subsequently indicated a lack of interest in communicating their personal views and stance on issues like sustainability through their manner of dress. This aligns to other research in the field which found that consumers are not concerned with the ethics of production in the context of a luxury purchase [4].

On a scale of 1, not interested, to 5, very interested, one third of the respondents rated their interest in wearing an adaptable garment as level four; however, the matter of wearing statement jewelry was divisive. Seven respondents rated their fondness of

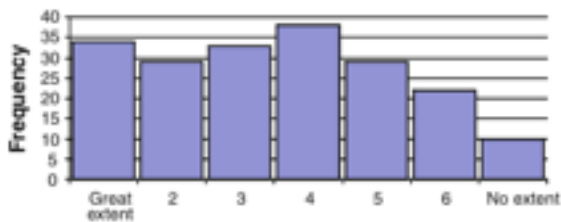


Figure 8: Models of ethical consumption

statement jewelry as level 1, the lowest. Meanwhile, 5 respondents rated their interest in such accessories as level four, relatively high.

One third of respondent noted that owning an accessory for adaptable fashion was neither likely nor unlikely to reduce the frequency of their extraneous clothing purchases, and only one respondent indicated that he or she was very likely to buy fewer extraneous garments if an adaptable garment were possible.

Only one respondent noted that the aesthetic quality of a wearable technology was unimportant to him or her, while 10 respondents indicated that aesthetic quality was of the highest level of importance to them.

Direct questions regarding the respondents' interest in and willingness to embrace technology for adaptive fashion yielded divided responses. It is worth noting that only one questionnaire was developed and circulated, and no measures were taken to survey males and females separately. As such, it is possible that potential male millennial respondents categorically responded with disinterest to the notion of wearing statement jewelry or adaptive clothing in general.

This potential issue is further compounded by the small and self-selected sample size. Nevertheless, male respondents are not the target demographic for the proposed technology, so the analysis of survey results is focused on data from respondents who indicated that they typically engage in behavior that supports fast fashion, and that they are amenable to the concept of adaptable fashion.

5.3 Launching a Trend

Creating a trend almost guarantees consumer support and media attention, and as such is a critical development goal for the adaptable fashion accessory.

In light of survey responses, some governing decisions for developing the proposed technology were made: the accessory for adaptable apparel should not trumpet its sustainable benefits. The responses show that perhaps the most salient environmental campaign will be one that consumers are unaware they support. It is clear that interest in the environment would not be a primary motivation for wearing the accessory, so it is best to embed these qualities and allow them to propagate quietly in the background.

Instead, advertising the form factor should be the focus, striving to appeal to the consumers' standards for statement jewelry. Engineering the proposed accessory such that it could sustain the weight of a smartphone attachment— and manage to hang on the body at the correct angle— introduced considerable design challenges and potential obstacles for adhering to contemporary

trends. However, designers like Una Burke and Helmut Lang have posited harnesses and sculptural body accessories as a high end trend for the daring and avant-garde.

Another governing goal for positing the proposed technology for easy adoption as a contemporary trend is striving for cultural capital early in the marketing process [10]. Studies indicate that fashion bloggers have a considerable amount of influence over consumers. Upon close examination of the dynamics of this

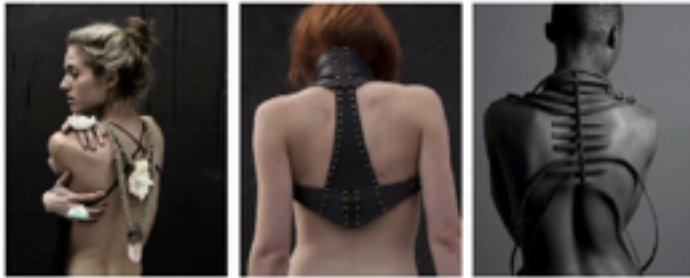


Figure 9: Statement jewelry precedents

relationship, the concentric feedback loops underscore the marketing potential of this avenue [10]. Bloggers are considered taste makers, and successfully establishing or endorsing an emerging trend grants the blogger cultural capital in the form of a captive audience.

In the next feedback loop the blogger is able to become an essential element of the fashion system once the audience reaches a critical mass. At this juncture it is common for prominent fashion heavyweights (e.g., magazine editors, fashion labels) to connect with the blogger, lending the blogger even more cultural

FEEDBACK LOOPS LINKING BLOGGERS CULTURAL CAPITAL, THE FASHION SYSTEM, AND BLOGGERS AUDIENCE PRACTICES

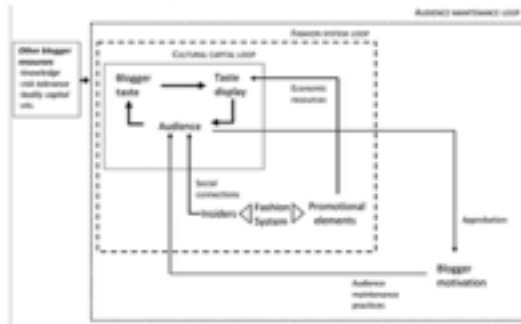


Figure 10: Symbiotic fashion blogging

capital and credibility within the realm. These milestones all work together to give bloggers potential to be key tastemakers. As a result, adaptable fashion accessories would be well served to get a strong foothold in the online fashion community.

Fashion innovators are the demographic likely to be called to action by the online fashion blogs. They are characterized by the tendency to be among the first buyers of new apparel and accessories, and are thought to comprise a unique and important cross-section of the fashion market in general. “These fashion opinion leaders are the first to adopt new fashion within their

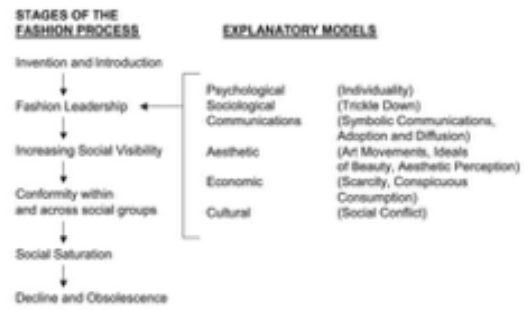


Figure 11: Fashion innovators

social group. They often bring attention to new fashion and play a role in early adoption of fashion innovation and “may legitimize and facilitate the spread of new clothing fashions to later buyers” [8].

6 Liquid Crystal Wearable Technology

6.1 Product Functionality

Liquid Crystal is a modular upper body jewelry piece designed to physically interface with the user’s smartphone by locking into the corresponding proprietary smartphone case. The smartphone display works with an embedded magnifying glass to form user-controlled projections on the user’s upper body.

In the same way consumers ordinarily update the liquid crystal display of a smartphone screen by launching different media, this accessory system lets consumers update the appearance of their garment on command. Deploying this accessory in the consumer marketplace is the critical first step for recalibrating industry and

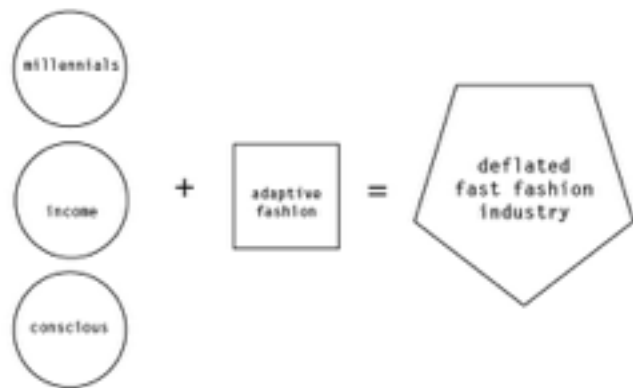


Figure 12: Liquid Crystal roadmap to sustainable fashion

societal standards for sustainability and environmental consciousness. Ensuring acceptance of this technology in the

marketplace, however, requires artful curation of the product’s values.

6.2 For Sustainable Fashion



Figure 13: *Liquid Crystal components*

Liquid Crystal takes a multi-pronged approach for making fashion sustainable: responsible consumption, and also production. Users will shop less frequently and irresponsibly if they can approximate the feeling of an “update” on an existing shirt. With respect to the environment, using light projection to generate patterns on a base garment alleviates the environmental strain that

comes from dyeing textiles.

Interestingly, the proposed technology provides the user with an innovative garment not by introducing a new garment entity, but rather through augmentation of what the user already owns. The wearer’s personal smartphone is responsible for overlaying the

visual augmentation on the user’s existing garment, and is a key differentiator of the proposed technology.

7 Analysis of Liquid Crystal Prototypes

7.1 Process and Development

The functionality of the Liquid Crystal prototype relies heavily on the concept of a do-it-yourself mobile projector comprised of a smartphone and a magnifying glass. This was selected as the mode of projection because it provides an innovative garment by augmenting what the user already owns. Users are already open to the expanding functionality of a smartphone, so using it as a tool for fashion is not a far stretch from its existing disparate use cases.

The prototypes presented in this paper were designed in Rhino 3D software for 3D modeling and printed on a Makerbot Replicator 2 machine in a range of PLA plastics. A standard 2x magnification lens was also incorporated into the configuration for creating a simple on-body projector.

The aesthetic of raw crystals stems from inspiring precedents by the designer Adina Mills, as well as a pun based on the overarching concept: turning a garment into a liquid crystal display. Crystal jewelry is constantly going in and out of fashion, and is popular in the contemporary mainstream— as such, Liquid Crystal seeks to take advantage of the trend.

A mobile application would be developed and released in conjunction with the set of accessories were it to enter the market formally. The application would feature a range of visual clips to play to form the content of their on-garment projections. Some examples include footage of the surface of a swimming pool with **Figure 1:** *Spring Training 2009, Peoria, AZ.*

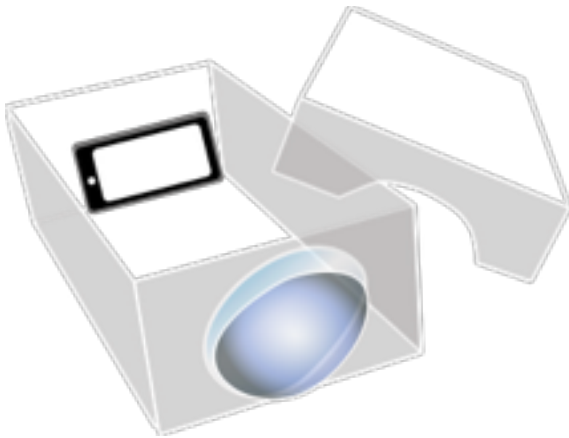


Figure 14: *DIY projector diagram*

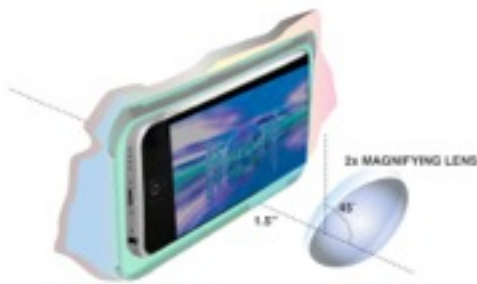


Figure 15: *Component schematic*



Figure 16: *Adina Mills design precedent*

rippling reflections, or a slowly changing landscape scene. The nature of the system also allows the user to project anything that can be viewed on a smartphone.

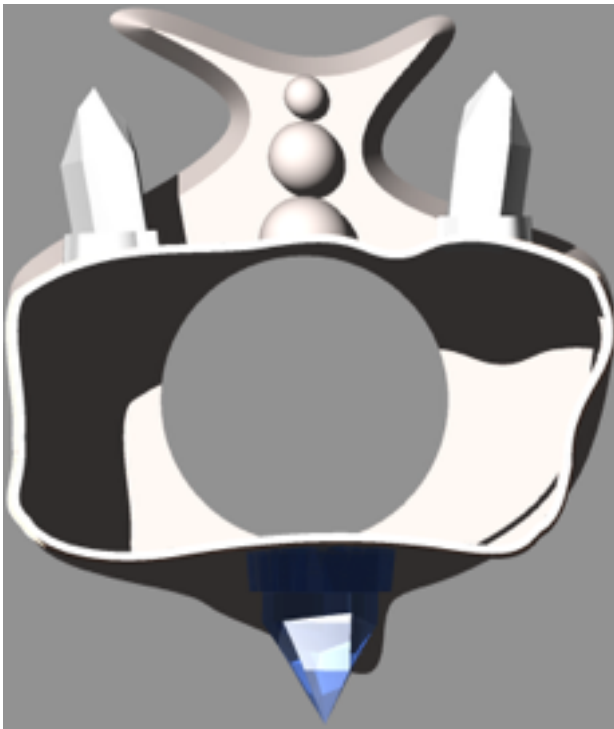


Figure 17: *3D rendering of necklace base*

A major advantage associated with the development of the dynamic garment display is the fact that the proposed technology provides the user with an innovative garment by augmenting what

the user already owns rather than a physical entity. This is because the functionality for this effect is housed in a jewelry accessory. As a result, there is increased freedom of design and development when the parameters of designing an actual “garment” are not a central goal. Accessories, especially jewelry, are accepted and expected to take unique and artful forms. This is an aesthetic factor that would be leveraged in the ongoing development of the dynamic garment display.

7.2 Testing and Findings

The do-it-yourself smartphone projector was initially and predominantly tested off of the body, as a separate stand alone projector. In this setting the display was crisp and details in the testing video clips could be accurately distinguished. However, the projection exhibited in the prototyped version was far less clear. This could be attributed to an imperfect fit between the necklace component and the iPhone case, which inadvertently allowed excess light into the system and dimmed the output. Future iterations should address this issue and attempt to move the iPhone more than 1.5 inches away from the magnifying lens in order to improve the image’s focus.

8 Discussion

Research within the field of wearable technology and on body computing supports the feasibility and relevance of a product offering with values rooted in reactive fashion over utilitarianism, especially in the context of a dynamic garment display.

This described arrangement of hardware elements satisfies the primary goal of the accessory for adaptable fashion: to provide the user with a garment that can keep time with emerging fads and stay abreast of trends. In so doing, the user is more likely to derive a sustained sense of aesthetic satisfaction from one item of apparel—a perception that positively impacts not only the user’s personal finances, but also their carbon footprint worldwide.

Extensive and detailed user tests should be done to identify future avenues of product expansion and development. The mechanisms and functionality that drive the proposed technology could have broader applications. In particular, the fact that the proposed configuration provides the user with an innovative garment by augmenting what the user already owns rather than a physical entity. Transposing another capability to an omnipresent item like a smartphone increases the likelihood that self-augmentation of fashion garments will be accepted as an intuitive and rational next step of smartphone ownership.

Deploying a technology like Liquid Crystal in the market is likely to be met with some objection and dissent from the fashion industry. Other industries have perceived technological advancements as a threat, but gone on to appreciate the change they imparted: “However, as with the movie industry and music industry before it - sufficiently disruptive platforms do not necessarily bring the doom and gloom to many an industry as most analysts rush to predict. Indeed both the music and movie industry are flourishing years after Sean Parker introduced the MP3 format and Bittorrent among others did the same to the movies and TV industry. Moreover, it has now been widely noted that results and reports from the movie industry’s own have

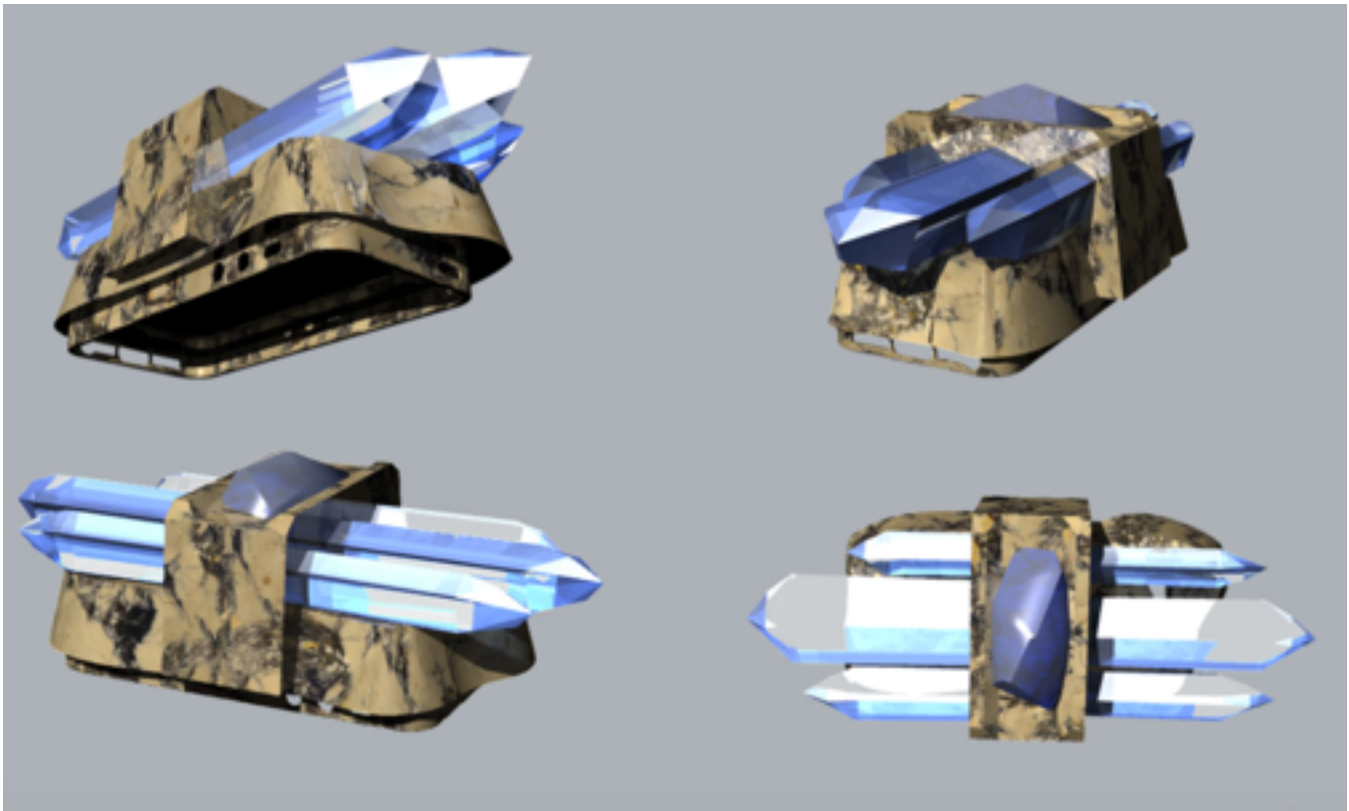


Figure 18: 3D rendering of iPhone case

shown that video piracy via P2P networks paradoxically boosts ticket, DVD and merchandise sales” [6].

Custom fabrication through CAD will result in refined improvements to each design iteration, engendering the proposed technology with more value. The proposed methodology for



Figure 19: Activated prototype

developing a dynamic garment display is such that the user also gains the source of the described wearable projections: an appealing and on trend iPhone case and statement necklace.

The proposed technology has potential for extension applications. Additional configurations of the above components could yield alternative visual effects worthy of exploration. Such an embodiment could reinterpret the “garment” as the user’s own literal skin. In so doing, the jewelry component could be adjustable and angled towards various body parts, lending a new dimension to the concept of second skin and suggesting a move away from textile-based clothing altogether.

In another embodiment the reimagined “garment” could also be a piece of everyday luggage, the user’s own face, or even their hair.

Using projected light as a medium removes material and substrate constraints characteristic of tangible displays, and this characteristic should be treated as a wholehearted advantage.

9 Conclusion

A number of projects in the reactive fashion, wearable projection, and on body projection space have already been proposed and developed. The proposed technology for achieving a dynamic garment display seeks to incorporate the successes observed in the relevant work in this field, which substantiate and inform the proposed methodology for achieving on body projection using a the user’s smartphone and a system of ornamental upper body chains.

A dynamic garment display is an original innovation that not only has market relevance, but is also capable of shifting the wearable tech consumer paradigm. The technology proposed in this paper shifts the paradigm by aligning to the concepts of reactive fashion and second skin, and “because it allows an extension of that which people are already doing with fashion and garments,

making choices about what they wear, how they appear, and what that appearance communicates to other people.” [4]. As such, it is a concept that begs for further exploration, research, and development, governed by the notion that “technology for ad hoc self expression and personalization does not need to be tacky or look geek. It could easily scale the very pinnacle of fashion without even any unnecessary hint that it is there.” [6].

The exploration described in this paper would benefit from ongoing research and prototyping in the realm of wearable computing localized in close proximity to the body. Advancements towards disguise, playful augmentation, and personal expression could have positive implications in fields that seem disparate at face at value.

Almost all societal systems are intertwined and complex, so it stands to reason that answers to systemic challenges like lack of sustainability in the fashion industry could be solved in a separate domain. Leveraging technology like the proposed adaptable accessory will become more feasible in the coming years, as cultural awareness and acceptance of alternative uses of technology takes hold as the new norm.

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