AN ABSTRACT FOR THE THESIS OF

Lauren Steinhardt for the degree of Master of Science in

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Title: Women’s Commuter Cycling Apparel: Functional Design Process to

Product

Abstract approved: __________________________________________________

Kathy K. Mullet

Bicycle commuting is increasing in popularity due to exercise benefits, cost savings, and environmental concerns. Available specialized cycling apparel does not reflect the aesthetic and expressive needs of the bicycle commuter. Urban bicycle commuters need clothing that allows them to bicycle safely and effectively while maintaining their identity as professionals. Female bicycle commuters face additional pressures due to increased emphasis on appearance and gender expression.

Many female bicycle commuters do not wear specialized cycling apparel because it does not meet their needs for self-expression. The purpose of this study is to identify the apparel needs of female bicycle commuters in Portland, OR and to design a garment based on those needs that is appropriate for both the workplace and the commute.
Watkins’ design process was applied in this research. The research design also incorporated Lamb and Kallal’s FEA (functional, expressive, aesthetic) model of consumer need. Analysis of the design problem was performed using qualitative interviews, researcher participation, and a content analysis of currently available garments marketed to the urban and commuter cycling market. Design criteria was developed and evaluated using interaction matrices, and six designs were developed from the criteria. One design of the six was developed as a prototype and evaluated.

The results of the qualitative interviews revealed that the fulfillment of expressive needs was key to satisfaction with cycling apparel. Therefore the expressive needs of the population were emphasized during the design process. This led to the development of a model for apparel needs of female bicycle commuters that involved the hierarchical ranking of needs in four areas of design: fit, fabric, design details, and color.
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Women’s Commuter Cycling Apparel: Functional Design Process to Product

by

Lauren Steinhardt

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Dean of the Graduate School

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Lauren Steinhardt, Author
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WOMEN’S COMMUTER CYCLING APPAREL:

FUNCTIONAL DESIGN PROCESS TO PRODUCT
CHAPTER I

INTRODUCTION

Commuting by bicycle is more popular than ever, especially in the city of Portland, Oregon (Portland Bicycle Counts, 2008). Oregon has the highest rates of ridership in the country (Pucher and Buehler, 2006). Bike commuting saves money on gas, cuts down on carbon emissions, and increases physical fitness (Bassett, et al., 2008). Fluctuating gas prices, increasing awareness of environmental issues and municipal support for bicyclists have only led to further increases in ridership over the past few years. However, there are several downsides to bike commuting. Commuting by bicycle can often take longer than driving, and there are also significant safety risks (Pucher and Buehler, 2006). In addition, the cyclist is exposed to the elements, which in Portland frequently includes wind and rain (PBC, 2008).

Having the right gear can mitigate many of these problems. Lights and reflective clothing increase visibility, and protective outerwear guards against inclement weather (Forester, 1978). Commonly worn cycling attire is often tight, aerodynamic, and made from breathable performance fabrics (Casselman-Dickson and Damhorst, 1993). Popular garments include skintight shorts or leggings, lightweight jerseys, and close-fitting jackets (Forester, 1978). There is also a large accessories market of helmets, messenger bags, and cycling shoes. However, the need for specialized gear can often add time to the commute by requiring the rider
to change before work, thereby negating whatever minimal aerodynamic advantage is gained by wearing specialized cycling attire in a stop-and-go urban environment. Another downside to specialized gear is the increased expense of additional single-purpose wardrobe components. For shorter commutes in stop-and-go traffic, many riders may feel it is not worth the additional cost and effort.

In addition to practical considerations, many cyclists simply do not feel comfortable in head-to-toe spandex. Tight-fitting cycling apparel is very body-conscious, and some people do not feel comfortable for reasons of modesty or self-consciousness (Casselman-Dickson and Damhorst, 1993). Specialized cycling attire adheres to many design aesthetics established by bicycling and outdoor enthusiasts that are not embraced by all cyclists (Lloyd, 2008).

Female cyclists have additional issues related to fit, comfort, performance and appearance beyond those faced by the general population of cyclists (Sami, 2006). Women’s bodies are proportioned differently than men’s bodies, and successful designs for women’s active wear must take this into account (Janov, 2005). Women typically have body image or appearance concerns that differ from the population at large, and may put a greater emphasis on clothing and overall appearance (Kaiser, 2005). Some women prefer a more feminine or “dressed up” appearance than what is currently offered in female cycling apparel.

Indeed, a cursory look at the bike lanes of Portland reveals that many urban cyclists opt to forego specialized cycling apparel. Nonetheless, functionality is a major consideration when choosing items of clothing for cycling in. Cycling
clothing must allow for a full range of motion in the legs, as well as forward positioning of the arms (Watkins, 1995). Depending on the type of bike, the angle of one’s body may vary (Wilson, 2004). Road bikes and touring bikes put the rider at a forward-leaning angle, which may lead to fit issues in the midsection and uncomfortable bunching of bulky fabrics. A greater forward-leaning angle also requires a greater range of motion in the shoulders, and greater lower back coverage either in the form of longer shirttails or a higher pant rise (Watkins, 1995). Safety is another concern when choosing proper biking clothes. Excessively loose clothing may get caught in the gears (Forester, 1978). Cyclists who choose street clothes may address this issue by wearing tighter pants, rolling up the pant leg, or securing excess fabric with leg bands. Many commuters also choose bicycles with covered chains to avoid this problem. Night visibility is also an issue, one that is generally addressed with the use of bike lights and reflectors (Forester, 1978). Protection from the elements is also a key concern for cyclists. Water-resistant garments must also be breathable and allow for range of motion. The face and fingers also need protection from cold temperatures (Watkins, 1995).

Practicality and appearance are also factors that may be taken into account by the rider. Women who use the bicycle as their main form of transportation often end up wearing their cycling apparel for work, errands, and even social engagements, which leads to a greater emphasis on appearance than that of the recreational rider. Keeping up a well-groomed appearance as an urban cyclist is an area of concern. Loose or long clothing could be marred with grease stains
(Forester, 1978). Women may choose to wear a skirt or dress when cycling, in which case modesty becomes an issue.

Taking into account the needs of the many women who choose not to wear specialized cycling attire, the design of suitable garments must be approached from the perspective of the everyday garment that can also be worn on the bicycle. That is, taking the features and elements needed for safe and functional cycling attire and applying them to garments that can be worn throughout the day. Because Portland has such a large rate of ridership, it is an ideal city in which to conduct such research. Limiting the study to one geographic area will allow for more consistent results regarding weather-related apparel needs. Portland also has a large community of cyclists, and one of the highest rates of bicycle ridership in the United States.

**Purpose of the Study**

Many women choose, for various reasons, not to wear specialized cycling attire when commuting to work by bicycle. The purpose of this study was to design a garment based on the needs of female bicycle commuters that is appropriate for both the bicycle and the workplace. The functional design processes of Watkins (1995) and Lamb & Kallal (1992) were used as a theoretical framework.
Objectives

The following research objectives were used to guide the research and design process:

1. Determine the functional, expressive, and aesthetic (FEA) apparel needs of female bicycle commuters in Portland, OR for apparel that can be worn both at the workplace and during their daily bicycle commute.
2. Develop design criteria for cycling apparel and accessories that are based on the functional, expressive, and aesthetic (FEA) needs of female bicycle commuters in Portland, OR.
3. Develop designs for apparel that incorporate the design criteria based on the FEA needs of female bike commuters.
4. Select and develop one prototype garment from those designs.
5. Evaluate the prototype to assess whether the garment meets the given criteria, and whether it is suitable for both bicycling and workplace apparel.

Assumptions of the Study

1. That the interview subjects will be able to perceive and identify their own clothing needs.
2. That women want clothing that can be worn both on a bicycle and in the workplace.

**Definition of Terms**

**Bicycle Commuter:** A person who uses a bicycle as the primary means of transportation to and from her place of employment.

**Commuter Cycling Apparel:** Clothing designed for the specific purpose of being worn in an urban environment, often by bicycle commuters.

**Non-Specialized Cycling Apparel:** Clothing chosen by cyclists to wear while cycling that was not specifically designed for that purpose.

**Specialized Cycling Apparel:** Clothing designed for the specific purpose of being worn while cycling, is usually made from tightly fitted spandex or other performance materials.

**Urban Cycling Apparel:** Clothing designed for people who use a bicycle as their primary means of transportation. It is closer in appearance to non-specialized cycling attire than it is to specialized cycling attire, but includes performance features (Krcmar, 2007).

**Urban Cyclist:** A person who uses a bicycle as the primary means of transportation in an urban environment; may consider herself part of the “urban
cycling movement”, which values bicycle transportation for its environmental benefits (Furness, 2005)
CHAPTER II

REVIEW OF LITERATURE

From the advent of the “modern” bicycle in the 1890’s, the bicycle has been a popular mode of exercise, recreation, and transportation for Americans (Smith, 1972). Since the 1970s, popular interest has shifted away from the use of the bicycle for transportation, and towards the athletic and recreational aspects of cycling (Wilson, 2004; Lloyd, 2008). However, in recent years several factors including high gas prices, increased focus on physical fitness, and concern for the environment have led to a renewed interest in bicycling as a form of transportation (Furness, 2005; Bassett, et al., 2008). This renewed interest is reflected in the emergence of a small but growing market for commuter cycling apparel (Krcmar, 2007; Wiebe, 2006).

History of Women’s Cycling and Apparel

The modern history of women’s dress is inextricably linked with the invention and popular adoption of the bicycle (Warner, 2006). Appropriate dress for American and European women in the 19th century was cumbersome and restrictive. It typically included a floor-length skirt, corset, and often a lower-body
shaping device such as a bustle or a hoop crinoline, depending on the fashions of the day (Cunningham, 2003). Although many attempts were made by artists, religious communities, and members of the nascent feminist movement to advocate for “rational” dress, it was not until the popularity of the bicycle exploded in the 1890s that women dared to be seen in public wearing bifurcated garments (Warner, 2006). Indeed, bicycling allowed women to appear in public wearing clothing that in previous decades would have seen them publicly ridiculed, or even arrested (Warner, 2006; Cunningham, 2003); while also allowing them greater freedom, mobility, and independence than ever before (Furness, 2005).

Bicycling was one of many athletic activities that the “New Woman” of the late nineteenth century embraced with vigor. Warner (2006) discussed the emergence of women’s athletic culture in the United States, and the effect this had on women’s dress. As women became more involved in organized physical activities, they began demanding performance-oriented clothing. By the late nineteenth century, women wore special gymnastic uniforms to participate in organized single-sex calisthenics, but the clothing worn by women in public to participate in public, mixed-gender sports such as badminton, tennis, and croquet remained largely unchanged until the advent of the bicycle (Warner, 2006).

Early bicycles were unsafe and difficult to ride; however, several developments in the latter half of the 19th century led to the introduction in the late 1880s of the “safety bicycle”, which incorporated many features such as
pneumatic tires, diamond frame structure, and gear-driven operation that are familiar to contemporary cyclists (Smith, 1972). For the first time, bicycles were marketed towards women riders, which led to the development of the drop-frame or “ladies’” bicycle as shown in Figure 1 (Grey and Peteu, 2005). Additional safety features such as chain guards and cage-like wheel coverings were developed to prevent women’s skirts from becoming entangled in the machinery (Smith, 1972).

Figure 1. A female cyclist circa 1893. She wears a shortened skirt atop a drop-frame bicycle (Smith, 1972).
Grey and Peteu (2005) examined 19th century patents for women’s cycling attire. They found that, although women comprised less than 1 percent of patent applicants in the United States, they accounted for 62 percent of patents for women’s cycling attire between 1893 and 1903. The authors suggest, “perhaps women were uniquely qualified to respond to their own difficulties in riding the bicycle” (Grey and Peteu, 2005, p28). Of these difficulties, appearance seemed to be a primary focus of many of the patents, which featured garments that could easily be converted from cycling clothes to conventional skirts.

Women’s bicycling apparel of the 1890s offered a variety of alternatives, but referenced many elements of reform dress such as bifurcated garments, alternatives to tightly bound corsets, and shorter, less cumbersome skirts as shown in Figure 1 (Warner, 2006; Grey and Peteu, 2005). Divided skirts were one of the more popular options. They were bifurcated to allow for ease of riding, but were cleverly constructed to appear as an ordinary skirt when the wearer was not on a bicycle (Warner, 2006). Bloomer costumes were considered a more daring alternative (Smith, 1972). However, in both cases the upper portion of the costume conformed closely to the fashionable norms of the day, including narrow waist, voluminous leg-of-mutton sleeves, and starched collar (Warner, 2006; Grey and Peteu, 2005).
Apparel and Social Roles

Each member of human society inhabits many different social roles, such as parent, shopper, supervisor, or student (Solomon, 1983). Many of these social roles also represent membership in a group, such as a member of a sports team or a professional affiliation. Apparel is one of the most important ways in which humans identify the social roles and group membership of themselves and others (Kaiser, 1990), and it may play a critical part in the adoption of professional social roles (Solomon & Douglas, 1985). When a person attempts to inhabit two contradictory social roles, they may experience role conflict (Kaiser, 1990; Rafaeli, et al, 1997). For example, a female athlete may feel that aggressive behavior appropriate to certain competitive sports is contradictory to her “feminine” self-image as a woman (Feather, Ford, and Herr, 1996).

According to Solomon (1983), consumption and use of products is motivated by many factors outside the simple functional need or convenience the products may offer. Indeed, some purchases (jewelry, art) serve no functional purpose at all. The products we consume and use are rich with symbolic meaning, which we use to identify our own social roles as well as the roles of others. Products may be purchased in order to conform to the norms of certain social roles, or the product may be used in such a way that the consumer is guided in their behavior towards appropriate role adoption. Symbolic aspects of products
may be used to assist in adopting new social roles, guiding behavior in uncertain situations, and transitioning to new roles (Solomon, 1983).

Kaiser (1990) discussed the social aspects of dress as it relates to gender roles, group identity, and professional identity. Gender differentiation in dress is common in virtually all cultures, and one of the most important communicative aspects of dress. Apparel is also a key aspect of group membership: “shared usage and understanding of clothes can cultivate a sense of interconnectedness among members of a group” (Kaiser, 1990, p.351). Uniforms and organizational dress codes are used to reflect the structure of the organization, which may include hierarchy, formalized behavioral expectations, and unified identity of large numbers of people. Many work environments do not have formalized dress codes, but rather “find that social control generally operates to produce conformity without a formal, written dress code, as individuals take their cues from one another and negotiate an organizational reality” (Kaiser, 1990, p. 365). According to Kaiser (1990), women who hold professional positions are perceived as more competent if they dress in “businesslike” attire that mimics male professional dress, but more creative and socially accessible in dresses and fashionable clothing.

Pratt and Rafaeli (1997) studied nurses’ occupational apparel in a hospital rehabilitation center. The nurses were engaged in a factional dispute over “appropriate” modes of occupational dress, with some nurses opting for casual street clothing and others insisting on medical scrubs. The authors found that the
dispute over dress reflected and embodied several deeper conflicts not only within the organizational structure, but also regarding the nurses’ own self-concepts about their identities and professional roles. Nurses who preferred to wear scrubs saw their dress as an important symbol of professional standing within the medical community (Pratt and Rafaeli, 1997).

Rafaeli and colleagues (Rafaeli et al., 1997) also studied the dress of female administrative employees at a large university. The authors found that subjects regarded dress as a potent symbol for engaging in work roles. The subjects used dress to communicate their role to others, and as an internal tool to define and prepare for the role they assumed in the workplace environment. Rafaeli (1997) found that the women in the study self-monitored in the absence of a formal organizational dress code, and preferred clothes they themselves described to be “conservative”, “coordinated”, and “professional”. They purposefully eschewed clothes that were sloppy, too casual, overly feminine, or “sexy”. The professional dress chosen by the women helped to focus and clarify their work roles by eliminating other possible roles such as student or romantic partner (Rafaeli et al., 1997).
Activewear, Identity, and Social Roles

In addition to fulfilling critical functional requirements, athletic uniforms can have a great psychological impact on the athlete regarding feelings of group membership, athletic proficiency, and body image (Feather, Ford, and Herr, 1996; Wheat and Dickson, 1999; Holland, 2007). In Wheat and Dickson’s (1999) study of female collegiate golfers, they found that fit, style, and femininity were just as important to the players as functional performance, and that golfers preferred uniforms made and sized for women over the men’s uniforms they were sometimes required to wear. Uniforms that foster positive feelings for athletes may help to boost performance (Wheat and Dickson, 1999). Uniform fit and style can affect body image and body satisfaction, which may also affect performance (Feather, Ford, and Herr, 1996).

Participants in recreational or non-team sports also use apparel to define their roles and identities as athletes (Dickson and Pollack, 2000; Chae, Black, and Heitmeyer, 2006; Casselman-Dickson and Damhorst, 1993). Chae, Black, and Heitmeyer (2006) found that female tennis players value fit and appearance, and that interest in fashion affects active wear preferences. Female recreational cyclists conform to the traditional dress of professional bicycle racers as a way of conveying their identity as bicyclists (Casselman-Dickson and Damhorst, 1993). Level of involvement in the sport is also a factor; more deeply involved cyclists tend to conform most closely to traditional European cycling attire (Casselman-
Dickson and Damhorst, 1993). Participants in emerging sports such as in-line skating may have more leeway in creating outfits appropriate to their sport; this may support the expressive needs of female athletes, who have previously worn athletic attire based on masculine uniforms and attire (Dickson and Pollack, 2000; Feather, Ford, and Herr, 1996).

The apparel needs and social role of recreational and professional cyclists have been examined, but the cyclist who uses the bicycle primarily as a form of transportation may not wish to identify in the role of recreational or professional cyclist (Casselman-Dickson and Damhorst, 1993; Lloyd, 2008). Furness (2005) identifies the “biketivist” as an urban cyclist who uses the bicycle as a form of transportation in conscious opposition to “car culture”. This suggests that many who choose to bike to work do so out of concern for the environment (Furness, 2005). However, research is lacking in the area of self-identification, role adoption, and apparel preferences of bicycle commuters of either gender.

**Cycling Apparel Design**

Traditionally, women’s cycling apparel has been similar in appearance to men’s apparel (Morgan, 2007). However, in the past several years, cycling apparel manufacturers have been making more options available to women, including cycling skirts with padded leggings underneath (Carpiet, 2008). Inspired by
several women-owned companies, cycling apparel manufacturers realize that women may put a higher value on aesthetics, style, and appearance (Janov, 2005; Morgan, 2007; Sani, 2006).

Motivated by high gas prices, environmental concern, and the need for physical fitness, Americans are increasingly choosing bicycling as a means of transportation (Basset, et al, 2008). The commuter bike-wear market has continued to grow over the past few years, with several manufacturers of cycling apparel adding pieces targeted towards the commuter and urban cyclist (Lloyd, 2008; Morgan, 2008). These pieces are differentiated from athletic or recreational cycling apparel by their more “mainstream” appearance, which takes cues from ordinary street clothes (Wiebe, 2006). Although these “urban” commuter designs are intended to be worn both on and off the bicycle, there are certain popular styles such as knickers, a knee-length bifurcated garment styled to look like a pair of trousers, that continue to identify the wearer as a cyclist (Krcmar, 2007). Knickers are available in many stylistic variations, from casual designs inspired by jeans and work pants to upscale versions made from wool suiting material (Krcmar, 2007). The growing popularity of knickers is evidence that those who bike for transportation purposes are developing their own sartorial codes (Furness, 2005).
The Functional Design Process

When designing apparel for an active task such as commuting by bicycle, a structured process is vital for organizing the complex array of consumer needs into usable design features (Watkins, 1995, Lamb and Kallal, 1992). The area of functional design is often approached with some sort of procedural framework (Watkins, 1995). This is useful for achieving consistency of results, as well as ensuring a thorough assessment of needs is performed (LaBat and Sokolowski, 1999; Lamb and Kallal, 1992; Watkins, 1995). Several researchers have described the design process with a series of steps (LaBat and Sokolowski, 1999; Lamb and Kallal, 1992; Watkins, 1995) proposed to aid the designer through the process.


- Acceptance: Motivation to solve the problem is established.
- Analysis: Exploratory research is done to gather as much information as possible about the problem.
- Definition: The most significant aspects of a problem are identified, and design criteria may be established.
- Ideation: Many solutions to the problems are proposed.
- Selection: The best solutions to the problem are identified, selected, and synthesized into product designs.
- Implementation: The design solutions are realized at a testable level.
- Evaluation: The resultant product is evaluated for effectiveness in addressing the design problems.

Although the seven steps are to be performed in order, the designer may go back to earlier steps at any time (Figure 2). The evaluation step of the process often leads back to an earlier step to refine the product (Watkins, 1995).

Lamb and Kallal (1992) developed a process that recognizes different types of needs the consumer of functional apparel may have. Functional needs include fit, comfort, protection, range of motion, and ease of donning and doffing. Expressive aspects relate to the communicative value of the apparel in defining
identity, values, and social roles. Aesthetic considerations relate to the artistic value of the design, and may include color, texture, and form. These three elements are interrelated as shown in Figure 3, and may be of varying importance within the context of each design situation (Lamb and Kallal, 1992).

LaBat and Sokolowski surveyed several functional design processes and found that among the many processes examined, several common elements emerge. All contain steps that fell into three categorical stages: problem definition and research, creative exploration, and implementation (LaBat and Sokolowski, 1999).

Figure 3. The FEA model of consumer needs (Lamb & Kallal, 1992).
The application of functional design processes can be used for a variety of specialized garments. LaBat and Sokolowski (1999) used their design model to develop a supportive ankle brace. Tung (2007) also used LaBat and Sokolowski’s model to develop designs for women’s body armor.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this study was to design women’s cycling garments that meet functional, aesthetic, and expressive requirements for an urban cycling environment and can also be worn throughout the day, including at the workplace. The functional requirements were examined with regard to fit, safety, mobility, and protection from the elements. The aesthetic aspects were addressed by examining style and color preferences of female bicycle commuters. The expressive requirements were examined in the context of the multiple social roles women inhabit throughout the day, including professional roles.

This study has identified the primary research objectives:

1. Determine the functional, expressive, and aesthetic (FEA) apparel needs of female bicycle commuters in Portland, OR for apparel that can be worn both at the workplace and during their daily bicycle commute.

2. Develop design criteria for cycling apparel that are based on the functional, expressive, and aesthetic needs of female bicycle commuters in Portland, OR.

3. Develop designs for apparel that incorporates the design criteria based on the needs of female bicycle commuters.

4. Select and develop one prototype garment from those designs.
5. Evaluate the prototype to assess whether the garment meets the given criteria, and whether it is suitable for both bicycling and workplace apparel.

**Conceptual Framework**

The procedures for this study are based on a functional design study done by Bye and Hakala (2005), which combined the seven-stage functional design process of Watkins (1995) with the three categories of consumer need identified by Lamb and Kallal (1992). The three categories of functional, expressive, and aesthetic needs (FEA) were considered as part of the definition stage of the process. Figure 4 shows the phases of Watkins’ design process as they align with the research steps and research objectives of this study.

**Acceptance**

The first stage of the process as outlined by Watkins is to accept the problem for which the researcher will discover a solution by engaging in the structured process. According to Strauss (1990, p. 36), “the touchstone of [one’s] own experience” may be a valuable indicator of research direction. For this study, the acceptance of the problem came from the researcher’s own experiences with urban cycling. The researcher found that most cycling clothes were inappropriate for the workplace or public social engagements, yet clothing not designed for bicycles often had fit and
performance issues when worn for that purpose. The researcher observed that women often chose to wear cycling apparel that was not designed for that purpose, despite the difficulties with fit and performance she had observed and experienced. Thus, the researcher became interested in further investigating the problem and identifying possible solutions.

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Acceptance</td>
<td>Awareness of problem, Commitment to address problem</td>
<td>Objective 1: Determine the apparel needs of female bicycle commuters in Portland, OR for apparel that can be worn both at the workplace and during their daily bicycle commute.</td>
</tr>
<tr>
<td>Analysis</td>
<td>Review existing research, Qualitative interviews, Direct participation</td>
<td>Objective 2: Develop design criteria for cycling apparel and accessories that are based on the functional, expressive, and aesthetic needs of female bicycle commuters.</td>
</tr>
<tr>
<td>Definition</td>
<td>Sort user needs by FEA categories</td>
<td>Objective 3: Develop designs for apparel that incorporates the design criteria based on the needs of female bike commuters.</td>
</tr>
<tr>
<td>Ideation</td>
<td>Create design criteria, Determine what types of apparel are needed</td>
<td>Objective 4: Select and develop one prototype garment from those designs.</td>
</tr>
<tr>
<td>Selection</td>
<td>Propose design solutions, Identify best design solutions</td>
<td>Objective 5: Evaluate the prototype to assess whether the garment meets the given criteria, and whether it is suitable for both bicycling and workplace apparel.</td>
</tr>
</tbody>
</table>

Figure 4. Research steps as phases of Watkins’ design process.
Analysis

Analysis is a key phase of the design process. A thorough analysis of the problem lays the groundwork for the success of the next phases of the process (Watkins, 1995). During the analysis phase a review of existing research was conducted, and data was collected from a variety of different sources including qualitative interviews, content analysis, and direct participation.

Definition

The definition phase of the study is the phase in which a design direction emerges. By performing a thorough analysis beforehand, the researcher ensures that the definition of the problem addresses the true needs of the end user, as the most salient elements of a design problem may not be those that are the most immediately obvious (LaBat and Sokolowski, 1999). The first step of the definition phase was to identify specific needs based on the research of the previous phase. Results from the interviews, direct participation, and content analysis of currently available commuter wear were used to identify specific user needs of female bicycle commuters. These user needs were then used to create design criteria. The design criteria were sorted by FEA category to ensure the final designs would address all three categories of user needs.
Ideation and Selection

Ideation is the step in which design solutions are proposed to address the problems defined in the previous step. This is the step most associated with the work of “design”, as it is the most creative step (Watkins, 1995). During the ideation phase, preliminary designs or design ideas are generated and evaluated. During the selection phase, the researcher works from the ideas and concepts she has gathered during the previous phase, refining and synthesizing various elements into final designs. In this phase, solutions matrices were used to determine the compatibility of identified design criteria, six designs were produced, and one design was chosen for prototype development.

Implementation and Evaluation

Implementation is the phase where the design solutions are realized at a testable level, and in the evaluation phase the resultant product is evaluated for effectiveness in addressing the design problems. In this phase of research, the prototype was produced by a sample sewer. The prototype was tested and evaluated with the help of a wear-testing subject.

Objective 1:
Determine the functional, expressive, and aesthetic apparel needs of female bicycle commuters in Portland, OR for apparel that can be worn both at the workplace and during their daily bicycle commute.
To meet Objective 1, qualitative interviews were conducted in both individual and focus group format. In order to verify the data collected from the interviews, the researcher participated in commuting to work by bicycle.

**Qualitative Interviews**

To determine the needs of female bicycle commuters, qualitative interviews were conducted. Qualitative research allows for a rich understanding of the topics of inquiry, and can aid in providing a deeper understanding of the reasons and motivations behind the choices made by a given population (Morse and Richards, 2002). Qualitative research is therefore ideal for defining categories of need, which will aid in establishing design criteria (Mc Cracken, 1988; Watkins, 1995). The subjects were contacted through word of mouth, using the researcher’s personal and professional contacts in the Portland area. The interview subjects were sampled purposively, to fit within given criteria regarding lifestyle and cycling habits. The criteria are as follows:

- Commute to and from work is less than five miles each way.
- Commute takes place in an urban environment.
- Subject does not wear specialized cycling attire during commute.
• Workplace environment is one in which a certain level of attention to dress is expected or required (this would preclude many physical jobs such as landscaping).

Interview participants were asked to sign an informed consent document (Appendix B). The names of the participants were not used in the study and the participants are identified by their initials only in the interview transcripts.

The one-on-one interviews were conducted in person at a variety of locations convenient to the participants, including cafes, the researcher’s home, and homes of the participants. The focus group was conducted in a shared recreational space available to the focus group participants. Time and place of the interviews was chosen by the participants to maximize the comfort and convenience of the interview process. The interview consisted of 16 questions listed in Appendix A. The interview questions were developed from similar questions used in Bye and Hakala’s study of female competitive sailors (2005). The interview was in a semistructured format, consisting of open-ended questions intended to elicit additional responses (Morse and Richards, 2002). The interviews were 30-45 minutes long and addressed issues of functional and expressive needs of the subjects. The goal of the interviews was to obtain information about the functional needs of female bike commuters, as well as the expressive needs related to working in a professional environment. The interview questions were also designed to provide insight into the motivations and decision-making processes of the participants as related to their choice of commuting apparel.
Interview data was collected using both one-on-one and focus group formats. This allowed the researcher to compare data obtained using two different methods as a check of internal consistency (Silverman, 1993). Redundancy in individual interview subjects was achieved within 4 interviews.

The goal of the interviews was to determine: 1) Level of commitment to bicycle commuting, 2) Level of satisfaction with current cycling apparel, and 3) Needs and preferences regarding cycling apparel. Questions addressed length and frequency of commute, description of current wardrobe and level of satisfaction, areas of dissatisfaction, and satisfaction with currently available cycling apparel (Appendix A). The interview data were coded using an open coding process, which allows themes and concepts to emerge organically from the data (Strauss, 1990).

**Direct Participation**

The researcher also engaged in direct participation as a bicycle commuter. Direct participation is a useful means of gathering additional data and establishing validity of data gathered through other methods (Silverman, 1993; Watkins, 1995). The researcher rode her bicycle to work on two separate occasions wearing non-specialized cycling apparel, a distance of 3.4 miles each way.
Objective 2:

Develop design criteria for cycling apparel and accessories that are based on the functional, expressive, and aesthetic needs of female bicycle commuters in Portland, OR.

Survey of Currently Available Products

The researcher conducted a content analysis on currently available commuter cycling apparel (Bye and Hakala, 2005). The researcher conducted research of cycling industry magazines to identify leading brands of cycling attire. Both men’s and women’s apparel was included in the analysis, with the criterion that the apparel was labeled or marketed as being either urban or commuter cycling apparel, and included technical cycling features. For example, t-shirts with cycling-related graphics were not included in the analysis. Accessories and base layers were also excluded. A closed coding scheme was used which examined the variables of cost, color, type of garment, gender (men’s, women’s unisex), fabrication, and functional features.
Identification of Design Criteria

Content analysis was used to analyze the qualitative data from the interviews and focus groups. The interviews were transcribed and coded using open coding, a technique that allows themes and commonalities to emerge organically rather than searching the text for predefined variables. The coding scheme was then further refined into categories, from which several key themes were identified regarding the cycling apparel needs of the subjects. The researcher used a grounded theory method to analyze the themes that emerged from the research.

Using the results of the interviews, the researcher’s own experience of direct participation, and results of the content analysis of currently available commuter bikewear, several key user needs were identified, including a determination of what types of apparel are most needed by the population.

At this point, the three categories of functional, aesthetic, and expressive (FEA) needs were used to further clarify the requirements of the user. The user needs were then translated into design criteria for each of the three garment types (Watkins, 1995). Interaction matrices were used to identify possible conflicts within criteria for each garment type.
Objective 3:

Develop designs for apparel that incorporate the design criteria based on the needs of female bike commuters.

Design Process

The design process was guided by the design criteria, and the resultant designs attempted to meet as many of the criteria as possible. The interaction matrix was the primary tool used for establishing design concepts and features. The researcher also reviewed historical costumes as inspiration for both style and function. Color trend reports were also consulted.

The result of the preliminary exercises was list of possible designs that addressed several of the design criteria. Design concepts were developed through rough sketches to reach final design phase.

Objective 4:

Select and develop one prototype garment from those designs.
Prototype Development

The prototype garment was chosen on the following criteria:

- The garment effectively fulfills the design criteria.
- The researcher is able to procure fabric and trim that closely match the specified materials both in appearance and functionality.
- The technical aspects of the production of the garment are within the researcher’s resources.

One interview subject was chosen after the interviews were completed to aid in prototype evaluation. The interview participants were notified at the time of the initial interview that they would be eligible to test the prototype if they were interested. The participants were informed that assisting in prototype evaluation would involve being photographed and having their body measurements taken. One subject was randomly selected from the group of interested participants, and offered the opportunity to test the prototype. The participant’s body measurements were taken and it was determined that she was within an appropriate size range to test the prototype. Agreement to help evaluate the prototype was not a requirement to participate in the interview process. The fit tester signed an informed consent document to participate in the fit testing process.
Objective 5:

Evaluate the prototype to assess whether the garment meets the given criteria, and whether it is suitable for both bicycling and workplace apparel.

**Prototype Evaluation**

The initial plan for prototype evaluation consisted of a fit session that involved standing, sitting, walking, and a brief bicycle ride. The tester gave verbal qualitative feedback while testing the prototype in sitting, standing, and walking positions. She was also photographed while wearing the garment, both standing and on a bicycle. The subject’s own pants were used as a control for the bicycle fit evaluation. The fit tester then wore the prototype garment on her daily commute to and from work, and then participated in a brief qualitative interview in which the functional aspects of the garment were addressed in regards to cycling performance, as well as the subject’s overall impression of the fit, appearance, and function of the garment and how well it addresses each of the identified design criteria. Expressive aspects of the garment were also discussed, including office appropriateness. An audio recording of this interview was made. Once the fit session was completed, the researcher used this information, along with her own recorded observations, to evaluate how effectively the garment met each of the
identified design criteria. Recommendations were then made as to how the prototype could be improved.
CHAPTER IV

RESULTS

This research followed the conceptual framework of Watkins’ design process (1992), using Lamb and Kallal’s FEA theory of consumer needs as discussed in Chapter II. In Chapter III, the objectives of the study were discussed in relation to the phases in Watkins’ design process (1992). The steps involved in the research process were also discussed in relation to Watkins’ design process. This chapter will present the data collected and research results. The data will be organized under each appropriate research objective.

Objective 1:
Determine the functional, expressive, and aesthetic apparel needs of female bicycle commuters in Portland, OR for apparel that can be worn both at the workplace and during their daily bicycle commute.

To meet Objective 1, qualitative interviews were conducted in both individual and focus group format. In order to verify the data collected from the interviews, the researcher participated in commuting to work by bicycle.
Qualitative Interview Results

The results of the qualitative interviews are discussed below, including both an overview of the sample group and their commuting experiences, and an exploration of emergent themes from interview data. Table 1 provides a summary of the most-discussed types of garments and the perceived needs of the interview respondents, along with FEA category.

Sample

The interview subjects were sampled purposively, to fit within given criteria regarding lifestyle and cycling habits. The criteria are as follows:

- Commute to and from work is less than five miles each way.
- Commute takes place in an urban environment.
- Subject does not wear specialized cycling attire during commute.
- Workplace environment is one in which a certain level of attention to dress is expected or required (this would preclude many physical jobs such as landscaping).

Five female bicycle commuters were selected and interviewed individually, and four female bicycle commuters were selected to participate in a focus group.
### Table 1. Summary of Qualitative Interview Results

<table>
<thead>
<tr>
<th>Garment</th>
<th>Need</th>
<th>FEA Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jacket/outer layer</td>
<td>Style</td>
<td>Expressive/Aesthetic</td>
</tr>
<tr>
<td></td>
<td>Easy to remove or unzip</td>
<td>Functional</td>
</tr>
<tr>
<td></td>
<td>Modesty</td>
<td>Expressive</td>
</tr>
<tr>
<td></td>
<td>Warmth</td>
<td>Functional</td>
</tr>
<tr>
<td></td>
<td>Weatherproof</td>
<td>Functional</td>
</tr>
<tr>
<td></td>
<td>Ventilation</td>
<td>Functional</td>
</tr>
<tr>
<td></td>
<td>Fabric</td>
<td>Functional/Aesthetic/Expressive</td>
</tr>
<tr>
<td></td>
<td>Fit</td>
<td>Functional/Aesthetic/Expressive</td>
</tr>
<tr>
<td>Pants</td>
<td>Style</td>
<td>Expressive/Aesthetic</td>
</tr>
<tr>
<td></td>
<td>Packable</td>
<td>Functional/Aesthetic</td>
</tr>
<tr>
<td></td>
<td>Modesty</td>
<td>Expressive</td>
</tr>
<tr>
<td></td>
<td>Won't be caught in gears</td>
<td>Functional/Aesthetic/Expressive</td>
</tr>
<tr>
<td></td>
<td>Warmth</td>
<td>Functional</td>
</tr>
<tr>
<td></td>
<td>Weatherproof</td>
<td>Functional</td>
</tr>
<tr>
<td></td>
<td>Fabric</td>
<td>Functional/Aesthetic/Expressive</td>
</tr>
<tr>
<td></td>
<td>Fit</td>
<td>Functional/Aesthetic/Expressive</td>
</tr>
<tr>
<td></td>
<td>Color</td>
<td>Aesthetic</td>
</tr>
<tr>
<td></td>
<td>Durable</td>
<td>Functional</td>
</tr>
<tr>
<td>Skirt/Dress</td>
<td>Style</td>
<td>Expressive/Aesthetic</td>
</tr>
<tr>
<td></td>
<td>Packable</td>
<td>Functional/Aesthetic</td>
</tr>
<tr>
<td></td>
<td>Modesty</td>
<td>Expressive</td>
</tr>
<tr>
<td></td>
<td>Won't be caught in gears</td>
<td>Functional</td>
</tr>
<tr>
<td></td>
<td>Fabric</td>
<td>Functional/Aesthetic/Expressive</td>
</tr>
<tr>
<td></td>
<td>Fit</td>
<td>Functional/Aesthetic/Expressive</td>
</tr>
<tr>
<td></td>
<td>Color</td>
<td>Aesthetic</td>
</tr>
</tbody>
</table>

**Summary of User Needs**

Participants ranged in age from 29-43, with creative, executive, and administrative positions in public, private, and nonprofit sector. Commutes ranged from one mile to five miles each way, with five of the eight women reporting that they “often” ride their bike to errands or social engagements as part of their commutes. Seven of the eight respondents described their bikes as “hybrid”, and
one respondent rode a mountain bike with road tires. A “more upright” position was considered preferable; reasons given included ”my back”, “plumber’s crack”, and “let’s face it, I’m pregnant”.

All women commuted to and from work in Portland, OR. Respondents rode to work anywhere between three to five times per week, although seasonal variation in frequency was also reported due to fluctuations in weather conditions. Average daily temperatures in Portland range from mid 80’s in the summer to mid 40’s in the winter. Rain is common in autumn and spring and frequent in the winter, during which high winds are also common. Because of its northern latitude, Portland also has decreased daylight during the winter, with a sunrise at 7:38 AM and sunset at 4:30 PM on the shortest day of the year. (NOAA, 2010).

Only two of the respondents rode with the same frequency all year round, while four listed bad weather as a factor curtailing their bike commuting frequency. Lack of fenders was cited by two respondents as a disincentive to winter riding, while others cited “rain, cold, and dark”.

**Interview Themes**

Although extensive data was provided by both one-on-one interviews and focus group, the results from the one-on-one interviews differed slightly as a group from the results of the focus group. This is to be expected, both due to differences in format and variance between individual participants. The focus group dynamic can jog people’s memory regarding experiences and ideas they have had, and build
enthusiasm for opinions and ideas they may have held to a lesser degree. On the other hand, focus group participants may be so caught up in the enthusiasm of group conversation that they may be distracted from mentioning things that would otherwise occur to them. Despite the difference both in formats and populations, the focus group data corresponded to the one-on-one data in many areas. The focus group participants showed a slightly higher interest in issues of sustainability and socially responsible consumption than did the one-on-one interviewees, and were less specific overall about the articles of clothing they wore while cycling. Beyond these two minor differences the two populations gave similar responses, so their responses will be pooled.

The major theme that emerged from the interview process was conflict between appearance and physical function. Participants expressed concern over their appearance for both aesthetic and expressive reasons, and expressed dissatisfaction in the level of functional performance available in clothing that met their aesthetic and expressive standards. Although most participants claimed that they “don’t really care” how they look on their bicycles, or have “given up on it”, all exhibited a strong preference against clothes and accessories they felt were “ugly” or “dorky”. Participants also discussed being cognizant of their appearance as they arrived at work “sweaty”, wearing “giant rain pants” or “soaking wet”.

Participants described a complex process of assembling suitable cycling outfits from clothing at hand as “catch as catch can”. Six of the eight women reported changing at least part of their clothes on a regular basis after commuting
to work. “Packability” was deemed an important attribute of clothes brought to change into; “it has to roll up, and unroll, and not wrinkle”. Most reported that situations like client meetings influenced their choice of apparel, whether they packed a change of clothes, and whether they may choose an alternate method of transportation that day; “the days when I’m not riding my bike it’s often because I’ve got to dress up”.

Seven women mentioned that they used a pannier or basket to carry a change of clothes or shoes, “I just wear whatever I want and then change when I get to work”. Women who did change their clothes often changed only part of their wardrobe; “I rarely wear the shirt I’m actually going to be at work in”, “I usually don’t want to change my entire outfit”, “I mostly just change the bottoms”. Participants reported a range of time spent changing between none at all and ten minutes, but generally felt that “it’s all about convenience”, doing a complete shower and change at work “takes too much time”, and “I do like to wear what I’m gonna wear to work on my bike”.

As a whole, the interview participants tended to be cautious consumers of clothing. All expressed concern about available apparel choices. Cost was a major area of dissatisfaction, with five respondents describing currently available commuter cycling apparel as “beyond my price range” or “not the cheapest things on the market”. Social responsibility was another concern, the economics of certain “bad” clothing was “horrible for working families internationally”, while buying from a “local company” is something “I want to support”. Concern over
durability was mentioned by four respondents; “you don’t wanna have something fall apart because it’s not made well”, but “I will save up” to buy something “that is useful and will last”. Both construction and fabrication were areas of concern related to durability. Four respondents reported that they wore second-hand clothing, obtained either from thrift shops, vintage clothing stores, or organized clothing swaps (“naked lady parties”); “I’m not gonna spend a lot of money…I’m just gonna buy something that’s affordable and wearable”.

Modesty was a major concern amongst respondents, seven reported modesty concerns. Several women noted that “low-cut pants give you the plumber’s crack”, and “trying to wear long shirts” was discussed as a possible solution. Modesty while biking in skirts was also a concern, women looked for skirts that “hit just right”, so they “feel covered but it doesn’t get in the way of the spokes”. Another solution was to layer a bifurcated garment under the skirt, like leggings, “pantyhose-type shorts”, or “jeans, yoga pants, or sweatpants”. Keeping the bosom contained while leaning over on the bike was also a concern for some women. One participant described “that little peek-a-boo hole” that happens when wearing a button-down shirt, another complained that sometimes “I’m wearing something that’s perfectly modest or acceptable standing up, but over on a bike it suddenly isn’t”.

Thermal comfort and ease of thermal regulation was a major need identified by participants. Because the interviews were conducted during the winter, cold weather was at the forefront of participants’ minds. Especially in the
winter, “I just want to be warm”, and “I don’t like to be cold so I end up choosing the sweaty over the freezing”. Thermal comfort needs are in flux throughout the ride as physical activity increases core body temperature. Six of the participants mentioned layering as a strategy to manage thermal comfort, and looked for clothing that is “easy to take on and off” while on the road. Arriving at work sweaty was also an issue. Some women changed part of their outfit, “I rarely wear the shirt that I’m actually gonna be at work in because I do sweat”, while for some, “it doesn’t bother me at all”. Women also looked for clothing that was “breathable” and “doesn’t show my sweat that much”.

As for articles of clothing that women preferred to wear on their bike, several mentioned “yoga pants” or “stretchy pants”, worn either on their own or layered under skirts or dresses. Also popular were “capris” or “cropped pants”, sometimes worn with “long socks” for warmth. Skirts were also a popular choice; “I do wear a lot of skirts”, “I wear skirts and dresses about half the time”. In addition to modesty concerns, skirts also presented a challenge in terms of thermal comfort, both of which were addressed by layering with “leggings”, “yoga pants”, or “pantyhose type shorts”. Some women biked in jeans, others disliked them because they were “too tight” and “not comfortable”.

Many women discussed biking in slacks or trousers, which presented a problem for those without covered chains due to the danger of “(getting) my long pants caught in my chain”. Solutions to this problem included rolling up the pant leg, wearing shorter pants, or tying down the pant leg with a strap. Each of these
solutions presented its own possible drawbacks. Pant rolling can result in “a slightly cold leg”, and tabs designed to keep rolled pants in place “looks like you’re going to the beach”, but overall women felt the rolled pant “looks a lot nicer” than the “hideous” ankle strap.

Respondents demonstrated strong preference for natural fibers over synthetic fabric content; “I love wool pants”, “I prefer cotton”. Several women gave positive mention to performance merino products such as Smartwool and Icebreaker, touted for their lightweight insulating properties. “It keeps you cool when you’re warm, it keeps you warm when you’re cold”, but it is “super-expensive”. The women felt natural fibers were more “breathable” and “never gets smelly”, although some women expressed concern that wool pants “don’t seem very durable”; “it just pills like crazy”. Synthetics were regarded as smelly and uncomfortable; “you never get the stink out”, of particular concern when heading into the office. Lycra was a popular topic of complaint, it was “too hot” and “I just really don’t like spandex”.

One of the most widely mentioned complaints was dissatisfaction with the appearance of currently available cycling apparel. Functional items such as leg straps, rain pants, and safety jackets were derided as “ugly” and “dorky”. Cycling apparel was perceived as being expensive, and its’ specialized appearance “looks ridiculous” off the bike; “why would I buy a special pair of pants just for biking?” Concern with fit was another complaint leveled at cycling apparel, especially unisex rain pants that were described as “giant” or “blobby”. One respondent
reported wearing children’s rain pants that were “still a little too big”. Commuter cycling apparel from companies such as Trek and Pearl Izumi was also a source of dissatisfaction; “that’s just not where I’m gonna buy clothes, is a bike shop”.

Several participants made negative statements about traditional cycling clothing, one woman stated that she “just really doesn’t like spandex” and another eschewed logo-laden cycling jerseys because “I’m not on a team”. Several women reported that they, in fact, did own traditional spandex shorts with chamois padding, but “that’s certainly not something I’m gonna wear for a commute”.

Even with traditional attire already in their closets, the women felt more comfortable in their everyday clothes.

**Direct Participation**

The researcher rode her bicycle to work on two separate occasions wearing non-specialized cycling apparel, a distance of 3.4 miles each way. The bicycle used was a mountain bike, chosen over the second option of a road bike because it allows for a more upright posture, which is preferable for reasons of both comfort and visibility. The researcher also prefers an upright posture because it decreases the likelihood of exposure of the lower-back area, important for reasons of both modesty and thermal comfort. Both commutes occurred in February of 2008. One of the days was partly cloudy and in the low 40s, the other day was raining but
slightly warmer, upper 40s. Previous to this exercise, the researcher has been a bike commuter when possible for the past seven years, with commutes ranging in length from one mile to five miles each way. The researcher’s office environment is casual but not overly so. Although jeans and even exercise clothing is a common sight in the office, a well-groomed, well-accessorized, and overall put together appearance is expected.

Apparel was chosen from the researcher’s existing wardrobe that would be both bike-appropriate and office appropriate. Each outfit was worn throughout the day at work, and for the commute both to and from work. Notes on functional performance, appearance, and expressive attributes of chosen outfits were recorded after both morning and evening commute on both days.

The outfit chosen for the first commute was a cotton knit skirt, lightweight merino wool leggings, wedge-heel leather boots, a cotton sweater, and a wool single-breasted trench with a tie belt, as well as a wool knit cap and a wool scarf. The outfit chosen for the second commute was a pair of stretch denim jeans, plush-lined leather boots, a cotton long-sleeved tee, a cotton zip-front hooded sweatshirt, and a quilted jacket with knit insets, along with a wool hunter’s cap, leather gloves, and wool scarf. On both days the researcher traded in her usual over-the-shoulder purses for a cotton messenger-style bag.

The choice of apparel was based on the researcher’s previous cycling experience, taking into account the need for range of motion, adequate warmth, and bicycle safety, particularly the need to keep clothing free of the gears and
chain. However, the goal of this exercise was not only to successfully commute by bicycle, but also to wear the same clothes at work. Therefore the choice of clothing was limited, and excluded such items as knit activewear pants and waffle-knit base layers. The choice of footwear was the most severely restricted, few pairs of shoes met the qualifications of being both office-appropriate and safe to wear on a bicycle. Ultimately, the determination was not whether these clothes would be the ideal cycling outfit, but whether they would be “good enough” to function for the 20-30 minutes of the commute.

Functionally, both outfits performed well enough to ride to work and back with no damage to the garments and minimal discomfort to the researcher. The main source of discomfort on the first ride was due to cold hands; the researcher was able to obtain a pair of gloves at work, which, while perhaps not the most suitable choice, somewhat mitigated the problem on the way home. The knit fabrics did not offer a great deal of wind resistance; however, the merino leggings had excellent insulating properties. There was also a great deal of bunching in the midsection of this outfit, due to the overlap in the waist area of leggings, skirt, sweater, and trench with belt. This bulkiness was a minor source of discomfort. The trench was left unbuttoned below the waist to facilitate ease of movement, which caused some flapping of the open coat. The tie belt was a source of concern, should it come untied it could become entangled in the spokes. A greater source of concern on both days was nighttime visibility during the evening
commute. Although the bicycle was equipped with both front and rear lights, the dark winter tones of the researcher’s wardrobe did nothing to enhance visibility.

The second commute took place during a light drizzle. The lack of any protective rainwear assured the researcher’s arrival at work would be slightly damp. In a heavier rainfall this could have presented a major problem, but in this case the rain did not penetrate through the outer layers and only the jeans were dampened, resulting in slight discomfort for about 30 minutes. The brimmed hunter’s cap did a fair job of blocking the rain, but its oversized fit cut down on peripheral visibility. While perfectly comfortable off the bicycle, the jeans pulled down at the back and dug into the waist while cycling. Likewise, although both the sweatshirt and jacket provided adequate lower back coverage off the bicycle, while riding lower back exposure became a cause for concern. Clothing adjustments were necessary during the ride to avoid exposure.

The researcher discovered that the social pressure to “fit in”, that is the expressive need to wear clothing appropriate to one’s environment, is present not only at the office but also during the commute. Riding through an urban area during rush hour means being seen by hundreds of people; whatever personal standards of appearance one might have while walking down the street do not disappear merely through the act of riding a bicycle. Additionally, for the researcher at least, the commute to and from work feels more like an extension of the workday than a separate activity of its own, whether commuting by car, public
transit, or bicycle. The inclination is to dress for the main activity of the day; the commute is but a minor aspect of the workday.

The desire to preserve aesthetic and expressive standards of appearance and personal identity created a conflict with the functional demands of cycling. As part of the exercise, the outfits were assembled to perform a dual function – both in the office and on the bicycle. Within these parameters, certain items were a particular cause of dissatisfaction. The messenger bag was chosen mainly for its functional qualities, but its casual appearance was not office appropriate. Shoes were also a problem, there were a limited number of choices. The outerwear worn on the second commuting day did not adequately protect against the rain. Being in the office with wet clothes was mildly physically uncomfortable, but also a cause for self-consciousness. If there had been a heavier rain, the results could have been much worse in both areas.

The direct participation experience had several parallels with the results of the qualitative interviews. Problem issues that occurred in both groups included visibility concerns, bulkiness in midsection, discomfort while biking in jeans, and concerns over lower back exposure. Like many of the interview respondents, the researcher found that layering leggings under a skirt was a successful strategy, and that wool was a superior means of keeping warm.

The researcher did not carry any additional clothes to work, and did not change any part of her clothing. Due to time constraints, the researcher was not able to participate in commutes during a wide range of weather and temperatures.
Overall, the experience reinforced many of the themes that emerged from the qualitative interviews regarding specific apparel needs as well as general expressive needs and issues.

Survey of Currently Available Products

The researcher conducted a content analysis on currently available commuter cycling apparel. The researcher conducted research of cycling industry magazines to identify leading brands of cycling attire. Both men’s and women’s apparel was included in the analysis, with the criterion that the apparel was labeled or marketed as being either urban or commuter cycling apparel, and included technical cycling features. For example, t-shirts with cycling-related graphics were not included in the analysis. Accessories and base layers were also excluded. The commuter cycling market is still rather small, so this resulted in a total of 58 garments from 15 companies. A closed coding scheme was used which examined the variables of cost, color, type of garment, gender (men’s, women’s unisex), fabrication, and functional features. Price range and average cost per garment type are reported in Table 3.

The breakdown of styles per company was varied. Several companies specialized in road cycling or mountain biking but also offered a few “urban” or “commuter” pieces. Three companies, Swrve, Chrome, and Sheila Moon, were
focused on the urban and commuter market. The knicker was the garment most commonly marketed towards the commuter. Commuter cycling apparel currently on the market can be roughly divided into two categories: that which is focused on commuters’ technical needs, and that which attempts to mimic the appearance of street clothes. Clothing marketed as urban cycling apparel generally avoids an overly “technical” appearance, but does not shy away from features such as droptails and short pants that brand the wearer as a cyclist. Of the garments surveyed, 20 were marketed as commuter cycling apparel, while 28 were marketed as urban cycling apparel.

Technical commuter apparel fell into the category of outerwear and included jackets and rain pants, clothing that would not be worn at the office. Eight of the garments surveyed were classified as technical commuter apparel. The main focus of these garments was visibility and protection from the elements. Color palettes included more bright colors and deep blacks, and fabrics were more likely to be technical synthetics. Other commuter wear, both outerwear and basic garments such as pants and skirts, more closely resembled everyday clothing in its design, palette, and fabric choices. Both wool and cotton were popular choices in this group. The palette was generally earthy and subdued, including wool tweeds. In the event that technical fabrics were used, the garment was styled like conventional clothing rather than activewear, such as the case of Swrve’s water and wind resistant softshell trousers. Clothing marketed as “urban” cycling apparel also followed the trend of earth tones and natural fabrics but tended to be
more casual and youthful in its styling, although there was a large amount of
crossover between these two groups.

Of the 58 garments surveyed, 35 were men’s or unisex, while 26 were
made specifically for women. All companies that offered clothing for men also
offered some styles for women, although the selection for women was in all cases
equal to or less than the selection for men, and often consisted simply of a
women’s version of the men’s styles. Making up the difference were two women-
oriented companies, SheBeest and Sheila Moon, each accounting for four of the
women’s styles.

Five garment types were identified in the analysis, including 25 pants, 13
jackets, four shirts, three skirts, and three zip-front hooded sweatshirts (“hoodies”).
Table 3 shows the price ranges and average price for each type of garment.
Leading features found on jackets include armpit zips for venting, zip pockets at
lower back and at front, reflective accents, droptails, and waterproof/windproof
fabrication and features. Knickers were the most popular pant style, 18 out of the
25 pant styles surveyed were knickers or other short pants. Full length pants
featured tabs, snaps, or other systems to keep fabric away from bike gears. Most
pants featured a high back rise, articulated knees, crotch gusset, and zip pockets.
The features most commonly available were consistent across both men’s and
women’s garments.

Many functional features identified through the content analysis were
consistent with needs expressed by interview participants, including droptail
jackets, culotte skirts and high back rises on pants to address issues of modesty, reflective materials and other visibility features, adjustable venting, and a variety of knickers and pant-leg systems. Currently available clothing also has many features to enhance comfort and range of motion, such as articulated limbs, crotch gusset, and stretch or adjustable waistband.

### Table 3: Price Range and Average Price by Garment Type

<table>
<thead>
<tr>
<th>Garment Type</th>
<th>Price Range</th>
<th>Average Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jacket</td>
<td>$70.00-$249.00</td>
<td>$148.00</td>
</tr>
<tr>
<td>Pants</td>
<td>$80.00-$159.00</td>
<td>$112.48</td>
</tr>
<tr>
<td>Shirt</td>
<td>$78.00-$115.00</td>
<td>$98.25</td>
</tr>
<tr>
<td>Skirt</td>
<td>$85.00-$90.00</td>
<td>$86.67</td>
</tr>
<tr>
<td>Hoodie</td>
<td>$150.00-$160.00</td>
<td>$156.67</td>
</tr>
</tbody>
</table>

### Interaction Matrices and Design Criteria

Content analysis was used to analyze the qualitative data from the interviews and focus groups. The interviews were transcribed and coded using open coding. Using the results of the interviews, the researcher’s own experience of direct participation, and results of the content analysis of currently available commuter cycling apparel, several key user needs were identified, including a determination of what types of apparel are most needed by the population.
Interview participants expressed the most interest in a stylish, high-visibility jacket, a durable, bike-friendly pair of pants, and a skirted garment that would be compatible with cycling. Therefore design criteria were compiled for a jacket, a pair of pants, and a skirted garment. An interaction matrix (Watkins, p 351) was used to analyze the criteria for each garment and identify any possible conflicts. The key for the matrices is as follows:

- 0 = conflict
- 1 = possible conflict, needs accommodation
- 2 = no conflict

**Jackets**

The design criteria for jackets were as follows:

- Aesthetically appealing in both fit and color
- Protection from elements: waterproof and windproof
- Ventilation for thermal comfort
- Easily accessible, adjustable venting with zippers
- High visibility
- Comfortable on and off bicycle
- Does not restrict movement while cycling
- Provides adequate coverage at lower back
The jacket interaction matrix (Table 3) did not contain any unresolvable conflicts. There were several minor conflicts. The aesthetic design and fit of the jacket (1) is constrained by the need for weatherproofing (3, 4) and ventilation (5, 6), as well as the need for comfort and range of motion while cycling (8, 9). Although these functional needs limit the scope of possible designs, they do not preclude the creation of an aesthetically appealing jacket. The need for an aesthetically appealing color (2) conflicts with the need for high visibility (7). High visibility materials such as reflective tapes and neon colors detract from the aesthetic appeal of the jacket. Limited, strategic use of these elements, as well as use of a less garish, yet still vivid color palette can mitigate these aesthetic

Table 3. Interaction Matrix for Jacket

<table>
<thead>
<tr>
<th>Design Criteria – Jacket</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Aesthetically appealing - design and fit appropriate on and off bicycle</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2. Aesthetically appealing - color</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Waterproof</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Windproof</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Ventilation</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>6. Adjustable venting</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. High visibility</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Comfortable fit on and off bicycle</td>
<td>2</td>
<td>2</td>
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<td></td>
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<td></td>
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<td></td>
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<tr>
<td>9. Does not restrict motion while cycling</td>
<td>2</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Lower back coverage</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tbody>
</table>
liabilities. The need for weather protection (3, 4) creates a conflict with the need for ventilation (5). The openings needed to create adequate ventilation also create openings for rain, wind, and cold to penetrate. This conflict can be addressed by using sheltered ventilation, ventilation on the back side of the body, and adjustable ventilation systems that can be altered as needed while cycling.

**Pants**

The design criteria for pants were as follows:

- Professional appearance, appropriate for office
- Durable construction and fabrication
- Warm
- Comfortable fit at waist
- Lower back coverage while cycling
- Pant leg won’t get caught in spokes
- Does not restrict movement while cycling
- Water resistant
- Packable - lightweight and wrinkle resistant

The only unresolvable conflict in the pant interaction matrix (Table 4) occurred with the interaction of water resistance (8) with packability (9) and professional appearance. Waterproof garments are made from fabric that is either
coated or bonded with a waterproof membrane, and may be seam sealed, all of which add bulk to the garment and are not compatible with a lightweight design. Waterproof fabric is also not generally appropriate in appearance for office use, and may be stifling in an indoor environment.

Table 4. *Interaction Matrix for Pants*

<table>
<thead>
<tr>
<th>Design Criteria - Pants</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Professional appearance - can wear to the office</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2. Durable</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Warm</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Comfortable at waistband</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5. Lower back coverage</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Won't get caught in bicycle spokes or gears</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Does not restrict motion while cycling</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Water resistant</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Packable - lightweight, does not wrinkle</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

There were also several minor conflicts. An office-appropriate appearance (1) was in conflict with durability (2), as the most durable fabrics are not appropriate for the office. This conflict can be mitigated by using the most durable fabrics that are also office-appropriate, and by using construction methods such as reinforced seaming to ensure maximum durability. Office-appropriateness was also in conflict with waistband comfort (4) and the need to keep fabric clear of
bicycle gears (6). Any waistband adjustment feature must be integrated into the overall professional appearance of the pant. This is also true for the means of keeping pant legs from the gears; whether this is accomplished by a shorter pant design or a system of constraining the fabric of the lower leg, it should be compatible with standards of office-appropriateness. Providing adequate range of motion for cycling (7) was also in conflict with office-appropriateness. Lycra cycling shorts are not office-appropriate, but adequate range of motion may be obtained by the use of woven fabrics with a small Lycra content, or by providing adequate ease in the garment. Durability (2) was in conflict with packability (9). Durable fabrics are heavier, therefore creating a direct conflict with packability. However, lightweight fabrics can be made with durable construction, and durability is not in conflict with wrinkle-resistance. Warmth (3) is also in conflict with packability. Warm fabrics tend to be heavier, creating a conflict between warmth and light weight. However, warmth is not in conflict with wrinkle-resistance.

**Skirted Garment**

The design criteria for skirted garments were as follows:

- Professional appearance, appropriate for office
- Durable construction and fabrication
- Appropriate length to ensure modesty while cycling
- Won’t ride up while cycling
• Comfortable fit at waist
• Won’t get caught in spokes or gears
• Packable – lightweight and wrinkle resistant

The skirted garment matrix (Table 5) did not contain any unresolvable conflicts. There were several minor conflicts. As with the pant matrix, office-appropriateness (1) was in conflict with durability (2), packability (8), and waistband comfort (6), and durability is in conflict with packability. Office-appropriateness was also in conflict with feature 4 (won’t ride up while cycling), and feature 5 (does not restrict movement while cycling). Although these needs limit the scope of possible designs, they do not preclude the creation of office-appropriate apparel. Appropriate length (3) has a conflict with freedom of movement (5) and not getting caught in bicycle gears (7), which itself has a conflict with freedom of movement (5). Longer skirts must have enough ease for freedom of movement while cycling, but cannot be long enough or full enough to get caught in bicycle machinery.
Table 5. *Interaction Matrix for Skirted Garment*

<table>
<thead>
<tr>
<th>Design Criteria - Skirted Garment</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Professional appearance - can wear to the office</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2. Durable</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Appropriate length - provides coverage while cycling</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Won't ride up while cycling</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Does not restrict movement while cycling</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
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<td>7. Won't get caught in bicycle spokes or gears</td>
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<td>8. Packable - lightweight, does not wrinkle</td>
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**Technical Sketches**

The final group of designs included two jackets, two pairs of pants, a skirt, and a dress. Detailed technical sketches and garment specifications were produced for the final designs using Adobe Illustrator™, and suitable fabrics and trims were selected.

**Jacket 1**

Jacket 1 (Figure 5) is a mid-length trench coat with reversible rain cape. The jacket hits just above the knee and has a slight a-line shape to facilitate range of motion. The placement of buttons on the skirt of the jacket is also higher to
facilitate leg motion. The double-breasted design keeps out wind and can be buttoned up to a standing collar or left open to form lapels. There is a looped strap at each sleeve opening that can be tightened for warmth. There is a back vent and mesh lining for ventilation. The rain cape is removable and reversible. One side matches the color of the coat, and the other side is a contrast bright color with reflective tape around hood opening and hem. The rain cape fastens at the side to prevent flapping in the wind. The hood can be drawn closed using bungee pulls and has a small opening at back neck for venting. Fabric is water-resistant wool gabardine and nylon mesh lining. Recommended color combinations for this jacket are beige with bright pink cape, grey with leaf green cape, or other combinations of traditional neutral trench color with vivid cape color for visibility.
Figure 5. Jacket 1
Jacket 2

Jacket 2 (Figure 6) is a loose-fitting car coat with back venting, mesh lining, and fleece sleeve liners with elastic openings. This jacket hits mid thigh and has a double-headed front zip with storm flap. This jacket has loose-fitting raglan sleeves for ease of movement with inner sleeve lining to block wind and rain. Recommended color for this jacket is dark teal or other toned-down bright. Fabric is wind-resistant poly-cotton twill with nylon mesh lining.

Figure 6: Jacket 2
Pant 1

Pant 1 (Figure 7) is a full-length pant with slim straight-leg cut. Pant has elasticized rib panels at back waist for comfort in any position. Pant also has high back rise for lower back coverage and crotch gusset for better range of motion when cycling. Pant legs roll up with tab-and-button system, and inner pant leg has reflective heat transfers for increased visibility. Back pockets are zippered and front pockets are extra-deep. Fabric is a stretch wool gabardine with cotton-lycra rib insets. Recommended color for this style is medium cool grey.
Figure 7: Pant 1
**Pant 2**

Pant 2 is a trouser-cut knicker that ends below the knee (Figure 8). Pant is fitted through the waist, cut wide through the legs to facilitate range of motion, and gathered into bands at leg opening. Bands have extra button for size adjustment. Rise is slightly dropped when standing, allowing for waist to shift upwards when riding. This pant also has zippered extra-deep zippered pockets in front for security. Recommended colors for this style are olive green or dark brown. Fabric is wool gabardine.

![Figure 8: Pant 2](image)
**Skirted Garment 1**

Skirted Garment 1 (Figure 9) is a gathered tulip skirt that can be worn with tights or leggings. It has a surplice opening at CF to facilitate range of motion while pedaling. It also has a panel of elastic smocking at back waistband, for comfort in any position. The shape and construction of the skirt provides adequate coverage and ease to facilitate range of motion, but is not so full that it will get tangled in the spokes or gears. Recommended color is dark brown. Fabric is merino wool.

Figure 8: Skirted Garment 1
Skirted Garment 2

Skirted Garment 2 is a sleeveless a-line dress that can be worn on its own or layered with shirt or leggings underneath (Figure 10). The dress has a high waist with elastic at back to avoid discomfort in cycling postures. The neckline is cut high for modesty in all postures. The dress has a removable tie belt with contrasting bright color on one side. Recommended color for this style is cerulean blue with white insets and bright pink tie belt. Fabric is lightweight stretch cotton woven.
Prototype Development

Pant 1 was selected from among the final designs to be fit and evaluated at the prototype phase. The prototype garment was chosen on the following criteria:

- The garment effectively fulfills the design criteria.
- The researcher is able to procure fabric and trim that closely match the specified materials both in appearance and functionality.
- The technical aspects of the production of the garment are within the researcher’s resources.

All six designs were created to meet as many of the criteria as possible, therefore the deciding factor as to which design would move to prototype phase was the ability to execute the design as intended. Both jacket designs were specified with heavy-duty, water-resistant outerwear fabric and lightweight mesh lining. In addition, the efficacy of Jacket 1 in meeting safety-related user needs was dependent on the high-visibility contrast color of the cape and the reflective tape used for drawcord casing. Obtaining the correct fabrics and trims to execute either of the jacket prototypes was difficult, as these products are not readily available at the consumer level.

Due to cost and time constraints, this study was limited to the production and evaluation of a single prototype. Therefore, the design selected must be constructed as specified and function as intended at the first prototype phase. In order to ensure that the prototype would be of the highest possible quality, the
researcher obtained the services of a professional sample sewer. The factory that was able to sew the sample was not equipped to execute some of the more complex designs. The factory used a predetermined fit block to develop the pattern, so a simple design was selected that would require the least amount of alteration from the available fit blocks. As shown in Figure 11, the original design was modified due to the limitations of the factory and limited availability of trims. The leg tab buttons were removed, and the researcher was unable to obtain reflective heat transfers for the inside leg. The fabric chosen for the prototype garment was a charcoal grey wool gabardine with 3% spandex, and 2 x 2 cotton rib panels with 1” wide elastic at the top.
One interview subject was chosen after the interviews were completed to aid in prototype evaluation. The interview participants were notified at the time of the initial interview that they would be eligible to test the prototype if they were interested. At the time of the interviews, six of the eight subjects verbally

**Prototype Evaluation**

Figure 11: Prototype Garment Sketch
expressed interest in participating in the prototype evaluation process. One subject was randomly selected from the group of interested participants, and offered the opportunity to test the prototype. The participant’s body measurements were taken and it was determined that she was within an appropriate size range to test the prototype.

The initial plan for prototype evaluation consisted of a fit session that involved standing, sitting, walking, and a brief bicycle ride. When the prototype was shown to the fit tester, the initial impression of the fit tester was that the prototype appeared to be successful both in its functional aspects and its office-appropriate appearance. Therefore, the option of a more extensive wear-test was considered. After discussing the risks and ramifications of engaging in a more extensive fit test, the fit tester determined that she would wear the garment at work, as well as bicycling to and from work. An informed consent document was signed by the fit tester.

The goal of the fit test was to evaluate the fit and function of the pants both verbally and visually, identifying positive attributes as well as areas in need of improvement. The fit tester, graphic designer JD, wore the garment for a brief fit evaluation. The garment was evaluated by standing, sitting, and walking. The fit of the garment was described verbally by JD, and the conversation was recorded. In addition, the researcher took notes on the visual fit and appearance. The pants were compared to a pair of control pants, a pair of jeans that the fit subject wears regularly for bicycling. The fit evaluation process was documented with still
photographs. JD also wore the pants on her commute to and from work. Due to the fact that leg tabs were removed from the prototype design, the pant legs were rolled up.

The initial impression by the fit tester was positive; “I could wear these pants all the time”. She felt that the overall fit was “so comfortable”, “I love the waist”, and “the butt feels great”. Bike friendly features were a positive element; “I like how long the [front] pockets are”, “I love the panels on the sides”. The appearance was also appealing, JD felt that the pants “look great”, are “really flattering”, and “the material’s really nice”, and “I like that the styling on it is so simple, it feels like a very straightforward pair of slacks”. The pants appeared to fit well through the waist, rear, hips, and through the legs. The pants fit and were comfortable in all positions, and did not impede movement in any way.

During the wear test, JD reported that the pants were “very functional” and “super comfortable” on the bicycle, especially at the waist. Regarding the fabric, “the stretchiness is really nice”. Although she got caught in the rain, she “stayed comfortable and fairly warm even though it was cold that day”. The pants appeared to fit well on the bicycle, and appeared more flattering in the waist area than the jeans used as control pants.

There were two main problem areas evident at the initial fit session. The thighs were “a little too tight” around the gusset area, which was exacerbated by sitting. The pants appeared visibly too tight in the thighs as well, and the poor fit through the leg caused the front pockets to gape (Figure 12). The gusset itself also
had fit problems. JD reported “it just seemed like there was some extra fabric” in the gusset while cycling. It was visible while seated due to the fact that it contained too much fabric and was set too far forward. The waist panels did not hold their elasticity throughout the subject’s commute, causing “a little bit of sliding in the back”.

Figure 12: Prototype pants worn by fit tester JD.
CHAPTER V

DISCUSSION

Research Design

The functional design process used in this study provided a step-by-step structure for functional apparel design. This process allowed the researcher to identify design elements that addressed the user needs of female bicycle commuters, and led to the successful production of a prototype that fulfilled the specified design criteria.

Analysis

The analysis phase consisted of qualitative interviews, direct participation by the researcher, and a content analysis of currently available commuter cycling clothes. The analysis phase addressed the following research objective: 1. Determine the apparel needs of female bicycle commuters in Portland, OR for apparel that can be worn both at the workplace and during their daily bicycle commute.

Participants felt generally dissatisfied with the availability of commuter cycling apparel that they deemed desirable. The common theme that emerged was a conflict between the functional needs of the participants as cyclists and the psychological need for attractive, office-appropriate clothing. The women felt that traditional cycling companies did not make “cute” clothes, and that their
expressive and aesthetic needs were not taken into account with currently available products.

The participants preferred to assemble cycling outfits from clothing that was not expressly designed for that purpose, and identified several areas of critical importance regarding functional performance, including weather protection, range of motion, high visibility, thermal comfort, mechanical safety, and comfortable fit. In addition to functional needs, the women also expressed concern over issues of modesty while cycling, and a desire to “look cute” on the bicycle.

The initial research plan consisted of one-on-one interviews only. However, one of the potential interview subjects resided in an intentional community, a communal housing cluster focused on sharing an ecologically sustainable lifestyle. When the participant discussed the project with other residents of the community, several other women expressed interest in the project. Due to the fact that the women lived together in an intentional community, the inclusion of all participants as separate interviews could potentially skew the data. Therefore the decision was made to hold a focus group that was open to all members of the community who were female bike commuters, and to also continue conducting one-on-one interviews with the goal of redundancy. The focus group data was compared with one-on-one interview data to triangulate results obtained by two different methods.

Due to the highly subjective and individualized nature of expressive and aesthetic needs, qualitative interview research is particularly helpful in
understanding the complexities of these user needs (Rafaeli, et al., 1997). Although each workplace environment has its own individualized set of expectations regarding employee appearance, and each individual person has their own set of aesthetic preferences, many commonalities emerged through the research. And although it is impossible to address the individual needs and preferences of all target consumers in the design process, these commonly identified needs must be taken into account, as they are crucial to consumer satisfaction.

The researcher’s experience with direct participation helped to verify the reliability and validity of the interview results (Silverman, 1993). It also fostered a deeper understanding of the needs of the target population and how to address those needs.

The content analysis provided an overview of currently available cycling apparel that was marketed as “commuter” or “urban” cycling apparel. The results of the analysis showed that, while there were several garments available that adopted the style and appearance of urban streetwear, there were few examples of dual-purpose wear appropriate for the office, and fewer still options available for women. The content analysis illustrated what type of apparel is currently available, and was also helpful in providing information about commercially available functional design solutions for cycling apparel.

The information gathered in the analysis phase helped the researcher to clarify the needs of female bicycle commuters, and to identify themes that could
be developed into design criteria. The common theme that emerged was a conflict between the functional needs of the participants as cyclists and the psychological need for attractive, office-appropriate clothing. The need for specific functional features such as ventilation, visibility, and range of motion was also identified.

Definition

The definition phase incorporated the user needs identified in the previous phase to identify most needed garment types and develop a set of design criteria for each garment type. The criteria were then examined with the use of interaction matrices to determine potential conflicts. The definition phase addressed the following research objective: 2. Develop design criteria for cycling apparel based on the functional, expressive, and aesthetic needs of female bicycle commuters.

The most-needed garment types were identified to be jacket, pants, and skirted garment. Design criteria for the jacket were: aesthetically appealing design and color that would be appropriate both on and off the bicycle, weather protection, adequate and adjustable ventilation, high visibility, comfortable fit both on and off bicycle, adequate range of motion, and lower back coverage. Design criteria for the pants were: professional, office-appropriate appearance, durability, thermal comfort, weather protection, comfortable fit, adequate range of motion, packability, lower back coverage, and mechanical safety. Design criteria for the skirted garment were: professional, office-appropriate appearance, durability,
appropriate length and coverage, comfortable fit, adequate range of motion, packability, and mechanical safety.

Interaction matrices were used to identify potential conflicts between criteria. The interaction showed several instances where concessions were needed to achieve both criteria. Two unresolvable conflicts were identified in the pant matrix: a conflict between professional appearance and water resistance, and a conflict between water resistance and packability. In the first conflict, professional appearance was determined to be more important than water-resistance. If the pants fail to achieve a professional appearance, they will lose their usefulness as commuter cycling apparel. Protection from rain can also be achieved by the use of rain pants. In the case of the second conflict, it had already been determined that water resistance was not achievable based on matrix results, so it was dropped from the final criteria. The results of the matrices laid the groundwork for the design process.

**Ideation and Selection**

The ideation and selection phases addressed the following research objectives: 3. Develop designs for apparel that incorporate the design criteria based on the needs of female bicycle commuters, and 4. Select and develop one prototype garment from those designs. The ideation and selection phases used the design criteria and the results of the interaction matrices to create several preliminary designs. These designs were then refined into six final designs, two jackets, two pairs of pants, a
skirt, and a dress. From these six designs, one design was selected for prototype development and testing.

The results of the matrices were used to develop preliminary designs. The researcher also considered interview feedback regarding the participants’ decision-making process. The researcher reviewed historical costumes as inspiration for both style and function. Historical costume such as riding wear, hunting wear, and old-fashioned cycling outfits provide clues to the construction of activewear garments before the advent of spandex and other performance fabrics. Many of the fabrics used for sportswear of the past are appropriate for the office environment of today, for example wool tweed or gabardine. Fabrics were chosen for the final designs based on identified needs. Color trend reports were also consulted and a color palette was included with each design.

A full-length pant design was chosen to proceed to prototype phase. The design was chosen because it fulfilled all the given design criteria, but also because it was the most likely to be developed into a successful prototype that closely matched the original design concept.

The ideation and selection phases completed the process of refining initial user needs into a final design that could be developed and evaluated. The researcher found it useful to combine these two phases into one, as illustrated in Figure 13. The ideation process as specified by Watkins (1995, p. 339) consists of proposing design solutions, while the selection phase involves selecting the best solutions and incorporating them into designs. It is this researcher’s opinion that
the division between these three steps is artificial and unnecessary, and that creates an unneeded level of complexity that impedes creative workflow.

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<td>Identify best design solutions</td>
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Division of steps within phases as defined by Watkins

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<td>Select one garment for prototype</td>
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Division of steps within phases as preferred by this researcher

Figure 13. Blending of the Ideation and Selection Phases.

**Implementation and Evaluation**

Based on designs developed in the previous phase, one garment was constructed as a prototype. The implementation and evaluation phase addressed the following research objective: 5. Evaluate the prototype to assess whether the garment meets the given criteria, and whether it is suitable for both bicycling and workplace apparel. The prototype meets most of the given criteria, and with some modifications is suitable for both bicycling and workplace apparel.

The evaluation process consisted of initial interview with fit tester, visual examination of garment fit while sitting, standing, walking, and on a bicycle, and interview with fit tester following wear testing. Based on the results of the evaluation, the prototype was determined to be successful in meeting the design
criteria. Several recommendations were made for improvement, including adjustment of gusset size and placement, tight measurement, and waistband fit. The evaluation phase helped to determine whether or not the process had produced a successful result, and generated a future direction for improving the garment.

Theoretical Model: Apparel Needs of Female Bicycle Commuters

Conflict between physical and psychological needs was found to be the key concern in meeting the apparel needs of female cycling commuters. The participants do not feel that existing technical garments marketed as “urban” or “commuter” apparel sufficiently fulfill their psychological needs. Furthermore, in many cases, the interview participants reported that they compromised on functional needs in order to fulfill psychological needs such as femininity and office appropriateness. Using Lamb and Kallal’s (1992) FEA theory of consumer need as a starting point, a model was developed that acknowledges different populations may have differing requirements as to the relative importance of each category. This population-specific ranking of need can be applied throughout the design process and guide the designer in creating a product that most accurately reflects the needs of the target consumer.
Figure 14: Apparel Needs Model for Female Bicycle Commuters
**FEA Model**

FEA categorization places functional needs within a cultural context, taking into account important aspects of preference beyond the utilitarian (Lamb & Kallal, 1992). Expressive needs and aesthetic preferences also play an important role in people’s apparel choices. In the case of female bicycle commuters, the importance of recognizing cultural needs is especially critical as this population adopts social roles that do not necessarily conform to the physical activities they perform (Kaiser, 1990; Casselman-Dickson and Damhorst, 1993).

**Physical and Psychological Needs**

When analyzing user needs based on the FEA model, one can see that expressive and aesthetic needs are more deeply connected to one another than either of those two categories is to functional deeds. Aesthetic and expressive needs can both be categorized as “psychological” needs as they relate to appearance and the emotional response of the user. Functional needs can be described as “physical” as they describe experiential aspects of the garment such as fit, comfort, and protection from the elements. Psychological needs are subjective, highly individual needs that are difficult to measure, and they are determined and influenced by changing socio-cultural circumstances. Functional attributes such as range of motion are absolute.
Functional Needs

Functional needs are of critical importance when designing apparel for athletic or activewear uses. Lamb and Kallal (1992) define functional needs as those needs concerned with physical aspects of garment performance such as range of motion, protection from elements, and ease of donning and doffing. The most prominent functional needs of the commuter cyclist population are those that allow functional operation of a bicycle: adequate range of motion, and prevention of clothing from getting tangled in the mechanism of the bicycle. Another important category of physical need is that of comfort. Fit is an important aspect of comfort, as is thermal regulation and the related need of weather protection. In addition to being an important functional need of its own accord, ease of donning and doffing is also important to the cyclist as part of a thermal regulation strategy. Visibility and durability were also mentioned often by the interviewees.

Expressive Needs

Expressive needs are defined by Lamb and Kallal (1992) as the need to communicate social roles, values and identity through apparel choice. As applied to this study’s target population, expressive needs were primarily manifested as the need for work-appropriate apparel. Other expressive needs conveyed by participants included gender expression through the desire for feminine clothing, the need to support a positive self-image by wearing flattering clothing, and the need to observe cultural norms of modesty by ensuring certain areas of the body
were covered. Although they bicycled to work regularly, the study participants primarily identified themselves in the role of office worker rather than cyclist, and felt it was important that their clothing reflect this identity.

The importance of promoting the correct social role is emphasized by the fact that the women complained loudly about currently available technical outerwear garments such as rain pants and safety jackets, even though these garments can be worn over appropriate “indoor” clothing. Several women mentioned that office-appropriate appearance is important “even just walking in” from a commute, while others were concerned with their appearance for errands or social engagements. To properly meet the expressive needs of this population, outerwear should be evaluated with similar expressive criteria as garments worn inside the office.

Aesthetic Needs

According to Lamb and Kallal (1992), aesthetic needs are concerned with the artistic value of the design and involve variables such as color, texture, line and proportion. Aesthetic preferences are often a matter of personal or individual taste. However, aesthetic needs played a large part in the preferences and choices of the interview participants. In several instances aesthetic preferences emerged as a point of consensus among interview participants, for example the universal dislike of brightly colored “safety jackets”. Although aesthetics can at times be deeply personal, these topics of consensus were included as important considerations to
achieve consumer satisfaction. Clothing that is flattering in fit, color, and design is an important aesthetic consideration that also relates to the expressive need to promote self-esteem through appearance.

The desire to follow fashion trends is a psychological need not addressed by Lamb and Kallal. It may be variously categorized as an expressive need (due to participation in group behavior), or an aesthetic need (due to focus on novel modes of appearance with regard to cut, color, and design details). For the purpose of this discussion it has been categorized as an aesthetic need.

**FEA Hierarchy**

One of the main themes that emerged from the interview data is that participants felt there was a conflict between functional needs and the two other categories of need, and often felt they had to choose one while sacrificing another. Women reported that they would “never wear” a brightly colored rain jacket “even though it’s safe”, and referred to bike branded outerwear as “stupid” and “dorky” even when describing clothing they themselves wore. In addition, three of the participants reported that they in fact owned padded Lycra cycling shorts, but stated that they would “never wear those” for commuting. Those same three interview respondents all reported wearing “yoga pants” or “workout capris” while commuting by bicycle. Although they used their bicycles for commuting, they did not see themselves in the role of “cyclist”, and preferred not to wear clothing that
identified them as such, even though that clothing may have been more appropriate from a functional standpoint.

Examining the interview data, there were many other instances where participants compromised on functional needs in order to ensure that their expressive needs were met. It became clear that the expressive needs were the dominant needs of this population, and garments that did not properly fulfill those needs would not be accepted. In order to meet the needs of the population, not only the categories of needs but the relative importance would have to be considered. When examining the design criteria in solutions matrix, each criterion was assigned to an FEA category. When determining solutions for criteria in conflict, this ranking of needs suggests the primacy of criteria in a higher-ranking category. For instance, office-appropriateness was in direct conflict with water resistance for the pants category, so it was determined the pants should not be water resistant.

This FEA ranking also came into play during the design process. The design method involved creating a rough concept of stylish, office-appropriate clothing and then modifying each piece with functional attributes. The groundwork for the design was laid by attempting to meet the psychological needs of the target consumer, the top needs of the hierarchy. The second-tier needs, the functional, were then added in. Some preliminary designs were not easily adaptable to functional needs and those designs were discarded. In this way, the
design process was modeled on the decision-making process of the research participants.

Aspects of Design

This study identified four main aspects of design that are critical to the functional design process: fit, fabric, design elements, and color. User needs can be categorized by these design aspects as well as the FEA categories. Each aspect is defined through the categories of expressive, aesthetic, and functional need.

Fit

Garment fit addresses the relation of fabric to the body, and is expressed through size, amount of ease, and garment style. Participants reported fit-related needs in all three FEA categories, but the expressive category was most prominent. In order to present a professional appearance, clothing appropriate to the office must fit properly. It cannot be too loose or ill-fitting, and it cannot be too tight. Too-tight clothing is also a concern related to modesty, another expressive need. Clothing that is too short or otherwise revealing while on a bicycle is also a problem. Flattering fit is an expressive need, but it is also an aesthetic need. Bunching, bulging, and other indications of poor fit are generally regarded as unattractive. Fashionable cut that reflects current trends or styles is also important, although for many female workers an overly “trendy” appearance may not be desirable. Many women declined to wear spandex bike shorts because they did
not like “the way they look”. Similarly, currently available rain pants were decried as “giant” and “dorky”.

Functional aspects of fit affect comfort, range of motion, and mechanical safety. A garment that is too tight can be uncomfortable for the wearer, and can also restrict range of motion. A garment that is too loose can become caught in the spokes or gears of the bicycle. Very often a single garment can have poor fit in multiple areas, such as a dress that is too tight in the waist, but has a full skirt that may get caught in bicycle spokes. A garment with the appropriate fit for cycling must take into account all functional and mechanical needs of the cyclist.

Fabric

Fabrication of commuter cycling apparel must take into consideration psychological needs such as appearance and hand feel. Participants expressed a preference for natural fabrics, both in terms of appearance and because they felt that synthetic fabrics retained too much odor. Lycra was maligned for being smelly, unflattering, and so inappropriate for the office that some women reported they would feel uncomfortable just walking through the door. Many participants also related that they occasionally wanted to wear garments too delicate for cycling, and they would pack these garments to change into. Concerns about mud, rain, and perspiration-inducing heat were other reasons women gave for carrying a change of clothes. For these women, lightweight and wrinkle-resistant fabric was important.
Functional requirements of fabrication must be balanced with psychological needs. Pant fabric must be durable to hold up to repetitive motion and friction in the seat area, but it also must maintain a professional appearance, and be lightweight enough to be stowed if necessary. In this regard a compromise between durability, hand, and appearance is necessary. Stretch fabric is helpful in providing a comfortable fit and adequate range of motion, but knit pants are not office-appropriate. Stretch wovens are a solution that addresses these needs. Thermal comfort and the related problems of breathability and weather protection must also be balanced with psychological needs. Wool provides excellent thermal comfort and breathability without retaining odor. The membranes and coatings used to achieve weather protection affect the hand, weight, and drape of a fabric to a degree that it would be very difficult to produce a pair of weather-resistant pants that was also office-appropriate. Jackets, on the other hand, can achieve a greater degree of weather resistance because they are not worn indoors throughout the day.

*Design Elements*

Design elements encompass both stylistic elements such as line, trim, and design details, and technical features relating to cycling performance. Stylistic elements are important in creating an aesthetically appealing garment with a fashionable appearance, and enhancing expressive communication aspects of the garment. Technical features must not impede the stylistic integrity of the garment;
if technical features are too obvious it may detract from the expressive value of the
garment as office apparel. Decorative elements such as ruffles and gathers allow
the wearer to express gender identification and participate in fashion trends.
Closures and fasteners must have a feminine, professional appearance as well as
being technically suitable for cycling. Zippers and Velcro are excellent for
technical purposes, but may not be appropriate for the office. Zippers on pockets
must be hidden by welts or invisible zipper construction.

Like stretch fabric, elastic panels and gathers on commuter cycling wear
can detract from a professional appearance, and must be integrated into the
garments in an unobtrusive way. This is also true of ventilation systems such as
underarm zippers and mesh panels, and integrated systems for securing pant legs.
Reflective material for visibility must be completely obscured from view during
the workday.

Color

Color serves many purposes in the design of these garments. First and
foremost the color must be appealing to the consumer. Fashion trends and
personal preference, as well as a sense of what colors are perceived as flattering on
a given complexion, contribute to this personal connection to color. Colors also
speak on an expressive level. Based on the results of the content analysis,
different palettes were associated with the “urban” and “commuter” markets, with
varying degrees of overlap to the colors deemed attractive and socially acceptable
by interview participants. Cycling wear marketed as urban cycling clothing commonly reflected a dark, earthy palette of browns, dark blues, and olive green. “Commuter” cycling wear was more likely to have a technical appearance and color palette; black was by far the most popular color, followed by high-visibility optical brights. The interview participants expressed a near-unanimous dislike of high-visibility brights, and mentioned grey, black, and navy blue as colors they would like. Nonetheless, bright colors are an extremely effective method of enhancing visibility while riding on busy streets. The use of slightly muted brights in tandem with complementary neutrals such as grey or khaki may help to enhance their acceptability to the target consumer. A garment that is easily modified to conceal the bright color, such as a removable or reversible cape, can also make the bright color more acceptable.

**Relation of This Model to Lamb and Kallal’s Model**

The model described above uses the three categories of consumer need as defined by Lamb and Kallal (1992), and also adopts their central concept that all three categories must be addressed to achieve consumer satisfaction. This researcher’s model identifies each category as either physical or psychological needs, and also takes into account the relative importance of those needs to a given consumer population. In this instance, expressive needs were the top-ranking need, followed by aesthetic needs and finally functional needs. This does not mean that functional needs are not important, but merely that any functional design
solution must conform to the expressive and aesthetic needs of the consumer. Furthermore, this ranking suggests a design process in which the initial design reflects the psychological needs of the consumer, and is then adapted to address functional needs as well.

The ranking of need categories is an approach that may be applied to other functional apparel design projects, but the relative importance of each need may change with the target consumer. A professional ski jumper, for instance, may have a need ranking of functional-expressive-aesthetic. The need for aerodynamics and protective gear are crucial to the performance of a ski jumper, while expressive needs of team affiliation are also an important element. Finally, an aesthetically attractive outfit is pleasing to athletes and spectators.

**Improvements to Prototype Design**

The results of the fit evaluation suggest that several improvements could be made to the prototype. Pattern adjustments to the gusset and thigh area would improve comfort, appearance, and mobility. Improved fit in the thigh would also help to eliminate gape in the front pockets. The elastic at the back waist panels also needs to be stronger to prevent the back rise from sagging down; this could be achieved either through the use of stronger elastic at the side insets, or by replacing the rib insets with fully elasticized panels. A system of keeping the pant leg secure, such as the tab and button detail that was removed from the original pant
design, would be useful to prevent the pant cuffs from slipping down while cycling.
CHAPTER VI
CONCLUSION

Although interest and participation in commuting by bicycle is on the rise in this country, there has been little research into the apparel needs of commuter cyclists, particularly women. These factors inspired the necessity of this study. The purpose of the study was to identify the functional, expressive, and aesthetic needs of female bicycle commuters, and to implement and evaluate designs for commuter cycling apparel based on those needs. User needs were assessed in the areas of fit, fabric, design elements, and color.

The data were collected through qualitative interviews both one-on-one and in focus groups, direct participation, and content analysis of available commuter cycling apparel. The design phases for this study were as follows: Analysis, Definition, Ideation and Selection, Implementation, and Evaluation.

The apparel needs model for female bicycle commuters illustrates the relationship between FEA categories of need and aspects of design such as fit and fabric. The conceptual framework developed as a result of the research provided a guideline for the design of women’s commuter cycling apparel. The three categories of user need as defined by Lamb and Kallal are subcategorized into psychological needs (aesthetic and expressive) and physical needs (functional). The FEA needs were also ranked in order of relative importance, based on results of qualitative interviews. Expressive need, more specifically the need for socially
appropriate office clothing, was found to be the most important concern of the interview participants. The need for socially appropriate office clothing was reflected in the need for appropriate, flattering fit, office-appropriate fabrics and colors, and minimizing the visibility of functional design features. Aesthetic needs were also a major concern of the interview participants, and included flattering and appealing fit, color, and decorative elements, fabric hand and texture, and fashionable appearance. Functional needs identified by the research included physical comfort, range of motion, weather protection, visibility, and mechanical safety.

**Significance**

The increase in interest and participation in bicycle commuting has increased the need for commuter cycling apparel. Although available commuter cycling apparel fulfills many of the functional needs of female bicycle commuters, expressive and aesthetic needs have not been adequately addressed. The research presented in this study contains several design solutions that take into account all categories of user need, as well as the primacy of expressive needs for this user group. The cumulative results of the research provide a framework for further development of commuter cycling apparel. Some of the designs included in this study may have
marketable features, including the elastic-paneled pants and trench with reversible rain cape.

Expressive needs were found to be the overriding concern of this user population. Currently available apparel did not meet both the physical and psychological needs of female bicycle commuters, who occupy a dual role as both cyclists and office workers. Taking into account the relative importance of various needs to the consumer population, and allowing this ranking to guide the design process results in a design that more accurately meets those needs. The application of this model and the system of ranked need categories has further application in the area of functional design and the assessment of user needs.

Limitations

The study was conducted with several acknowledged limitations. The sample selected to participate in the qualitative interviews is not representative of all female bicycle commuters, and the bicycle commuters of Portland, OR are not representative of all bicycle commuters. As a bicycle commuter herself, the researcher brings attendant bias to the study, as well as prior knowledge of cycling and apparel design concepts and techniques. The development of the prototype was limited by time, cost, access to resources, and the construction skill of the researcher.
Future Research

This study culminated with the production of one design at the prototype level and the evaluation of that prototype by one user. Further research should include the further development and testing of the prototype design, the production of prototypes based on other designs from this study, and evaluation of all designs or further prototype garments by multiple subjects or focus group.

Future research should also include a similar needs assessment using the results of the qualitative interviews from this study to perform quantitative research with a larger sample. The qualitative interviews laid the groundwork for establishing the user needs of this population, these needs can be further identified and refined through the use of quantitative research. A future study should also include quantitative evaluation of design concepts with a large sample. It is not convenient to perform a fit test or wear test using a large sample, however visual and verbal descriptions of design concepts may be evaluated in this manner. Quantitative research in this area would provide a further understanding of the population and their needs.

This study focused on the needs of female bicycle commuters. It would be valuable to note the gender differences between the user needs of women and men, particularly in regards to the differences in standards of appearance in the workplace perceived by women and men. Male bicycle commuters may have their own unique user needs that have not been met, which is also a possible topic of
research. Likewise, bicycle commuters in other cities may have different needs than Portlanders, another area of further research that could be explored.

As bicycle commuting becomes more popular, commuter cycling apparel will represent a growing share of the cycling apparel market. The model developed through this research can aid both researchers and designers in the creation of commuter cycling apparel for both men and women. The model and the system of hierarchical user need identification can also be applied to the study of other functional apparel and activewear.
BIBLIOGRAPHY


_Bicycle retailer and industry news, 15_ (16).

APPENDIX A: INTERVIEW QUESTIONS

This interview is being conducted for the purpose of learning more about what people wear when they ride their bicycle to work. For the purpose of this interview, questions about “biking” “bike riding” or “cycling” refer to commuting by bicycle, unless otherwise specified.

1. How often do you ride your bike to work?
2. Do you ride your bike for other transportation purposes such as errands or social engagements?
3. On average, how many miles do you ride every day?
4. Do you ride year round? If not, what conditions keep you from riding year round?
5. What kind of bicycle do you ride?
6. Describe what you would wear to bike to work on an average day.
7. Do you change your clothes between riding to work and working? If so, do you change all your clothes or just some of them? How much time do you spend changing?
8. Describe the apparel most people wear at your place of employment. Are there any brands or stores that you feel most represent the way most people dress in your workplace?
9. Do you think about the way you look when you are on your bike? If so, are there any specific aspects of your appearance that you think about or worry about the most?
10. What are some of the functional needs you take into consideration when choosing clothing to wear while biking?
11. Are there any specific features you particularly like about your cycling attire?
12. Are there any specific areas where you feel dissatisfied with the attire you have worn while cycling?
13. If there was one outfit from your current wardrobe you could wear every day to bike in, what would it be? Why do you like this outfit? Is there anything you would change about it?
14. If you could have any item of clothing to ride your bike in, what would it be and what would it be like?
15. Do you buy clothes with bicycling in mind? Where are you most likely to buy these clothes?
16. How would you characterize the market availability of clothes you would feel comfortable cycling in?
APPENDIX B

INFORMED CONSENT DOCUMENT

Project Title: Women’s Commuter Cycling Apparel: Needs Assessment and Functional Design
Principal Investigator: Dr. Kathy K. Mullet, Design and Human Environment
Co-Investigator(s): Lauren Steinhardt, Design and Human Environment

WHAT IS THE PURPOSE OF THIS STUDY?

You are being invited to take part in a research study designed to help us design better clothing for women who ride their bikes to work. We want to know how women feel about the clothes they wear to ride their bikes in and work in. We are hoping that this information will help us to better understand the clothing needs of women who bike to work. This study will be used as part of a Master’s thesis. We are studying this because we would like to design clothing that women can wear to ride their bike in and also wear throughout the day, including at the workplace.

WHAT IS THE PURPOSE OF THIS FORM?

This consent form gives you the information you will need to help you decide whether to be in the study or not. Please read the form carefully. You may ask any questions about the research, the possible risks and benefits, your rights as a volunteer, and anything else that is not clear. When all of your questions have been answered, you can decide if you want to be in this study or not.

WHY AM I BEING INVITED TO TAKE PART IN THIS STUDY?

You are being invited to take part in this study because you are a woman who rides her bike to work in an urban environment with such features as bike lanes and roads shared with motor vehicles. Participants in this study are women who usually wear the same clothes to work and to ride their bikes, and work in an environment where attention to dress is expected.

WHAT WILL HAPPEN DURING THIS STUDY AND HOW LONG WILL IT TAKE?

If you agree to take part in this study, your involvement will last for one hour. You will participate in an interview about your bicycling habits and the clothes you wear while biking. The interview will be recorded with an audio recording device. The interview will take place at a location that is convenient and comfortable to you that may include your home, a public space, or other location.
WHAT ARE THE RISKS OF THIS STUDY?

The possible risks and/or discomforts associated with the procedures described in this study are minimal. No sensitive questions will be asked in the interview.

WHAT ARE THE BENEFITS OF THIS STUDY?

You will not benefit directly from being in this study. However, we hope that, in the future, other people might benefit from this study because it will help to improve the appearance and functionality of commuter cycling apparel.

WILL I BE PAID FOR PARTICIPATING?

You will not be paid for participating in this research study.

WHO WILL SEE THE INFORMATION I GIVE?

The information you provide during this research study will be kept confidential to the extent permitted by law. To help protect your confidentiality, we will keep your personal information, your interview recordings, and interview transcripts in a secure location. All digital files will be password protected. We will also identify participants only by their initials on interview transcripts and file names.

One aspect of this study involves making audio recordings of you. The recordings will be transcribed and the information will be used to help design better cycling attire. Only the principal investigator and the co-investigator will have access to the recordings and transcripts, which will be stored as password-protected digital files.

If the results of this project are published your identity will not be made public.

DO I HAVE A CHOICE TO BE IN THE STUDY?

If you decide to take part in the study, it should be because you really want to volunteer. You will not lose any benefits or rights you would normally have if you choose not to volunteer. You can stop at any time during the study and still keep the benefits and rights you had before volunteering.

You will not be treated differently if you decide to stop taking part in the study. You are free to skip any interview questions you would prefer not to answer. If you choose to withdraw from this project before it ends, the researchers may keep information collected about you and this information may be included in study reports.

WHAT IF I HAVE QUESTIONS?

If you have any questions about this research project, please contact:

Dr. Kathy K. Mullet, (541) 737-3818, Kathy.Mullet@oregonstate.edu
Lauren Steinhardt, (503) 805-5693, steinhal@onid.orst.edu
If you have questions about your rights as a participant, please contact the Oregon State University Institutional Review Board (IRB) Human Protections Administrator, at (541) 737-4933 or by email at IRB@oregonstate.edu.

Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Participant's Name (printed):

__________________________________________

(Signature of Participant) (Date)
Project Title: Women’s Commuter Cycling Apparel: Needs Assessment and Functional Design
Principal Investigator: Kathy K. Mullet, Design and Human Environment
Co-Investigator(s): Lauren Steinhardt, Design and Human Environment

WHAT IS THE PURPOSE OF THIS STUDY?
You are being invited to take part in a research study designed to help us design better clothing for women who ride their bikes to work. We want to know how women feel about the clothes they wear to ride their bikes in and work in. We are hoping that this information will help us to better understand the clothing needs of women who bike to work. This study will be used as part of a Master’s thesis. We are studying this because we would like to design clothing that women can wear to ride their bike in and also wear throughout the day, including at the workplace.

WHAT IS THE PURPOSE OF THIS FORM?
This consent form gives you the information you will need to help you decide whether to be in the study or not. Please read the form carefully. You may ask any questions about the research, the possible risks and benefits, your rights as a volunteer, and anything else that is not clear. When all of your questions have been answered, you can decide if you want to be in this study or not.

WHY AM I BEING INVITED TO TAKE PART IN THIS STUDY?
You are being invited to take part in this study because you are a woman who rides her bike to work less than five miles each way, in an urban environment. Participants in this study are women who usually wear the same clothes to work and to ride their bike, and work in an environment where attention to dress is expected.

WHAT WILL HAPPEN DURING THIS STUDY AND HOW LONG WILL IT TAKE?
If you agree to take part in this study, your involvement will last for approximately two hours. There will be two visits, with a period of three to six months between the visits. At the first visit, your body measurements will be recorded. This will take approximately thirty minutes. The first visit will take place at your home or another location that is comfortable and convenient to you.

The second visit will take place three to six months after the first visit. During this visit, you will be asked to wear and evaluate a prototype garment. You will be asked to wear the garment while sitting, standing, and walking, and while participating in a short bicycle ride. You will be asked questions about the fit, performance, and appearance of the garment. The
evaluation will take place at your home or a location that is comfortable and convenient to you. The bicycle ride will take place on low-traffic streets in a location convenient to the evaluation location.

**WHAT ARE THE RISKS OF THIS STUDY?**

The possible risks and/or discomforts associated with the procedures described in this study include:

- Physical injury resulting from bicycle ride. You will be required to wear a helmet and any appropriate safety equipment during the bicycle ride. In the event of research related injury, compensation for medical treatment is not provided by Oregon State University or the researchers.
- Your garment evaluation experience may be uncomfortable if the garment fails to perform as expected.
- You personal information, including body measurements, video recordings, photographs, and audio recordings will be collected. This data will not be labeled with your name or personal information.

**WHAT ARE THE BENEFITS OF THIS STUDY?**

You will not benefit directly from being in this study. However, we hope that, in the future, other people might benefit from this study because it will help to improve the appearance and functionality of commuter cycling apparel.

**WILL I BE PAID FOR PARTICIPATING?**

You will not be paid for being in this research study.

**WHO WILL SEE THE INFORMATION I GIVE?**

The information you provide during this research study will be kept confidential to the extent permitted by law. To help protect your confidentiality, we will keep your personal information, your audio and video recordings, your photographs and interview transcripts in a secure location. All digital files will be password protected. We will also identify participants only by their initials on transcripts and file names.

One aspect of this study involves taking photographs, video and audio recordings of you. The recordings will be used to help the researcher evaluate the prototype. Only the principal investigator and the co-investigator will have access to the recordings and transcripts, which will be stored as password-protected digital files. Photographs of you may appear in the study, however, your identity will be obscured.

If the results of this project are published, your identity will not be made public.

**DO I HAVE A CHOICE TO BE IN THE STUDY?**
If you decide to take part in the study, it should be because you really want to volunteer. You will not lose any benefits or rights you would normally have if you choose not to volunteer. You can stop at any time during the study and still keep the benefits and rights you had before volunteering. You will not be treated differently if you decide to stop taking part in the study. If you choose to withdraw from this project before it ends, the researchers may keep information collected about you and this information may be included in study reports.

WHAT IF I HAVE QUESTIONS?

If you have any questions about this research project, please contact:
Dr. Kathy K. Mullet, (541) 737-3818, Kathy.Mullet@oregonstate.edu
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If you have questions about your rights as a participant, please contact the Oregon State University Institutional Review Board (IRB) Human Protections Administrator, at (541) 737-4933 or by email at IRB@oregonstate.edu.

Your signature indicates that this research study has been explained to you, that your questions have been answered, and that you agree to take part in this study. You will receive a copy of this form.

Participant's Name (printed):
__________________________________________________________

________________________________________
(Signature of Participant)  (Date)
APPENDIX C

DETAIL SKETCHES AND GARMENT SPECIFICATIONS FOR PROTOTYPE

Table 6. Prototype Specifications

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>WAIST - relaxed</td>
<td>16</td>
</tr>
<tr>
<td>FLY OPENING - top of WB to bottom of &quot;J&quot; stitch</td>
<td>6</td>
</tr>
<tr>
<td>HIP WIDTH - 6&quot; down from top of waistband</td>
<td>20 1/2</td>
</tr>
<tr>
<td>THIGH - 1&quot; down from rise seam</td>
<td>13</td>
</tr>
<tr>
<td>HIGH KNEE - 9 1/2&quot; down from rise seam</td>
<td>8</td>
</tr>
<tr>
<td>LEG OPENING</td>
<td>8 3/8</td>
</tr>
<tr>
<td>FRONT RISE LENGTH - top of WB to gusset</td>
<td>7</td>
</tr>
<tr>
<td>BACK RISE LENGTH - top of WB to gusset</td>
<td>13</td>
</tr>
<tr>
<td>INSEAM - rise seam to bottom hem</td>
<td>31</td>
</tr>
<tr>
<td>GUSSET WIDTH</td>
<td>10</td>
</tr>
<tr>
<td>GUSSET LENGTH</td>
<td>4</td>
</tr>
</tbody>
</table>

Figure 15. Prototype Gusset Detail
Figure 16. Prototype Side Detail