ABSTRACT

DUTTON, KATHRYN CHRISTINE. Consumer Acceptance of Nonwoven Fabrics for Apparel and Accessory End-Uses. (Under the direction of Dr. Cynthia L. Istook.)

Technological advancements have made substantial strides in the development of nonwoven fabrics. New generations of nonwoven fabrics are more durable, have better drape, are stretchable, and overall have a better hand than past generations of nonwoven fabrics. With these advancements come new product development opportunities. One possible opportunity is expansion into the apparel and accessories market, not as a support fabric, but as the shell (visible, outside) fabric.

The purpose of this study was to determine the consumer's acceptance of nonwoven fabrics for apparel and accessory end-uses through the use of subjective fabric hand evaluation. A review of the literature guided the development of an appropriate subjective fabric hand evaluation method to study the average consumer's acceptance of traditional woven fabrics versus spunlaced (spunbond and hydroentangled) nonwoven fabrics. In the development of this study, Bishop's (1996) six elements were considered, in addition to, three key publications: Civille and Dus (1990); Cardello, Witherhalter, and Schutz (2003); and the AATCC Evaluation Procedure 5: Guidelines for the Subjective Evaluation of Fabric Hand (2006).

Prior to conducting the experiment, the fabrics were chosen and prepared for testing. Three woven fabrics were chosen based on their common and wide spread use in apparel products. Three spunlaced nonwoven fabrics were chosen, one because it was a commercial product and the other two because they represent the most recent generation of nonwoven fabrics. The experiment was comprised of two parts, a rating and a ranking section, which

were conducted simultaneously. In Part I of the experiment, the subjects were asked to rate each of the six fabrics for comfort and five different attributes – cool/warm, smooth/rough, thin/thick, flexible/stiff, and tight/stretchy. The samples were presented to the subjects, one at time, in random order, and kept from their view. In Part II of the experiment, the subjects conducted a simple ranking procedure. They were shown four images, one a time, in random order. The four images included a short sleeve button-down collared shirt, a long sleeve button-down collared shirt, a pair of pleated shorts, and a bag. The six fabric samples were placed in front of the subjects in random order, on a non-textured, non-metal table. Again, the fabrics were kept from their view. The subjects were asked to rank the fabrics in order from most desirable (best) to least desirable (worst) for the image. Through the use of the statistical software JMP, nonparametric statistics were conducted to analyze the data and respond to the research questions.

The sample consisted of 197 male and female subjects primarily from the central North Carolina region. Data supported the following conclusions regarding the rating and ranking of woven and nonwoven fabrics, and the influence of gender and age on those ratings and rankings. Comfort depended more on the fabric and not necessarily whether the fabric was a woven or nonwoven. Overall, woven fabrics were preferred over nonwoven fabrics for apparel products. However, nonwovens were most preferred for a tote bag along with a woven fabric. The nonwoven fabric similarities and differences varied among attributes. Overall, gender did not influence the fabric rating or ranking responses. It appears age affected only the attributes that involved the surface of the fabrics. If the fabric had a texture, the older the subject, the smoother they perceived the fabric. Age influenced the rankings for shorts and a bag, but not for the other garments. As is the case with consumer studies, other

variables, including individual biases, contributed to the fabric rating and ranking responses. However, significant relationships indicate there is potential for new product opportunities for the nonwoven fabrics.

Consumer Acceptance of Nonwoven Fabrics for Apparel and Accessory End-Uses

by
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DEDICATION

To my wonderful family,

Mom, Dad, and Rho,

for all of their loving support and understanding.

To Ben,

who may not have known what he was getting into three years ago,

but was there for support and encouragement

through the good, the bad, and the ugly.

BIOGRAPHY

Kathryn Christine Dutton was born on February 13, 1980 in Camp Lejeune, North Carolina. Her parents are Rhoades and Christine Dutton and she has a younger brother, Rhoades Dutton, Junior. Kathryn grew up in Phoenixville, Pennsylvania and later moved with her family to Wilmington, North Carolina, where she attended John T. Hoggard High School. Kathryn graduated from high school in 1998 and went on to study at the College of Textiles at North Carolina State University. She graduated from NC State with a Bachelor of Science degree in Textile and Apparel, Technology and Management with a concentration in Apparel Management in December 2002. A year and a half later, after working in retail management, she returned to North Carolina State University to pursue a Master of Science degree in Textile Technology and Management. Upon receiving her Master's degree in August 2006, Kathryn went on to pursue a doctorate in Textile Technology Management. She completed the requirements for her degree in the summer of 2009 and is pursuing a career in her field.

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an electronic version of my survey. Without him, I would still be sorting through surveys and entering data into excel.

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CHAPTER I: INTRODUCTION

The consumer decision-making process is, in part, driven by the attraction of the tactile properties – how good or comfortable a fabric feels. This process is perhaps more prominent for apparel product purchases than other textile products. Marketers are attuned to the consumer desire for "feel good" fabrics and have begun to use the comfort and touch sensations as a marketing strategy (Philippe et al., 2003). Cotton Incorporated, for example, has recently promoted the use of, or purchase of, cotton apparel by advertising the softness and comfort of the fabric's feel through television and magazine media which can be seen on the company's web page (Cotton Incorporated, 2008). A firm's knowledge of consumer preference for fabric hand attributes is a valuable resource in the development and ultimately the success of the end product.

There are two nonwoven markets, disposables and durables. Nonwoven fabrics developed for the apparel market are durable nonwovens. The durable nonwoven market comprises 35%-45% of the overall nonwoven market. The annual average growth rate for the apparel market was 9% from 1997-2007. There will still be growth in the apparel market; however, the annual average growth rate is projected to decline to approximately 6.5% for the ten year projection period 2007-2012. However, there is opportunity for this market to expand with the continued development of bicomponent spunlaced nonwovens. Bicomponent spunlaid webs can be bonded via hydroentangling; also referred to as spunlaced fabrics. This is a developing technology with no available data prior to 1997 (Garland, 2009). It is this fabric technology, however, that has qualities which lend

themselves to apparel applications. Though the understanding of consumer desires, this market could have the potential to expand.

Consumer testing can be used to determine consumer acceptance or preference of a product. Subjective evaluation of fabric hand is used to predict consumer acceptance of a textile product. Next to cost and appearance, hand is one of the first characteristics a consumer encounters. Instinctively, a consumer will use fabric hand to determine quality and suitability for end-use. Consumer opinion is a valuable resource for the design and development of fabrics. Understanding and incorporating consumer preferences can help designers tailor fabrics to meet these preferences and ultimately produce a successful product.

Purpose of this Study

The purpose of this study was to determine the consumer's acceptance of nonwoven fabrics for apparel and accessory end-uses through the use of subjective fabric hand evaluation. A review of the literature guided the development of an appropriate subjective fabric hand evaluation method to study the average consumer's acceptance of traditional woven fabrics versus spunlaced (spunbond and hydroentangled) nonwoven fabrics. The research questions included:

Research Question 1: How do nonwoven fabrics compare to woven fabrics?

1a. How do nonwoven fabrics rate in comparison to woven fabrics for comfort and each attribute?

1b. How do nonwoven fabrics rank in comparison to woven fabrics for general apparel and accessory products?

Research Question 2: How do nonwoven fabrics compare to one another?

2a. How do nonwoven fabrics rate among one another for comfort and each attribute?

2b. How do nonwoven fabrics rank among one another for general apparel and accessory products?

Research Question 3: Does gender and age affect consumer acceptance of nonwoven fabrics?

3a. Does gender influence fabric rating and ranking responses?

3b. Does age influence fabric rating and ranking responses?

Significance of this Study

As traditional nonwoven markets, such as medical and industrial products, reach saturation and nonwoven technologies continue to advance, the new generations of nonwovens may lend themselves to new uses in the apparel and accessory markets. While the industry feels there are opportunities for the new fabrics, there is no information concerning the consumers' opinions and their willingness to accept nonwoven fabrics in place of the knits and wovens that have been used traditionally. Consumer behavior and consumer decision-processes determine whether a consumer will accept or reject products. Data obtained through the use of subjective fabric hand evaluation can determine the consumer's acceptance of a fabric. This information can provide valuable feedback for the design and development of nonwoven fabrics for apparel and accessory end-uses. This information can

also be used to market nonwoven fabrics by understanding consumer interest in sensory attributes and advertising the product based on the desirable attributes.

Scope of this Study

This study focused on new generation nonwoven fabrics developed from the latest technologies; more specifically, spunlaid hydroentangled nonwoven fabrics. This technology creates a fabric suitable for apparel and accessory end-uses. However, even within the spunlaid hydroentangled category, numerous fabric designs are available, due to machine variables, fiber content, textures, and finishes. The scope of this study included three specific nonwoven fabrics: 1) a spunlaid islands-in-the-sea hydroentangled polyester/nylon blend nonwoven, 2) a spunlaid segmented pie hydroentangled polyester/nylon blend nonwoven, and 3) a textured spunbonded bicomponent hydroentangled elastomer/polyester blend nonwoven. In addition, six fabric attributes were included for the fabric evaluation. These were determined through a literature review to be most likely linked to determining consumer acceptance of fabrics. This study focused on male and female subjects, 18 and older, primarily from the central North Carolina region.

Limitations of this Study

The sampling method was a convenience sample and limited to the central region of North Carolina.

CHAPTER II: LITERATURE REVIEW

Nonwovens and Apparel

While nonwovens have been used in the protective and medical clothing arenas, the market is reaching its saturation point. In North America, feminine care and baby care products each have a market penetration of approximately 90%, and medical fabrics are at approximately 80% penetration (Pourdeyhimi, 2004). Nonwoven products for apparel end-use, however, are only at approximately 10% market penetration, making the apparel market a viable area for expansion of nonwoven fabrics.

In the past, nonwovens have been used in the fashion market mainly as insulation and interlining, but not as the dominant, or shell, fabric. "The dream has always been that the process could be expanded to bring nonwovens into the apparel shell market" (Maycumber, 2000, p. 56). In recent years, advancing technologies have provided opportunities for significant progress in nonwoven fabrics, such as durability, hand, drape, texture, and stretch; therefore, lending themselves to be more acceptable for apparel applications (Pourdeyhimi, 2004; Walzer, 2001). This move towards apparel, however, should not be seen as a threat to the traditional markets because nonwoven apparel is not expected to replace traditional garments, but instead to be an additional and alternative option within the marketplace (Pourdeyhimi, 2004). Still, nonwoven companies will have to increase consumers' perception of the quality of nonwovens (Tilin, 2001; Jarvis, 1997). Some companies have looked at activewear and sportswear as markets for the newer nonwoven fabrics due to the fabrics characteristics, such as light weight, UV protection, moisture management, insulation,

and windproof. However, what the industry needs is garment development so that the manufacturers can work on the comfort features of the fabrics (Walzer, 2001).

Over 30 years ago, Bloomingdale's sold disposable nonwoven bathing suits, but, at the time, technologies were not there and the product failed. In the past decade, there has been a move to promote the development of nonwovens for the apparel market. Several companies involved in this movement include DuPont, Freudenberg, and Polymer Group, Inc. (Maycumber, 2000). DuPont is the source of their own raw materials and has a history of marketing to fashion. The company has developed a fabric known as Nova, which contains spandex, and provides special characteristics – stretch and recovery. The fabric is made by a flashspun process and contains polyethylene fibers (Maycumber, 2000). Several companies have used DuPont nonwoven fabrics to produce garments. Design Development Concepts (DDC) based in New York City designed a line using Tyvek®, a fabric developed in 1955, but found it unacceptable due to low stress tolerance and no stretch or breathability (Harkin, 2002). Neotis, a start-up company with DuPont, modified Tyvek® to be more breathable and pliable by stitching in Lycra®, which improved the fabric for apparel applications. At the time of publication, Neotis had 24 fabrics and customers which included Nike, Levi's, and Tommy Hilfiger (Tilin, 2001). Freudenberg, the world's largest producer of nonwovens, currently produce a fabric known as Evolon®, a bicomponent fabric produced by spunbond and hydroentangling technologies. The fabric can be manufactured to have good drape and the microfibers give the fabric a soft hand, lending itself as an apparel fabric. Another company exploring nonwovens for apparel is Polymer Group, Inc. The company developed Miratec®, produced with staple fibers, bonded via hydroentangling, and given a three-

dimensional design using laserography technology which mimics denim and other twill fabrics (Maycumber, 2000).

In 2003, Australian Wool Innovation (AWI) and Macquarie Textiles began a project to develop nonwoven wool fabrics using the needlepunch process. The products are of interest for the defense and protective clothing arenas. To date, a nonwoven, wool-lined vest by Driza-Bone® (an Australian icon comparable to L.L. Bean) and a disposable blanket have been commercialized (Dockery, 2003). One nonwoven has proven successful in the apparel market; Ultrasuede® from Japan which was introduced to the market in the 1970s. The fabric, to this day, is still very expensive, which keeps the product in the high-end retail sector.

Nonwoven fabrics can be produced at higher speeds and greater widths in comparison to traditional woven and knit fabrics. Due to fabric characteristics, nonwoven fabrics do not fray, and therefore, require less sewing. The fabrics also do not have a grain which reduces fabric waste in the marker making and cutting process. Researchers and industry members feel the technology of nonwoven fabrics will soon be ready for apparel, but wonder if the consumers will be ready for nonwoven apparel.

Consumer Behavior

Consumer behavior is an immense and complex subject that evolved from consumer science and human behavior in the mid- to late 1960s (Ambaye, 2005; Block & Roering, 1976; Nicosia, 1966; Walters & Paul, 1970). It is an applied science that includes multiple disciplines such as economics, psychology, sociology, anthropology, and statistics

(Blackwell, Miniard & Engel, 2006; Robertson & Kassarjian, 1991). Consumer behavior is the study of how a consumer makes a decision and not just why a consumer makes a decision (Blackwell et. al., 2006). Research prior to the mid-1960s focused on the *why*, known as buying behavior (Block & Roering, 1976; Erasmus et. al., 2001), but as consumer knowledge increased, researchers began to understand there was more to the decision than just the act of purchase. With the development of consumer decision models, research focused on the *how* of consumer behavior, known as consumption behavior, which includes the process leading up to purchasing, purchasing, consuming, and disposing of a product or service (Ambaye, 2005; Block & Roering, 1976; Erasmus et. al., 2001; Walters & Paul, 1970). Consumer behavior knowledge is used by firms and marketers to increase profits, through use of consumer decision models, to better understand their target consumers. Knowledge gained from these consumer studies is used to influence target consumers through effective development of new or improved products and marketing mix strategies (Ambaye, 2005; Blackwell et. al., 2006; Howard, 1989; Howard & Sheth, 1969; Schiffman & Kanuk, 1978; Walters & Paul, 1970).

Comprehensive Consumer Decision-Making Process Models

The consumer decision process is a sub-category of consumer behavior (Ambaye, 2005) and is the process consumers negotiate when making a purchase decision (Cooper & Argyris, 1998). Consumer decision-making process models should simplify and organize knowledge to explain consumer behavior and show the relationships and interactions between variables such as, the consumer, his environment, and the firm (Block & Roering, 1976; Lewis & Littler, 1999; Walters & Paul, 1970). Models are a tool, meant to be used as a

guide, or framework, by students and researchers to study consumer behavior and assist firms and marketers in developing more effective strategies to persuade their target consumers (Blackwell et. al., 2006; Block & Roering, 1976; Engel & Blackwell, 1982; Erasmus et. al., 2001; Lewis & Littler, 1999; Walters & Paul, 1970). These models are not meant to be interpreted as defining the "real world" (Ambaye, 2005; Engel & Blackwell, 1982; Walters & Paul, 1970). The following consumer decision-making process models have made significant contributions to the field: Nicosia (1966); Engel, Kollat, and Blackwell (1968); Howard and Sheth (1969); Schiffman and Kanuk (1978); and Blackwell, Miniard, and Engel (2006).

Consumer decision-making models contain five basic stages: problem recognition, information search, information evaluation, purchase, and post-purchase evaluation (Ambaye, 2005; Schiffman & Kanuk, 1994). Table 1 shows an overview of the well known comprehensive consumer decision-making models. Each model covers the five basic decision-making stages, and therefore, appears quite similar. However, some models focus more heavily on certain stages than others. For instance, the latest version of the Blackwell CDP model has several stages within the post-purchase evaluation stage including divestment, not discussed in other models. While it cannot be depicted in the table, note the consumer decision process stages may overlap, feedback to other stages, and/or may skip stages, all depending on the type of decision and the consumer. For example, a consumer may recognize a problem and move through to the purchase stage, but once at the store, he may be influenced by in-store promotion. At this time, the consumer may loop back to information evaluation to reconsider evaluative criteria before a final purchase.

There have not been significant changes since the development of the original 1960s models. The change is seen in the knowledge gained on consumers through the use of these decision-making process models and by the way in which researchers and firms are collecting that knowledge. For example, the Internet has provided a new avenue in which to collect data, advertise, and sell.

Table 1. *Comprehensive Consumer Decision-Making Process Models*

<table>
<tr><th>Model</th><th>Problem Recognition</th><th>Information Search</th><th>Information Evaluation</th><th>Purchase</th><th colspan="4">Post-Purchase Evaluation</th></tr>
<tr><td>Nicosia 1966</td><td>Field One</td><td colspan="2">Field Two</td><td>Field Three</td><td colspan="4">Field Four</td></tr>
<tr><td rowspan="2">EKB 1968</td><td colspan="2">Input & CCU</td><td rowspan="2">Evaluation of Alternatives</td><td rowspan="2">Purchase Process</td><td colspan="3">OUTCOMES</td></tr>
<tr><td>Problem Recognition</td><td>External Search for Alternatives</td><td>Postpurchase Evaluation</td><td colspan="2">Further Behavior</td></tr>
<tr><td rowspan="2">Howard & Sheth 1969</td><td rowspan="2">Inputs</td><td colspan="2">HYPOTHETICAL CONSTRUCTS</td><td colspan="5" rowspan="2">Outputs</td></tr>
<tr><td>Perceptual Subsystems</td><td>Learning Subsystems</td></tr>
<tr><td rowspan="3">Schiffman & Kanuk 1978</td><td colspan="2">Input</td><td>-</td><td colspan="5" rowspan="2">OUTPUT</td></tr>
<tr><td colspan="3">PROCESS</td></tr>
<tr><td>Need Recognition</td><td>Prepurchase Search</td><td>Evaluation of Alternative</td><td>Purchase</td><td colspan="4">Postpurchase Evaluation</td></tr>
<tr><td>CDP 2006</td><td>Need Recognition</td><td>Search</td><td>Pre-purchase Evaluation of Alternatives</td><td>Purchase</td><td>Consumption</td><td>Post-Consumption Evaluation</td><td colspan="2">Divestment</td></tr>
</table>

Note. Italic stages denote that they are a subfield of the capitalized stage. Output and outcome are the same stage, just different terminology used by the authors. The CDP 2006 model is the latest version of the EKB 1968 model.

Blackwell, Miniard, & Engel: 2006

The most recent and commonly used decision-making process model is the Blackwell, Miniard, and Engel's Consumer Decision Process (CDP) model, which originated in 1968, by authors Engel, Kollat, and Blackwell. This model was a roadmap to understanding consumer behavior and consumer decisions. By the 1986, fifth edition of *Consumer Behavior,* Kollet had departed the team and Miniard joined. These authors revised the EKB model to the EBM model which consisted of seven decision-making stages still reflected in today's model. The CDP model is general enough to be applied to many industries, to study the specific variables of the model, and to understand how those variables affect a specific industry, product, or consumer. Blackwell et. al. continued research on consumer behavior offers the most "state of the art" model to be used as a tool for gathering further knowledge to understand the future of the consumers' decision process.

CDP Model Overview & Stages. The CDP is a seven stage decision-making model showing variables from internal and external forces that affect and interact with the seven core stages. The seven stages include: need recognition, search, pre-purchase evaluation of alternatives, purchase, consumption, post-consumption evaluation, and divestment. The internal and external forces include three categories: individual differences, environmental influences, and psychological processes. The individual differences include five major categories: demographics; psychographics; values and personality; consumer resources; motivation; knowledge; and attitudes. The environmental influences include culture, social class, family, personal influence, and situation behaviors. The last category, psychological processing consists of three basic processes: information processing; learning; and attitude

and behavior change. There are three types of decision processes that can influence the CDP: initial purchases, repeat purchases, and impulse buying. Each of these processes involves different levels of time, search, and perceived risk. Other factors shown to affect the CDP are degree of involvement, perceptions of difference among alternatives, time availability, and the consumer's mood state (Blackwell et. al., 2006). Table 2, developed by the author, with information gathered from the tenth edition of *Consumer Behavior* by Blackwell et. al., defines the seven stages of the CDP model, the components of each stage, and how companies can benefit from understanding each stage. The model can be viewed on page 85, in the tenth edition, of *Consumer Behavior* by Blackwell, Miniard, and Engel.

CDP Advantages & Disadvantages. The CDP model is the most "state of the art" model due to the ongoing research by Blackwell et. al. and has benefited academia, market strategists, and firms. The model shows the consumers' entire decision process activities including before, during, and after the purchase of a product (Blackwell et. al., 2006). However, the model is a general model, as are the others and meant to be used as a tool and not to define the "real world".

Model Uses. Firms and researchers can use the CDP model to identify relationships between stages and variables and how these relationships affect the consumer decision process; identify additional research topics; and develop and implement effective marketing mix strategies. A better marketing mix strategy can lead to proper decisions on product line mix, SKUs, display techniques, proper pricing of products for the chosen consumer market, and knowing where to promote the product to the target market. In previous years, retailers left the first three stages to the manufactures that developed new products. Now retailers are

focusing on the first three stages of the CDP model and manufactures are assisting with in-store sales by training salespeople, and providing signage and fixtures. If the seven stages are understood, marketers will have a better understanding as to why consumers are buying, or not buying, products and how to get them to purchase, or continue to purchase, their products (Blackwell et. at., 2006).

Table 2. *Seven Stages of CDP: Components and Company Uses*

Stage	Definition	Components	Company Uses
Need Recognition	• Recognition occurs when the consumer perceives the ideal, or desired, state is different from the actual state. • Also known as problem recognition.	A firm activates a need by: • Change consumer's desired state • Change how consumers perceives their actual state • Remind consumers of a need Demands stimulated by firms activating needs: • Primary demand • Selective demand	Use of advertising to: • Change desired state • Change perception of actual state • Remind consumers of product benefits Design or develop products to remind consumers of a need. Changes in consumer trends can identify changes in needs →creates opportunity for new products.
Search	• Consumers search to find a solution to satisfy their need or problem. • Occurs once a need or problem is perceived. • Consumers develop the external search set and evaluative criteria.	Reasons consumers may not act on a need: • Feel they do not need to act • May not have the means to act Time spent on search: • Seconds to months • Depends on multiple variables • Perceived risk Types of search: • Internal search • External search	Provide stimuli and information through: • Advertisements & promotions • Salespeople • Point-of-Sales (in-store) media • Internet Firms use brand equity and brand image to get their message to the consumer and have the consumer retain the message.
Pre-Purchase Evaluation of Alternatives	• The consumer begins to evaluate all the alternative options they discovered during search. • Search and pre-purchase intermix. • Consumers develop an evoked set and evaluative criteria to choose among the evoked set. • Consumers may use cognitive or emotional assessment during the evaluation process.	Ways to build criteria: • Pre-existing criteria from memory • New criteria gained from search Types of evaluation techniques: • Categorization or piecemeal • Compensatory or noncompensatory Alternatives evaluated by two attributes: • Salient • Determinant	Be a part of the evoked set. • Shows brand loyalty • Identifies competitors • Identifies need for improvement (if not a part of the evoked set) Use promotions and coupons to be considered in the evoked set.

Table 2. *Seven Stages of CDP: Components and Company Uses (cont.)*

Stage	Definition	Components	Company Uses
Purchase	• The decision or act to purchase. • Based on pre-purchase evaluation.	Purchasing phases: • Choice of retailer or retail outlet • Accept or not accept influences by in-store choices	Companies micromanage all details of the consumers' shopping experience through in-store choices: • Salespeople • Promotions • Signage • Displays
Consumption	• Occurs when the consumer has made the purchase and takes possession of the product/service AND the product is used.	Consumption can be: • Immediate • Delayed	Understanding consumption can create opportunities for: • Product improvements • Packaging improvements • New product development
Post-Consumption Evaluation	• The stage where the consumer experiences satisfaction or dissatisfaction. • Evaluation is stored in memory for future purchases. • The consumer may also experience post-purchase regret, or cognitive dissonance.	• Consumer refers back to pre-purchase evaluation stage and uses evaluative criteria to assess satisfaction or dissatisfaction. • Consumer may experience post-purchase regret.	• Evaluation criteria used in brand extensions: satisfaction extends to perceived satisfaction of the brand in other categories • Satisfied consumer: created brand loyalty and difficult for competitor to move in • Dissatisfied consumer: competitors present consumer with a product that promises something better • Post-purchase regret: companies acknowledge regret by providing hang tags, toll free numbers, and follow up sales calls to confirm consumers' decision
Divestment	• How the consumer disposes of the product.	Disposes through: • Disposal • Recycling • Remarketing	Disposal & Recycling: play to consumers' environmental concerns Remarketing: eBay

Note. Information adapted into table from *Consumer Behavior* by R. D. Blackwell, P. W. Miniard, and J. F. Engel, 2006, 10th ed., Mason, OH: Thomson South-Western.

Use of the CDP Model in Apparel

Researchers have studied various stages of the model, key variables that influence apparel decisions, and evaluation criteria used when evaluating apparel. Several studies (Blackwell and Hilliker, 1978; Chae, Black & Heitmeyer, 2006; Hart and Dewsnap, 2000) have looked at various stages of the Blackwell et. al. CDP model. Blackwell and Hilliker

(1978) conducted exploratory research, using a former version of the CDP, to identify key variables female consumers used when making apparel purchase decisions. They specifically looked at the pre-purchase and purchase stages. The study led to further questions that authors felt should be looked at quantitatively. Hart and Dewsnap (2000) used the model as a framework to better understand a females' decision process when considering the high involvement decision process of a bra purchase. The study looked at all stages of the model and found that situational factors spark a need which leads to a critical and extensive search due to the high involvement of the decision. Consumers in this study evaluated a set of bras for comfort and fit and evaluated product attributes specific to a bra. Chae et. al. (2006) studied female tennis clothing and found that while it was not an overall high involvement decision-making process, woman who saw themselves as fashionable created a high involvement decision-making process.

Several studies (Cassill & Drake, 1987; Forney, Park, & Brandon, 2005; Hsu & Burns, 2002; Lee & Burns, 1993) used the CDP model as a framework to better understand stage three, pre-purchase evaluative criteria. Cassill and Drake (1987) found that female consumers' employment status influenced lifestyle and the evaluation criteria used in making an apparel purchase. Other studies used Cassill and Drake's research, and apparel evaluative criteria, to look at international consumers' evaluation criteria of apparel versus American evaluation criteria (Hsu and Burns, 2002; Lee & Burns, 1993). As shown in the CDP model, culture, an environmental influence, influences the decision process. Lee & Burns (1993) found similar results between the international and American consumers suggesting that globalization is closing the distance on cultural difference in fashion. However, Hsu and

Burns (2002) found that the international group they studied, evaluated clothing differently suggesting that firms and researchers should be aware that some cultures still have strong influence regarding apparel decisions. Hsu and Burns also suggested that the evaluation criteria for clothing be added to the consumer decision model. A similar type change can be seen in the modified CDP model used in May-Plumlee and Little's (2006) research. Forney et. al. (2005) worked to identify which of the apparel evaluative criteria were used when making a decision on home furnishing and how the use of these similar criteria could predict purchase behavior of brand extension products. The study found that brand image was the most influential apparel criteria consumers used when considering the purchase of an apparel brand in the home furnishing category.

Influence of the Internet

Consumer behavior is more dynamic than ever before as the discipline tries to keep up with the fast-pace, dynamic consumer of the 21st century (Blackwell et. al., 2006). With the introduction of the Internet, new issues affecting consumer behavior include e-commerce, Internet influences, and other advancing technologies (Blackwell et. al., 2006). Understanding the consumers purchase strategies and decision-making process when shopping on the Internet, has changed the way researchers and marketers look at consumer decision models. Sales on the Internet have challenged the marketer and consumer with regard to selling and purchasing sensory products, such as apparel, online and how the decision process is different for these purchases in comparison to the traditional retail outlet decision process. Blackwell et. al.'s CDP model has been used as a framework for several e-based research studies (Ambaye, 2005; Scheepers, 2001; Shin, 2007).

Scheepers (2001) conducted a case study on a small Australian boot company and determined that selling sensory products online is feasible but challenging. Consumers are wary of such products because they cannot judge fit, comfort, or fabric hand over the Internet, which is an important criteria when purchasing products that are worn. By providing consumers sensory attribute information, consumers feel more comfortable shopping online for sensory products. Scheepers states ways for companies to succeed by using each stage (except divestment) of the CDP model. Research by Ambaye (2005) also looked at the purchase of sensory sales via the Internet. An earlier version of the CDP model was the framework for her eCDP (Electronic Consumer Decision Process Model). Ambaye concentrated on the first four stages of the CDP model, need recognition, search, pre-purchase evaluative criteria, and purchase, where she felt Internet shopping created a different consumer decision process than that of traditional retail outlets. Research by Shin (2007) studied external search because the Internet has provided a strong external search tool through chats, blogs, company websites, and consumer reviews. Communication methods are convenient and fast, yet, provide confidentiality unlike face-to-face information gathering. The Internet also provides a convenient way to shop with 24 hour access and a wide selection of products and retailers. However, the Internet also has its limitations, such as perceived risks. Companies have tried to limit these risks by offering consumer reviews. Teo and Yeong (2003) found similar results to Shin.

Future of Consumer Decision-Making Models in Apparel

While the research above has provided insight into the consumers' apparel decision-making process, the information on the consumer is limited. The consumer is dynamic, and

therefore, their wants, needs, and criteria constantly change (Blackwell et. al., 2006). Therefore, consumer behavior, specifically the consumers' decision process, remains important to companies. For companies to remain profitable, they must continue to research and understand their target customer. Through the use of consumer decision process models, marketers can gain a better understanding of their target consumer. Apparel companies, like Jockey International and VF Corporation, have developed departments such as "consumerology" and "consumer insight" with the sole purpose of collecting and analyzing data on their target consumers. The Internet has become a valuable research tool for companies. For example, VF Corporation conducts surveys online to research a mass number of consumers and gather a large amount of information quickly, which is important and valuable in today's fast paced market. The company also stages mock online shopping experiences to see what their target consumers will purchase from the product lines of future seasons. This data is then used to determine the SKUs and floor plans for the future seasons (Norgren, 2008). Studying the consumer's behavior will be important to the future success of apparel firms.

Consumer Behavior and New Product Development

Research by May-Plumlee and Little (2006), displays a 1995 version of the Blackwell CDP model modified to explain the high involvement decision process of apparel items. Intrinsic and extrinsic criteria that affect consumer decisions when considering an apparel purchase were added to the CDP model. The authors incorporated the CDP model into an apparel product development process to develop a model known as Proactive Product

Development Integrating Consumer Requirements (PPDICR). The model was developed to assist companies in developing successful apparel products by considering consumer input during the product development process.

May-Plumlee and Little found 13 "universal" evaluative criteria that are used by consumers to evaluate apparel for various situations and end-uses (see Table 3). The researchers added these criteria to the CDP model. The model shows that the criteria are influenced from the market dominated stimuli and personal memory, and are used as input for the third stage of the consumer decision process model, pre-purchase alternative evaluation criteria. As seen in Table 3, fabrication is one of the universal evaluative criteria used by a consumer during the decision process. Therefore, fabrication is one criteria consumers may use to determine their acceptance or rejection of a product. A method used to determine acceptance of fabrication is fabric hand evaluation studies. Understanding the consumer's interest in certain sensory attributes can help designers develop fabrics which meet the consumer's desired fabric hand, or "feel", and develop a successful fabric. Furthermore, as previously mentioned, the evaluative criteria are influenced by marketing stimuli. When desirable sensory attributes are identified, marketers can use these terms to catch the attention of consumers as they begin to form their pre-purchase evaluative criteria, stage three of the CDP model.

Table 3. *Universal Evaluative Criteria*

Extrinsic	Intrinsic	
Brand Price	Color/pattern Style/design/uniqueness Fabrication Fashionability Appearance/attractiveness	Care Construction Durability Fit/sizing Quality Comfort

Note. Adopted from "Proactive product development integrating consumer requirements," by T. May-Plumlee and T. Little, 2006, in *The International Journal of Clothing Science and Technology*, 18(1), 53-66.

Fabric Hand Evaluation

As seen in Behery (2005), the definition of fabric hand has been defined various ways by numerous researchers and the definitions tend to change based on the researchers' interests. Fabric hand is defined in the 2006 edition of the AATCC Technical Manual as "the tactile sensations or impressions which arise when fabrics are touched, squeezed, rubbed or otherwise handled" (p. 384). Often fabric hand, handle, or feel is used interchangeably but El Mogahzy et al. (2005, p. 45) explains there is a difference between 'fabric hand' and 'fabric handle.'

> *Fabric Hand: "describes the way a fabric feels when it is touched and manipulated by hand. It is an action noun that implies evaluation of fabric reaction to different modes of low-stress deformation imposed by the human hand."*
>
> *Fabric Handle: "A more general term that is commonly used in the industry is 'fabric handle'. This is an action verb that reflects the evaluation of fabric reaction to different modes of deformation at all levels of applied stress (low or high). In this case, fabric handle may imply different handling actions such as touching, folding, cutting, transporting, sewing, and pressing."*

Fabric hand is considered a phenomenon because of its complex notion involving the interrelations of a fabric's physical properties and the psychology of the human's response. Elements that relate to the fabric hand are fiber structure and characteristics; yarn type; fabric structure; and finishing processes (Behery, 2005; Lundgren, 1969; Vaughn & Kim, 1975). However, the complexity of the human's response to tactile and kinesthetic (muscular) sensations of the fabric produces a greater challenge. From the industry expert to the end consumer, the assessment of fabric hand has been done for decades to determine and communicate fabric quality and characteristics (Kawabata et al., 1994; Mahar & Postle, 1989).

Textile experts cannot agree on the meaning of hand, which has led to no one agreed upon definition nor a specific set of terms to describe fabric hand. Communication becomes confusing due to the numerous terms used and the various definitions of those terms. Attempts to solve this problem are evident in the early 1940s when the ASTM Committee D-13 studied the overall sensation of fabric hand to identify and define terminology (Dreby, 1942). The committee developed the Standard Terminology Relating to the Hand of Fabrics which can be found in ASTM D-123 (ASTM, 2007). They determined there are eight physical properties relating to hand and provided a range of terms that could be used to measure those eight properties (see Table 4). Common or important terms used within the industry and in research have become known as 'primary hand expressions'. Various objective methods have been developed to quantify primary hand terms through standard measurements, but none can replace or predict the complexity of the consumer (Ellis & Garnsworthy, 1980; Lundgren, 1969; Kawabata et al., 1994; Vaughn & Kim, 1975). While

experts are highly trained to feel the slightest change in hand from fabric to fabric, the consumers are the ultimate decision makers who will determine product success or failure through their acceptance, and in turn purchase, or rejection, of the product comprised of that fabric. Attempting to understand the various differences and ever changing preferences of a consumer produces a challenge to firms (Behery, 2005; Stearn et al., 1988; Vaughn & Kim, 1975).

Table 4. *ASTM D-123 List of Terms Relating to the Hand of Fabrics*

Physical Property	Explanatory Phrase	Terms to be Used in Describing Range of Corresponding Component of Hand
Flexibility	Ease of bending	Pliable (high) to stiff (low)
Compressibility	Ease of squeezing	Soft (high) to hard (low)
Extensibility	Ease of stretching	Stretchy (high) to nonstretchy (low)
Resilience	Ability to recover from deformation	Springy (high) to limp (low). Resilience may be flexural, compressional, extensional, or torsional.
Density	Mass per unit volume (based on measurement of thickness and fabric weight)	Compact (high) to open (low)
Surface contour	Divergence of the surface from planeness	Rough (high) to smooth (low)
Surface friction	Resistance to slipping offered by the surface	Harsh (high) to slippery (low)
Thermal character	Apparent difference in temperature of the fabric and the skin of the observer touching it	Cool (high) to warm (low)

Note. From *Standard Terminology Relating to Textiles* (p. 69), by American Society for Testing Materials, 2007, West Conshohocken, PA: Author.

When there is a new development within fibers, yarns, fabrics, or finishes, fabric hand is one of the first assessments conducted, especially in the apparel market, because fabric hand has such a large effect on the success or failure of a new textile product. Aside from cost and appearance, fabric hand is used by consumers to determine the overall quality, suitability, and preference for a textile product (Behery, 2005; Bogaty et al., 1956; Byrne et

al., 1998; Civille & Dus, 1990; Dawes & Owen, 1971a; Dreby, 1942; Kim, Yoo, & Kim, 2005; Paek, 1979; Vaughn & Kim, 1975; Wallenberger, 1982). Fabric hand is also related to comfort, style, and appearance of a fabric or garment. Therefore, it is essential for designers and manufacturers to consider the hand of a fabric for an apparel end-use if they intend to have a marketable product (Ellis & Garnsworthy, 1980; Merkel, 1991; Shenai, 1989; Zeng & Koehl, 2003).

Fabric hand evaluation consists of subjective measurements, those measurements performed by human subjects using psychophysical or psychological techniques, and objective measurements, those measurements performed by instruments or objects (Behery, 2005; Bishop, 1996). Fabric hand and the method of evaluation have been studied by a plethora of researchers since Binns (1926) and Peirce (1930), pioneers of the subject, first published their work. Binns, Brand (1964), and Lundgren (1969) are considered to have made significant contributions on subjective fabric hand evaluations while Peirce is considered a pioneer on objective fabric hand evaluations. Other researchers known to have made significant contributions to the field are Howorth and Oliver (1958), and Matsuo and colleagues, Kim and Vaughn, and Kawabata during the 1970s. These studies, as well as others, have tried to correlate objective and subjective hand evaluation in an attempt to eliminate the need for subjective hand measurements. Subjective measurements are complex because of the human psyche. The measurements are also expensive and time consuming. The ultimate goal was to replace subjective measures with more reproducible and standard objective measurements. Several studies have concluded in the development of the following fabric hand evaluation systems: the Kawabata Evaluation System for Fabrics (KES-F), the

Fabric Assurance by Simple Testing (FAST), and the PhabrOmeter. A detailed review of significant contribution to the evaluation of fabric hand can be found in Bishop (1996), Ellis & Garnsworthy (1980), and Vaughn and Kim (1975).

Subjective Fabric Hand Evaluation

Consumer acceptance is important to the success of a product. There are several ways in which to assess consumer acceptance. From the blatant question of whether they like or dislike a product, subjective and objective measurements, or point-of-sales data. The subjective tactile assessment of fabric hand is a common way in which to assess consumer acceptance of a textile product and the consumer's acceptance or rejection of a product is based on consumer behavior.

Subjective fabric hand evaluation is the tactile and/or visual evaluation of a fabric. The human's evaluation is a psychological mental reaction to the physical properties of the fabric. Subjective evaluation is a very complex measurement due to the individual difference in sense of touch. Personal experience as well as cultural, social, and economic background contributes to this complexity (Brand, 1964; Dreby, 1942; Ellis & Garnsworthy, 1980; Hyun, Hollies, & Spivak, 1991; Kim et al., 2005; Mahar & Postle, 1989; Shenai, 1989; Zeng & Koehl, 2003). The difficulty in understanding these differences and the inability to collect consistent and repeatable data causes this type of measurement to sometimes be perceived as problematic in the scientific community (Hyun et al., 1991). While the textile industry has struggled to accept and standardize subjective evaluation, other industries (food, beverage, cosmetic) commonly use subjective assessment to evaluate sensory attributes of products (Bogaty et al., 1956; Civille & Dus, 1990; Szczesniak, Loew, & Skinner, 1975). The use of

subjective evaluation is a valuable tool for textile firms. Testing fabrics can determine if consumers will perceive the end product as acceptable. While some may be concerned with differences among evaluators, one must remember that in most circumstances, a firm's target market is comprised of consumers with different backgrounds, and therefore, different preferences (Ellis & Garnsworthy, 1980).

Measurement of Subjective Fabric Hand Evaluation

While instruments and standardized methods can test the physical and mechanical properties of fabric, no instrument is as sensitive as the human hand, nor can these instruments emulate the psychological aspect of a human (El Mogahzý et al., 2005; Ellis & Garnsworthy, 1980). Subjective assessment through tactile evaluation, even to those who are not experienced in fabric hand evaluation, can provide information regarding the fabric that no instrument or set of instruments can produce (El Mogahzý et al., 2005). These instruments are not capable of understanding human perception, or the way in which the mind transforms, organizes, and structures sensory information. Only humans can understand perception, and therefore, subjective evaluation remains important to the assessment of fabrics and textile products (Hyun et al., 1991).

Fabric hand is studied by either active or passive perception. Active perception is the intentional handling of a fabric to produce an initial perception of the fabric which can lead to the decision of purchase to that textile product. Passive perception is the unintentional handling of a fabric as it is worn which produces a more realistic feeling of the fabric. Active perception is the most often used because it's simple and practical approach. The approach

can reveal helpful information, but there is concern regarding the unreliability and reproducibility of the data (El Mogahzy et al., 2005).

Through subjective fabric hand evaluation, an evaluator can either quantify their perception of a fabric property (e.g., softness, stiffness, thickness) or express their preference for the fabric. These two general evaluations are known as sensory analysis, or hedonic analysis, respectively. Sensory analysis is a psychophysical measurement that describes part of the fabric hand using scales such as high-low (e.g., hot-cold). Judges are typically a trained panel and the knowledge of the end-use application is not relevant. The results are not affected by individual background and considered more consistent. Hedonic analysis is a psychological measurement describing fabric hand as a whole. These preferences are measured on a good-bad or like-don't like scale. Judges are consumers and the end-use application is taken into account. These results are therefore affected by the individual's background (Bishop, 1996; Brand, 1964; Philippe, Schacher, Adolphe, & Dacremont, 2003; Zeng & Koehl, 2003). With sensory analysis, and the development of a psychophysical method, there are two fundamental perceptions of sensation when a fabric is in contact with the skin, descriptive, and intensive. The descriptive dimension is the perception of a specific sensory attribute (e.g., softness, stiffness, roughness) where as, the intensive dimension is a perceived magnitude of sensation (e.g., very soft, very stiff, etc.) (Cardello, Witherhalter, & Schutz, 2003; Szczesniak et al. 1975).

In general, there are two approaches used in subjective hand evaluation to collect quantitative information, the direct method and the comparative (relative) method. When using the direct method, each fabric is given a score based on an ordinal scale (e.g., 0 = very

poor, 1 = sufficient, 5 = very good, 6 = excellent). The comparative method, also known as ranking, is to order the fabrics based on subjective criteria (e.g., best to worse), but not to assess the magnitude of the difference. This method is more acceptable and more meaningful statistical analysis can be applied. The most common comparative methods are paired comparisons and simple ranking. Paired comparison is when the evaluator is presented with all possible fabric pairs. Each pair is presented one at a time and in random order. The evaluator is asked to choose the superior fabric based on a specific attribute. The number of times the fabric is chosen as superior is the fabric's total score. The fabrics are then ranked based on the total score. When simple ranking is used, all fabrics are presented to the evaluator at one time and they are asked to rank the fabrics based on a subjective attribute. This method is preferred when the total number of fabrics is six or less (Ellis & Garnsworthy, 1980; Militký, 2005).

Related Literature on Subjective Fabric Hand Evaluation

Throughout literature, specific studies have been noted as providing significant contributions to the field of subjective fabric hand evaluation. Research on subjective fabric hand evaluation began with Binns, in 1926. Other researchers, noted in literature as providing significant contributions to subjective fabric hand evaluation, include Brand (1964), Howorth and Oliver (1958), Howorth (1964), and Lundgren (1969). A more recent method known as the Handfeel Spectrum Descriptive Analysis method (HSDA) was developed by Civille and Dus (1990) which has been validated by Cardello, Witherhalter, and Schutz (2003). Also, the American Association of Textile Chemists and Colorists (AATCC) developed Evaluation Procedure 5: Guidelines for the Subjective Evaluation of Fabric Hand in 1990.

Binns (1926) is considered the first to publish work regarding subjective fabric hand evaluation. Interested in the psychological aspect of wool trade, Binns conducted a study in which technical persons of the wool industry, non-technical persons of the apparel industry, and consumers were asked to rank wool fabrics. Binns found there to be a "striking uniformity" between the mean rankings of three subject groups. He continued research on experienced and non-experienced judges' ability to assess fabrics (Binns, 1934). Overall, the correlation among groups was high showing one's ability to tactually assess fabrics was innate. However, he stated to buy and sell textiles, which requires a more sensitive and keen sense of touch, one would need to be trained. The study also showed a group of judges provided a more reliable and sensitive evaluation than one single judge (Bishop, 1996; Ellis & Garnsworthy, 1980; Mahar & Postle, 1989).

In 1958, Howorth and Oliver published the first study known to apply the factor analysis technique to identify primary attributes of fabric hand which had complicated interrelationships. Findings showed stiffness, smoothness, and thickness could be used in conjunction with one another to define fabric hand for worsted suiting materials. Howorth (1964) conducted the previous research again on suiting, lingerie, and dress fabrics. Findings showed stiffness, smoothness, and thickness or weight could be used conjunctively to describe a fabrics overall hand. While Howorth and Oliver did not include warmth in the final list of attributes, it was part of the list of attributes that made up 86% of decision for total fabric hand acceptance. This makes for a total of four attributes used to describe fabric hand - stiffness, smoothness, bulk (weight and thickness) and thermal character (a combination of warmth, weight, and thickness) (Ellis & Garnsworthy, 1980). These attributes

are commonly accepted in fabric hand evaluation (Barker & Scheininger, 1982, Laing & Ingham, 1983; Lundgren, 1969; Paek, 1975, 1978, 1979; Sülar & Okur, 2007; Winakor, Kim, & Wolins, 1980).

Brand (1964) introduced the idea of using polar-pair word scales to judge fabric qualities. Polar-pair words should be commonly understood (not technical or textile jargon) and have opposites (e.g., smooth-rough). He used component analysis to identify which polar-pair words would describe a fabric concept, such as surface texture. The polar-pair words can convey primary hand expressions, or terms identifying the most important qualities of fabric hand (Ellis & Garnsworthy, 1980). The polar-pair words also helped identify objective measures that could be used to evaluate the fabric hand.

Lundgren (1969) used four attributes, identified by Howorth (1964), which are the attributes that account for more than 80% of total fabric hand. He also applied Brand's (1964) idea of polar-pair scales to the four attributes (roughness-smoothness, stiffness-flexibility, compactness-openness, and coldness-warmth) to determine which properties judges favor for a specific end product. Information Theory and Decision Theory was then used to determine the probability of acceptance by consumers. This information was expected to help fabric finishers develop more acceptable fabrics by focusing on the properties that were identified as more favorable for specific end products. However, Brand (1964) stated consumer preferences can only be evaluated by consumers themselves. Assuming the consumer acceptance based off of a trained panel, and not the actual consumer, could result in an unsuccessful end product.

Civille and Dus (1990) developed the Handfeel Spectrum Descriptive Analysis method (HSDA) which was modeled after successful, descriptive sensory analysis methods used for consumer products such as food, perfumes, and skin care products (Brandt, Skinner, & Coleman, 1963; Meilgaard, Civille, & Carr, 1987). HSDA was developed to provide a more standardized way to qualitatively and quantitatively describe tactile properties of woven and nonwoven fabrics and paper. The method includes 21 terms that fall within two main sensory categories: tactile (mechanical, geometrical, moisture and thermal characteristic) and sound. Correct use of each attribute is ensured by use of standard definitions and sample manipulation procedures, and corresponding rating scales for each term. The authors state not all terms are appropriate for every fabric, and therefore may not be used in evaluating those fabrics. Strict protocols for sample preparation and presentation, the environment, and the panelists (evaluators) are developed to minimize bias from extraneous variables (see Table 5). The benefits of the method, as stated by the authors, are flexibility of application to a variety of products; defined terminology, evaluation procedure, and reference scales provide data with analytical character; and the ability to use this method in relation to objective and consumer data. While the HSDA method is comprehensive and validated as highly sensitive and reliable over time by Cardello et al. (2003), the process appears to be very tedious and expensive for a company to develop and maintain. This procedure may be better suited as a service provided by a company that trains, maintains, and provides analysis to textile firms.

Table 5. *Protocols of the Handfeel Spectrum Descriptive Analysis Method*

Section	Protocols
Sample Preparation	• 10 in. X 10 in., edges square to the grain (machine direction for nonwovens) • Markings: o Arrow to indicate the weave or machine direction o Random 3 digit code to prevent evaluator from being biased • Preconditioned to testing environment 24 hours prior
Environmental Controls	• 73°±2°F and 65±2%RH* • Specimen is to be evaluated on a low gloss, non-textured table top • Use of colored lighting to mask sample color differences • Screens or boxes can be used to control visual bias
Panelist Conditioning	• Condition hands prior to testing: o 12-15 hours prior: buff fingers with emery board o 2 hours prior: Wash hands with mild soap and apply 1mL of Vaseline Intensive Care Lotion • Wear prewashed fabric lined rubber gloves when working in water between evaluation sessions
Sample Handling	• Manipulation procedures are provided for each attribute to be evaluated
Panelist Screening	• Good health without callouses, impaired circulation, central nervous system disorder, dry/chapped skin. • Screened for ability to detect and describe textural characteristics and intensities • Available to participate on a regular basis
Panelist Training	• Reference fabrics demonstrate qualitative and quantitative differences • Reference scale for each attribute to indicate intensity ranges from very low to very high o 15cm length linear scale with end anchor words o Category scale with several points and end anchor words • Several months of training required

Note. *Conditions can be based on the conditions in which the products will be used. Adapted into table from "Development of terminology to describe the handfeel properties of paper and fabrics," by G. V. Civille and C. A. Dus, 1990, *Journal of Sensory Studies*, 5, p. 23.

Evaluation Procedure 5: Guidelines for the Subjective Evaluation of Fabric Hand was originally developed by AATCC Committee RA89 in 1990. The guidelines are suggestions to help standardize the subjective evaluation of fabrics and provide outlines for specimen and evaluator preparation, procedures, and evaluation methods (see Table 6). The procedure states that a blind evaluation is preferred because visual impressions (e.g., luster, texture, and

color) of the fabric can bias the evaluator's tactile assessment. Terms, which can be used for the evaluation procedure, are provided and categorized by physical attribute.

Table 6. *Guidelines recommended by AATCC Evaluation Procedure 5*

Section	Guidelines
Specimens	• 200 mm (8 in.) – 900 mm (35.4 in.) • Avoid using the specimen more than once • Markings made with pen or pencil o Length directions o Specimen id o Surface to be evaluated • Condition 4 hours at 21°±1°C and 65±2% RH (report other conditions)
Evaluator Preparation	• Wash hands 0.5 hours prior to evaluation • Use same soap which does not contain moisturizers • Use same towel to dry hands • Avoid activities that would cause hands to perspire • Avoid temperature changes • Avoid moisture
Procedure	• Facilitator is to provide the following instructions to evaluator: o Elements of hand to be evaluated o Rating scale to use o Number of specimens to evaluate o Order of presentation o Duration of evaluation session • Blind or non-blind procedure (blind is preferred) o Use of a screen or drape o Closing the eyes o Using a blindfold • Specimen is to be evaluated on a smooth, nonmetallic surface • Specimen should be place with evaluation side up and aligned as indicated by markings • If thermal attribute is evaluated, it must be done so first • Descriptions on how to evaluate the fabric are provided
Evaluation	• Evaluated by pairs or sets • Evaluated for the direction or magnitude difference • Evaluated against a reference, ranked between two extremes, or ranked by comparative assessments

Note. Adapted into table from "Evaluation Procedure 5," 2006, in *AATCC Technical Manual*, pp. 684-685.

Development of Subjective Fabric Hand Evaluation Methodologies

The assessment of fabric is influenced by the products, evaluators, and end-uses (Ellis & Garnsworthy, 1980). When developing a subjective fabric hand evaluation methodology, it is helpful to consider the following six key elements proposed by Bishop (1996, p. 8):

1.	Judges	particularly their expertise/naïveté
2.	Criteria of judgment	the choice of descriptors for fabric attributes
3.	Assessment conditions	seen or unseen; controlled temperature and relative humidity
4.	Assessment technique	free or specified fabric-manipulation technique for assessment of given attributes
5.	Method of ranking or scaling the assessments	rank order, graded standards, magnitude estimation
6.	Analysis of results	relative importance of individual descriptors for end-use, correlation between descriptors, redundancy, fabric-specification profiles, vector maps, sensory space.

When developing the psychological scales for a subjective fabric hand study, the following six elements proposed by Hollies (1977, p. 108) should be considered:

1. Must be a commonly recognized attribute or group of attributes to measure
2. Language of terms to describe the attribute must exist
3. Needs to be a scale assignment of two or more steps to represent the attribute level and its anticipated changes
4. For a quantitative measure of the attribute, it is common to choose a rating panel and let them apply the rating scale to attribute measurement
5. Data handling appropriate to the type of rating being made needs to be recognized and used
6. It is often useful to compare the results from psychological scaling with objective measure of the same attributes (optional)

Both of these sets of elements have been taken into consideration in the development of the methodology for this research. The following discusses the six key elements proposed by Bishop in more detail.

Judges. One cannot judge a fabric based on a single judge's assessment, whether an expert or not. Instead, an average of the panel's assessment can differentiate among fabrics (Binns, 1934; Bogaty et al., 1956). Hand is one of the first interactions a consumer has with a fabric and plays an important role in the consumer's initial assessment of a fabric and the decision to purchase (Militký, 2005; Shenai, 1989; Smith, 1986). Winakor et al. (1980) states that consumers are better suited for expressing preference of hand, or specific sensory attribute, while experts or trained panels are more suited for quantifying sensory attributes. However, one study found that even a panel of judges with more than 10 years experience in the textile industry can have difficulty agreeing on the rating of fabric attributes (Yick, Cheng, & How, 1995). Several studies have shown that consumer judges can be consistent in the assessment of fabric attributes (Binns, 1926, 1934; Elder, Fisher, Armstrong, & Hutchison, 1984; Mahar & Postle, 1989), but the variability is slightly greater than those groups comprised of expert or trained judges (Mahar & Postle, 1989; Winakor et al., 1980). Use of a larger number of subjects (30 or greater) can overcome this issue (Winakor et al., 1980). A trained panel can be viewed as an objective instrument because they correlate to objective measures, but they are too artificial and removed from reality, therefore, lacking the realistic desires of a consumer (Shenai, 1989; Szczesniak et al., 1975). Szczesniak and Skinner (1973) concluded that a consumer can understand the meaning of textural attributes and can therefore provide meaningful and viable information.

Fabric attributes: acceptable terminology and definitions. As stated previously, there is a vast amount of terminology to describe fabric hand and no standard set of terms has been agreed upon. However, there are several studies which provide terminology that have been proven useful in describing fabric hand (see Table 7). Brand (1964) suggested that bipolar adjectives would better express fabric hand attributes than singular descriptors. ASTM D-123 and the HSDA method both provide a list of bipolar adjectives. Grinevičiūtė & Gutauskas (2004) found that the use of fewer terms increased the subjective assessment of fabric hand. Furthermore, use of all the terms listed by the HSDA method and the AATCC Evaluation Procedure 5 could be overwhelming, especially to an untrained, consumer group. However, these methods provide a bank from which to choose acceptable terms for subjective evaluation of fabric hand.

Table 7. *Accepted Terminology in Fabric Hand Evaluation*

Study/Method/Standard	Terminology			
Standard Terminology Relating to the Hand of Fabrics (ASTM D-123)	Pliable/stiff Soft/hard Stretchy/nonstretchy	Springy/limp Compact/open Rough/smooth	Harsh/slippery Cool/warm	
Howorth & Oliver (1958) Howorth (1964)	Stiffness Smoothness	Bulk (weight and thickness) Thermal character (warm/cool)		
Handfeel Spectrum Descriptive Analysis method (Civille & Dus, 1990)	Force to Gather Force to Compress Stiffness Fullness Compression Resilience Depression Depth Noise Intensity Noise Pitch	Roughness Grittiness Graininess Lumpiness Fuzziness Thickness Warmth	Depression Resilience Tensile Stretch Tensile Extension Hand Friction Fabric Friction Moistness	
AATCC Evaluation Procedure 5 (AATCC, 2006)	Hard Thin Thick Springy Fullness Bulky Firm Soft Lively Lofty Resilient	Stiff Pliable Supply Crisp Limp papery Lively Springy Boardly	Supple Clinging Tight Loose Firm Pliable Elastic Stretchy	Harsh Smooth Fuzzy Soft Scratchy Slick Waxy Nappy Oily Raspy Warm Cool

Tactility is considered a major comfort factor. It has been found that a consumer's preference for tactile comfort will match their comfort preference during wear, or clothing comfort (Bertaux, Lewandowski, & Derler, 2007; Laing & Ingham, 1983; Morris & Prato, 1981; Pontrelli, 1977; Wallenberger, 1982). Comfort can generally be defined as the absence of unpleasant feelings (Fuzek & Ammons, 1977). It is commonly determined by the human's judgment of sensations felt when handling a fabric and, therefore, people consider comfort to be the combination of all elements of fabric hand (Byrne et al., 1998; Barker, 2002; Merkel, 1991). Comfort perception, in general, is comprised of three elements, physical, psychological, and physiological variables (Cowan, Tilley, & Wiczynski, 1988; Merkel, 1991; Smith, 1986; Wallenberger, 1982), and occasionally a fourth element is noted, stored modifiers (Barker, 2002; Pontrelli, 1977). Physical variables include those such as the physical properties of material, thermal insulation, fabric breathability, stretch, fabric tactility, and fabric response to moisture. These are intrinsic variables that can be built into the fabric or garment structure. Psychological variables are considered to be price, color, fashionability, style, appropriateness, or state of mind. Physiological variables include sensory or tactile attributes such as cold/warm, itchiness, or garment fit. Stored modifiers, or human expectations, influence comfort assessment based on past experiences and expectations (Barker, 2002; Cowan et al., 1988; Merkel, 1991; Pontrelli, 1977; Smith, 1986; Wallenberger, 1982). This paper will study the physiological variables related to comfort. Sensory attributes that are closely related to the comfort of clothing include smoothness, stiffness, thickness, weight, and stretchiness (Barker & Scheininger, 1982; Cowan et al., 1988; Fourt & Hollies, 1970).

Assessment conditions. Subjective evaluation of fabric hand should be made without the significant bias of fabric appearance (Lundgren, 1969). Visual aesthetics such as color, texture, and pattern can influence an individual's final decision during subjective assessment (Militký, 2005). For example, a velvet fabric may suggest softness or tweed may present a pleasant appearance but an unpleasant, harsh hand (Brand, 1964; Workman & Caldwell, 2007). Since visual aesthetics have such an influence on the like/dislike of a fabric, there is a need to separate the bias of visual aesthetics by conducting a blind study so the judge can focus on the physical fabric characteristics attributing to fabric hand (Griffin & O'Neal, 1992). Furthermore, human sense of touch can better discriminate and recognize complex patterns over the visual system (El Mogahzy et al., 2005).

Environmental variables, including temperature and relative humidity, are not commonly reference in the literature. Controlled environments are typically not found with untrained or consumer studies (Bogaty et al., 1956; Byrne et al., 1998; Kim & Piromthamsiri, 1984; Laing & Ingham, 1983; Morris & Prato, 1981; Morris, Prato, & White, 1984; Paek, 1975; Winakor et al., 1980). While it is not noted as to why an uncontrolled environment was used, possible reasons could be lack of access to a controlled environment, or that consumers do not shop for or wear everyday apparel in controlled environments. Typically, when subjective results are being compared to objective results, subjective testing is conducted under the condition in which the objective testing will take place (Bishop, 1996).

Assessment technique. A specified manipulation of fabrics is helpful with an untrained consumer panel. Individuals will all have their own way of manipulating the fabric (Bishop, 1996). Therefore, use of untrained, consumer judges will require a standard

assessment technique to ensure all judges are manipulating the fabric in the same manner. The HSDA method has developed a standard method for manipulation of sensory attributes that describe fabric hand (Civille & Dus, 1990).

Method of ranking or scaling the assessment. There are four general categories of scales – nominal, ordinal, interval, and ratio scales. The ordinal, interval, and ratio scales are typically used for sensory evaluation. Ordinal scales are used for ranking or ordering where there is no magnitude, or judgment of distance, between categories (Stone & Sidel, 1993). As previous discussed, ranking is comprised of paired comparison and simple ranking. However, ranking provides limited information and therefore rating scales are commonly used. The most common rating scale is a category scale; they are easily prepared and highly reliable. The scale typically contains verbal and/or numerical labels at each point along the scale. These scales can range from five to 99-points. However, a 99-point scale is more desirable for expert judges. A seven or nine point scale, with bipolar or single descriptor words, is used most often. The simplicity of the scale makes it easy understood by untrained, consumer subjects (Bishop, 1996; Cardello et al., 2003; Militký, 2005; Stone & Sidel, 1993). Finally, there are a variety of magnitude-estimation techniques which use interval or ratio scales. Unlike an ordinal scale, the distance between points on the scale has meaning and is not arbitrary. These scales required training of judges, or the use of experienced judges. See Bishop (1996) and Stone and Sidel (1993) for more detail of these type scales.

Analysis. Depending on the use of the scale, the statistics used to analyze the data will vary. The most common used scale in sensory studies is ordinal ranking and rating scales. These scales are commonly analyzed by correlation, *t*-tests, analysis of variance, mean and

standard deviation (Behery, 2005; Stone & Sidel, 1993). These statistics are used to answer specific research questions and basic subjective evaluation analysis such as level of agreement between judges (Bishop, 1996).

Objective Fabric Hand Evaluation

The purpose of fabric objective measurement (FOM) is to identify and measure fabric properties associated with the perception of fabric quality for specific end-uses (Bishop, 1996). Objective measurement of fabric hand can provide precise quantitative data. Several researchers have made significant contributions by working to identify and define physical properties that correspond to the subjective assessment and could be measured objectively (Cardello et al., 2003; Dawes & Owen, 1971a, b; Howorth, 1964; Howorth & Oliver, 1958; Kim & Vaughn, 1979; Lundgren, 1969; Matsuo et al., 1971). These measurements have helped to define fabric hand and guide designers and manufactures in the development of new fabrics, but a direct relationship to the prediction of subjective evaluation has not been found. As discussed in the previous section on subjective evaluation, the complexity of the human sensory system and psychology present a challenge. Bishop states that while Japan has developed and accepted FOM, others around the world are still questioning the relationship of the data to subjective assessment. This has undoubtedly caused the overwhelming amount of research on the relationship of objective and subjective evaluation of fabric hand.

In the 1930, Peirce pioneered the development of objectively measuring fabric hand. Peirce notes that certain sensations (stiffness or limpness, hardness or softness, and roughness or smoothness) are experienced when feeling a fabric, and was interested in

developing physical tests that could assign a numeric value to these sensations. In this work, he focused on stiffness and developed tests to measure this sensation. Mainly, he introduced the use of a cantilever to measure the bending length of fabric. With this measurement and the fabric weight, flexural rigidity, or stiffness, can be determined. Since fabric hand is more complex than just stiffness alone, researchers continued to define and develop tests to quantify fabric hand (De Boos, 2005). Peirce's work was a foundation for simple measurements of fabric hand that are still used today (Barker, 2002). Examples of these methods, and other methods mentioned in the literature are list in Table 8.

Table 8. *Test Methods Used to Objectively Measure Fabric Hand*

Compression and Thickness - Thickness Gauge - Micrometer - Schiefer Compressometer - Universal Testers (Compression cells) - ASTM 1777 - ASTM D 5729	**Drape (drape coefficient)** - MIT Drape-o-meter - FRL Drapemeter - Cusick Drape Tester - ISO 9073-9
Tensile/Shear - Universal Tensile Testers (ex: Instron)	**Friction** - Friction Meter - Universal Testers (Sledge Meter)
Smoothness/Roughness - Roughness tester - Bekk/Sheffield paper smoothness testers - Comparison with smoothness standards - Sled Test (IST 140.1)	**Warmth** - Guarded hot-plate - Density method - Cover-factor method - Thermal transmittance (ASTM D 1518)
Stiffness (bending) - ASTM D 1388 - ASTM D 5732 - Cantilever Test - Heart Loop or Double-Cantilever Test - Circular Bend Stiffness Test (ASTM D 4032) - Flexometer - Planoflex - Clark Stiffness Tester - Gurley Stiffness Tester - Olsen Stiffness Tester - Shirley Cyclic Bending Tester	**Other** - Fabric-Extraction Methods: · Ring pull through method · Ring push through method - Air Permeability (ASTM D 737) - Static Electricity · ASTM D 4238 · AATCC Test Method 76 · AATCC Test Method 84 · AATCC Test Method 115 · AATCC Test Method 134 - Robotics (ex: Ramkumar's research)

Note. Methods are listed by physical properties. Compiled from "Artificial Finger," 2000; Bishop, 1996; Kim and Vaughn, 1975; and Merkel, 1991.

Fabric Hand Evaluation Systems

As previously mentioned, several researchers have worked to develop a system for fabric hand evaluation. These systems test fabric surface and mechanical properties under low stress conditions that better relate to how a fabric is handled by humans as opposed to the way the fabric is handled during manufacturing (Bishop, 1996; De Boos, 2005). Two well known fabric evaluation systems were developed in the 1970s and 1980s, the Kawabata Evaluation System for Fabrics (KES-F) and the Fabric Assurance by Simple Testing (FAST). A lesser known fabric evaluation system, the PhabrOmeter, has also been developed.

Professor Kawabata of Japan released his series of tests to standardize the evaluation of fabric hand in 1973 (Kawabata, 1980). The Kawabata Evaluation System for Fabrics (KES-F) measures physical, mechanical, and surface properties through four different instruments (see Table 9). The output of these instruments results in 16 measurements, or primary hand values, which are used to calculate Total Hand Value (THV) (De Boss, 2005; "Fabric evaluation", 1984). For a background on the development of the system as well as a detailed description, see Kawabata (1980). This system was very expensive and complex and therefore was not widely accepted commercially. Furthermore, the system was developed for men's woven suiting fabrics which is very specific considering that hand is sensitive to the consumer perception and the end-use product (De Boos, 2005).

Table 9. *Instruments and Measurements of the Kawabata Evaluation System for Fabrics*

Instrument	Measurement
KES-F1 Tensile and Shear Tester	Load-extension characteristics Stress-strain characteristics
KES-F2 Bending Tester	Couple-curvature characteristics
KES-F3 Compression Tester	Pressure-thickness characteristics
KES-F4 Surface Tester	Frictional force Vertical movement of a probe

Note. Information adapted into table from De Boos, 2005 and Kawabata, 1980.

In the 1980s, SiroFAST, Fabric Assurance by Simple Testing also known as FAST, was developed by Commonweath Scientific and Industrial Research Organization (CSIRO), a part of the Division of Wool Technology in Australia, in response to the complexity and cost of the KES-F system. The FAST system was designed to be simple to use, less expensive, and provide in depth information on several important fabric properties. FAST measures mechanical, physical, and dimensional properties by using three instruments and a test for dimensional stability (see Table 10). FAST-4, dimensional stability, is critical in the manufacturing and appearance of the garment when worn (De Boos, 2005; Tester & De Boos, 1990).

Table 10. *Instruments and Measurements of SiroFAST*

Instrument	Measurement
FAST-1 Compression Meter	Fabric thickness under two loads
FAST-2 Bending Meter	Bending length (stiffness) in both the machine and cross direction
FAST-3 Extension Meter	Extensibility of the fabric in the machine, cross, and bias directions
FAST-4 Dimensional Stability Test	Wet relaxation shrinkage and the hygral expansion of the fabric from wet to dry

Note. Information adapted into table from De Boos, 2005 and Tester & De Boos, 1990.

Unlike the KES-F system, FAST was developed for manufactures of garments; therefore, properties measured were properties important to garment construction, or tailoring. The results are presented in a way that shows the fabrics' pros and cons in terms of garment development instead of fabric hand. This means that the interpretation of data was found to be more complex in terms of determining fabric hand. (De Boos, 2005).

There are noted differences between KES-F and FAST. For instance, FAST does not measure hysteresis or recovery properties which relate to softness, nor does it measure surface properties which relate to smoothness and roughness. FAST, however, does measure dimensional stability and while this does not affect hand, it is important for predicting the performance of the fabric during manufacturing and wear. FAST does not measure a total overall hand, but does measure and report a great amount of information regarding fabric hand. The system was designed for a more overall view of fabric hand and is useful in detecting the problems a fabric will cause during garment manufacturing (De Boos, 2005).

Since the 1980s, Ning Pan and colleagues have been working on a new approach to objectively measure fabric hand after identifying problems with the Kawabata system (KES-F). His research led to the development of the fabric fingerprinting method and the

PhabrOmeter, a fabric evaluation system. The fingerprinting method is a circular chart with nine radii evenly distributed. Each radius represents a fabric characteristic (geographical roughness, smoothness, stiffness, thickness, compression, sheering, and three tensile measurements). In total, the chart identifies, or fingerprints, the softness of the fabric. The PhabrOmeter measures the fabric by a fabric extraction technique in which the sample is pushed through a ring. The fabric is deformed in a complex yet low stress state which includes tensile, shearing, bending, and frictional actions that are similar to the state when a human handles a fabric. A computer collects the measurements and reports a load-displacement curve for the fabric being tested. Typically, researchers only looked at the peak and the slope of the curve. However, Pan et al. looked to derive more points of the curve and relate those points to fabric attributes. They have been able to identify stiffness, smoothness, and softness within this curve (Pan, 2007; Pan et al., 1998).

Research continues as they try to find FOM technology that can be applied to and improve manufacturing, converting, buying, or retailing operations. However, this is becoming increasingly challenging as technology advances, environmental friendliness becomes of greater concern, the number of innovations is becoming overwhelming as companies try to gain a competitive advantage in a global market, and the overall challenge of keeping up with an ever changing consumer. Despite these complications, researchers and industries continue to research FOM because they feel FOM would provide a faster and cheaper measure than subjective evaluation (Bishop, 1996). At this time, however, little research has been successful in the ability to predict or measure the psychophysical aspects of fabric handle.

CHAPTER III: METHODOLOGY

The purpose of this research was to develop a subjective fabric hand evaluation method in order to study a sample of American consumers in the central North Carolina region so the following research questions could be answered:

Research Question 1: How do nonwoven fabrics compare to woven fabrics?

1a. How do nonwoven fabrics rate in comparison to woven fabrics for comfort and fabric attributes (cool/warm, smooth/rough, thin/thick, flexible/stiff, tight/stretchy)?

1b. How do nonwoven fabrics rank in comparison to woven fabrics for general apparel and accessory products (long sleeve button-down shirt, short sleeve button-down shirt, pleated shorts, bag)?

Research Question 2: How do nonwoven fabrics compare to one another?

2a. How do nonwoven fabrics rate among one another for comfort and fabric attributes (cool/warm, smooth/rough, thin/thick, flexible/stiff, tight/stretchy)?

2b. How do nonwoven fabrics rank among one another for general apparel and accessory products (long sleeve button-down shirt, short sleeve button-down shirt, pleated shorts, bag)?

Research Question 3: Does gender and age affect consumer acceptance of nonwoven fabrics?

3a. Does gender influence fabric rating and ranking responses?

3b. Does age influence fabric rating and ranking responses?

Subject Recruitment

Subjects were recruited by visiting local companies to test employees and customers, by visiting public schools (middle school, high school, and university levels) to test teachers, faculty, and students, and by attending group gatherings at private residences. The genders and ages of subjects were checked throughout data collection to ensure an even distribution of gender and age.

Fabric Sample Preparation

Three woven fabrics were chosen based on their common and wide spread use in apparel products. Three spunlaced nonwoven fabrics were chosen, one because it was a commercial product and the other two because they represent the most recent generation of nonwoven fabrics. A pretest was conducted to finalize fabric selection. See APPENDIX A and APPENDIX B for more information. Table 11 describes the six fabrics used in the study. Basis weight and thickness measures were obtained following ASTM methods D 3776 and D 5729 respectively (ASTM, 1996; ASTM, 1997). The woven fabrics and nonwoven Fabric E are commercially available fabrics. Nonwoven fabrics D and T were produced in house at The Nonwovens Institute's Partners' Lab (U.S. Patent Appl. Serial No. 11/473,534, 2006; U.S. Patent Appl. Serial No. 11/769,871, 2008). All nonwoven fabrics were produced via the spunbond process and bonded via hydroentangling, commonly referred to as a spunlaced nonwoven. Since the woven fabrics were already dyed when purchased, the three nonwoven fabrics were placed in a Theis Jet Dye, run through a blank polyester dye cycle reaching 265ºF (130ºC) and holding for 30 minutes, and dried. This was done so the samples would

have equivalent processes to the dyed woven fabrics. Once dry, the nonwoven fabrics were run through a Stork® laminator at 175°F (80°C) with a dwell time of 27 seconds and a pressure of 35 psi to remove any wrinkles. As suggested by the literature, each sample fabric was cut into 8 x 8 inch (20.3 x 20.3 cm) samples, with edges parallel to the warp, or machine direction. The samples were labeled with a permanent marker so as not to affect the fabric surface. Each sample was marked with the fabric identification letter and an arrow to indicate the warp, or machine direction. All samples were ironed and lint rolled to remove any wrinkles or particles that would affect the surface of the fabrics which in turn could affect the testing results.

Table 11. *Fabric Samples*

Fabric ID	Fabric Construction	Fiber Content	Basis Weight (g/m^2)	Thickness (mm)
A	Plain Weave	65%/35% Polyester/Cotton	141	0.30
B	Plain Weave	65%/35% Polyester/Cotton	144	0.36
C	Sateen Weave	97%/3% Cotton/Spandex	199	0.44
D	Bicomponent Spunlaced Nonwoven	50%/50% Polyester/Nylon	131	0.58
E	Segmented Pie Spunlaced Nonwoven	70%/30%* Polyester/Nylon	111	0.60
T	Textured Bicomponent Spunlaced Nonwoven	50%/50% Elastomer/Polyester	107	0.49

Note. Light gray shading indicates a nonwoven fabric.
* Fabric shipment unlabeled, typically 70%/30% blend.

Testing Procedure

While there is no industry standard for subjective fabric hand evaluation, Bishop (1996) has noted six key elements to consider when developing a subjective fabric hand evaluation methodology. In the development of this study, these six elements were considered, in addition to three key publications: Civille and Dus (1990); Cardello, Witherhalter, and Schutz (2003); and the AATCC Evaluation Procedure 5: Guidelines for the Subjective Evaluation of Fabric Hand (2006).

The results of the pretest addressed concerns that assisted in finalizing the experimental design. First, the pretest helped ensure the computerized survey, developed for this research, would function properly and record data correctly. Secondly, the pretest confirmed subject understanding of the testing and evaluation procedures. Thirdly, it was used to determine testing time. Finally, this pretest allowed for an opportunity to conduct statistical analysis to ensure data collected could be properly analyzed. See APPENDIX A and APPENDIX B for the pretest methodology and results. APPENDIX B also includes proposed changes in testing procedure which guided the development of the final testing procedure. Appendix C includes the pretest questionnaire, proctor's guides, survey, and fabric ranking form.

The experiment was comprised of two parts, a rating and a ranking section, conducted simultaneously. The entire experiment was conducted as a blind study, as suggested in the literature. Due to the use of consumer subjects, the study was not conducted in a controlled environment. As suggested in the literature, subjects were required to wash their hands with non-moisturizing hand soap and dry their hands with a paper towel before participating in the

experiment. Subjects were not to expose their hands to moisture, lotions, or powders until the evaluation of all specimens were completed. This prevented any contamination to the surface of the fabric samples that would affect the sensory evaluation of the fabrics.

In Part I of the experiment, the subjects were asked to rate each of the six fabrics. The samples were presented to the subjects, one at time, in random order. The samples were hidden from the subjects view by using a box and screen (see Figure 1). Holes on the side of the box, with plastic 'curtains', allowed for subjects to easily place their hands in the box to evaluate the fabric while still keeping the fabric from view. The cardboard screen allowed for the proctor to easily move fabrics in and out of the box without subjects seeing the fabric. The cardboard screen also prevented other subjects from seeing the fabrics when more than one subject was being tested at the same time.

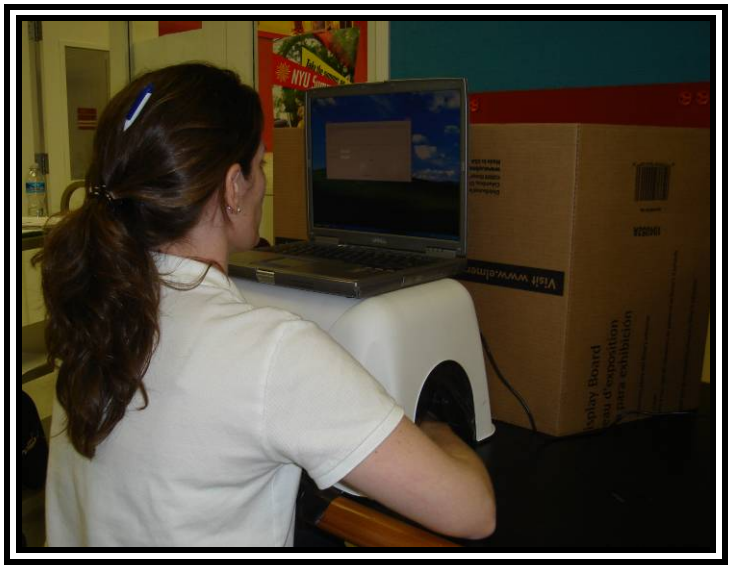


Figure 1. The experimental set-up for Part I: Rating.

The subjects were asked to rate each fabric based on comfort and five fabric attributes – cool/warm, smooth/rough, thin/thick, flexible/stiff, and tight/stretchy. For each fabric attribute rating, a definition and evaluation procedure was provided to keep the untrained subjects consistent in their evaluation technique (see Table 12). The definitions and evaluation procedures were adopted from the Handfeel Spectrum Descriptive Analysis (HSDA) method (Civille & Dus, 1990). A 7-point, verbally labeled, categorical rating scale was used in the evaluation. For example, the scale for cool/warm was labeled very cool, cool, slightly cool, neither cool nor warm, slightly warm, warm, and very warm. The rating evaluation was guided by a computer software program designed by a research scientist in the department. The survey was opened on a laptop which was positioned on top of the box, in front of the subject, refer back to Figure 1. The survey was self-guided and showed only one question at a time. The questions were ordered in a manner so that the prior evaluation would not alter the fabric, which could affect the following evaluations. See APPENDIX D for the complete survey as seen by the subjects. Each fabric was only evaluated once to prevent change in hand which could be caused by excessive handling.

Table 12. *Fabric Attribute Definitions and Evaluation Procedures*

Fabric Attributes	Definition	Evaluation Procedure
Cool/Warm	The difference in thermal character between the fabric and the hand.	Gather fabric into palm with fingers closed; flex fingers and squeeze sample gently for 3 seconds. Do not squeeze fabric again or longer than 3 seconds.
Smooth/Rough	The overall presence of gritty, grainy, or lumpy particles in the surface.	Lay sample flat on the table; place wrist on the table top; move index and middle fingers across the surface lightly (left to right) using weight of hand; rotate fabric to stroke along all four directions of fabric.
Thin/Thick	The perceived distance between thumb and fingers.	Hold corner of sample with non-dominant hand thumb, index and middle fingers; grasp sample with thumb and index finger of dominant hand just next to non-dominant hand; run dominant hand fingers over sample using light pressure; do not go off the edge.
Flexible/Stiff	The degree to which the sample feels pointed, ridged, and cracked.	Place dominant hand on top of sample; gather sample with fingers toward palm; close hand slightly and manipulate by rotating sample in palm.
Tight/Stretchy	The degree to which the sample stretches from its original shape.	Grasp opposite edges (near the edges) in hands; pull sample square across in direction 1 (left and right side) for 5 seconds; repeat for direction 2 (top and bottom side) for 5 seconds.

Note. Adopted from "Development of terminology to describe the handfeel properties of paper and fabrics," by G. C. Civille and C. A. Dus, 1990, in *Journal of Sensory Studies,* 5, 19-32.

In Part II of the experiment, the subjects conducted a simple ranking procedure. The subjects were shown the four images, one at a time, in random order. The four images included a short sleeve button-down collared shirt, a long sleeve button-down collared shirt, a pair of pleated shorts, and a bag (see Figure 2). These images were chosen because of their general application to apparel and accessories, and were appropriate for the fabrics used in the study. Once the subjects were shown an image, they were asked to put on a blindfold to prevent them from seeing the fabric, as suggested in literature. The six fabric samples were placed in front of the subjects in random order, on a non-textured, non-metal table (see Figure 3). The subjects were asked to rank the fabrics in order from the most desirable (best) fabric to the least desirable (worst) fabric for the image. The ranking was recorded by the

proctor, the fabrics were removed from view, and the subjects were asked to remove the blindfold to see the next image. The process was repeated until the subjects had seen all four images.

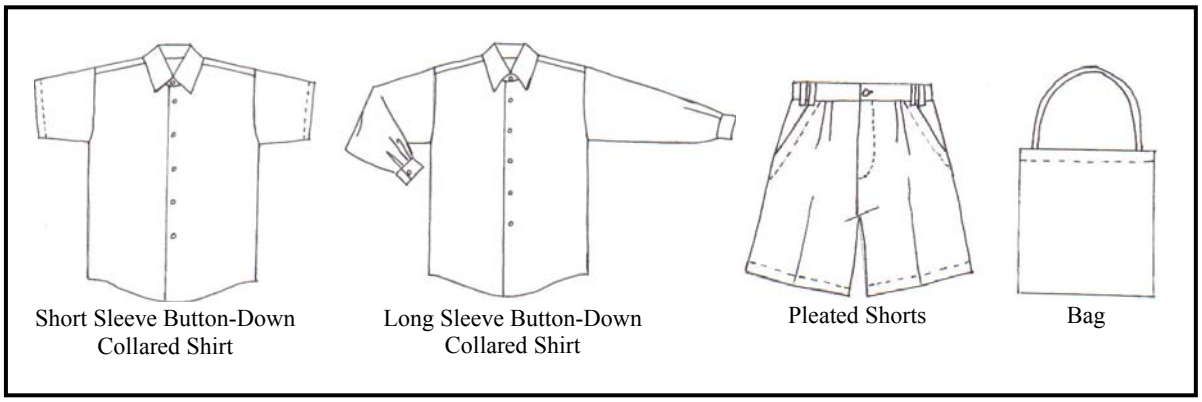


Figure 2. The four images used in Part II: Ranking.

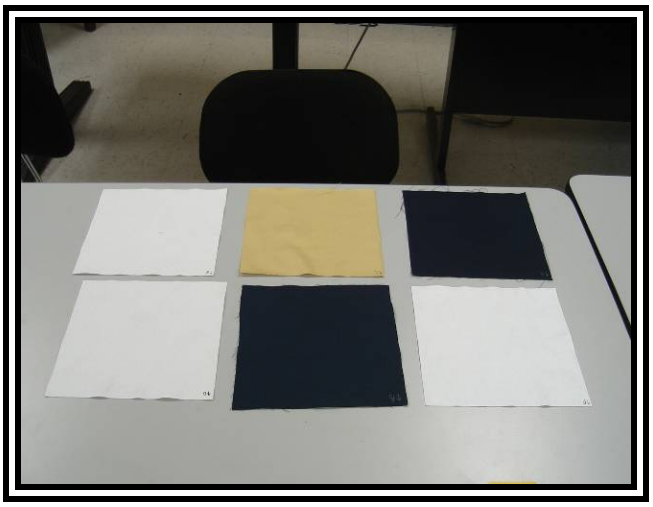


Figure 3. The experimental set-up for Part II: Ranking.

CHAPTER IV: RESULTS

Sample

Subjects were recruited by visiting local companies to test employees and customers, by visiting public schools (middle school, high school, and university levels) to test teachers, faculty and students, and by attending group gatherings at private residences. The sample included 197 North Carolinians. There was one unusable subject because not all of the fabrics in the computerized rating section recorded. The sample included 86 males and 111 females who ranged in age from 18 to 76 (see Figure 4). Less than 10% of the sample were older than 61.

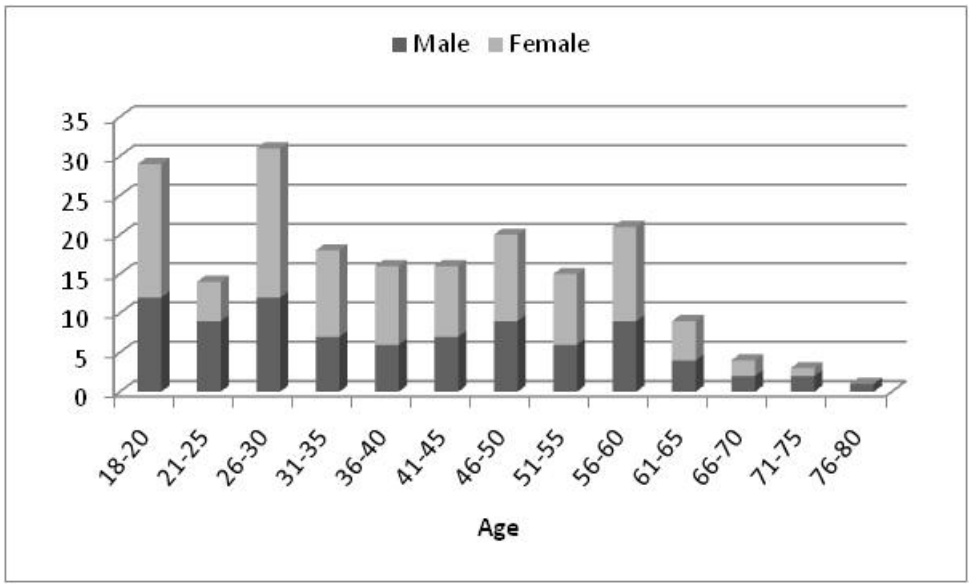


Figure 4. Age of the subjects.

Figure 5 shows the breakdown of subjects by race. Over 85% of the sample identified themselves as Caucasian or White. There were no Native Americans who completed the survey and the subject who chose "other" stated they were American Pacific Islander.

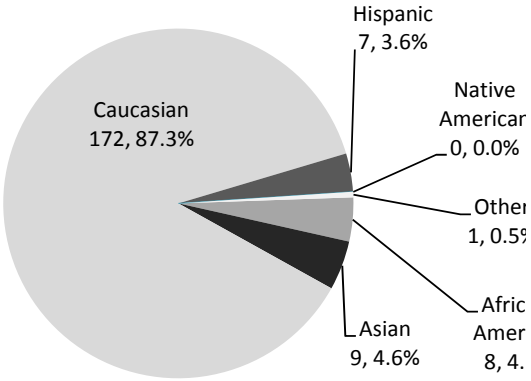


Figure 5. Race of the subjects.

Over 75% of the subjects in this study worked full-time. The second largest group were 'not employed' at 13.2%; 8.6 % were part-time and 1.5% were full- and part-time. Figure 6 displays the yearly household income before taxes of the sample. The subjects were also asked to state their occupation. Using the Bureau of Labor Statistics' Occupations Groups for guidance, the subjects' occupations were grouped into categories and subcategories (see Table 13) (Bureau of Labor Statistics, 2009). The largest occupational group was 'Student' at 17.3%. The second largest group included 'Office and Administrative Support Occupations' (13.7%) and 'Sales and Related Occupations' (13.7%).

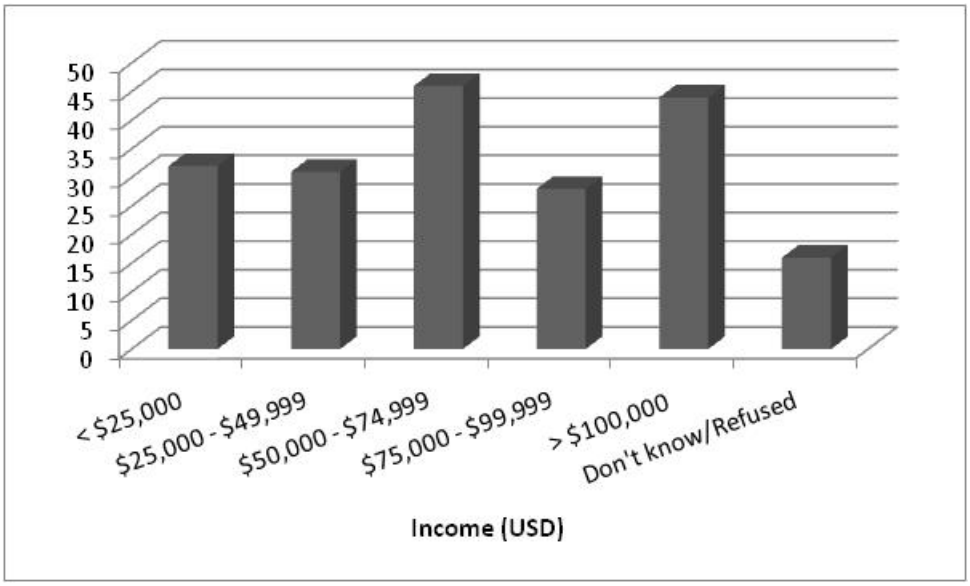


Figure 6. Household income level before taxes of the subjects.

Table 13. *Occupation of the Subjects*

Occupation Categories	Category Totals	Category %	Subcategories	Sub Totals	Sub %
Architecture and Engineering Occupations	3	1.5	Architects	1	0.5
			Civil Engineers	1	0.5
			Engineers, All Other	1	0.5
Arts, Design, Entertainment, Sports, and Median Occupations	6	3.0	Cabinet Designers	2	1.0
			Floral Designers	2	1.0
			Freelance Artists	1	0.5
			Web Designers	1	0.5
Business and Financial Operations Occupations	13	6.6	Accountants and Auditors	6	3.0
			Analysts	2	1.0
			Claims Adjusters, Examiners, and Investigators	1	0.5
			Human Resources, Training, and Labor Relations Specialists, All Other	2	1.0
			Loan Officers	2	1.0
Community and Social Services	3	1.5	Counselors, All Other	2	1.0
			Counselors, Children	1	0.5
Computer and Mathematical Science Occupations	2	1.0	Database Administrators	1	0.5
			Network and Computer Systems Administrators	1	0.5

Table 13. *Occupation of the Subjects (cont.)*

Occupation Categories	Category Totals	Category %	Subcategories	Sub Totals	Sub %
Education, Training, and Library Occupations	17	8.6	Psychology Teachers, Postsecondary	1	0.5
			Teachers (k-12)	14	7.1
			Teacher Assistants	2	1.0
Food Preparation and Serving Related Occupations	1	0.5	Bartenders	1	0.5
Government	1	0.5	Legislative Representatives	1	0.5
Healthcare	3	1.5	Clinical Researchers	3	1.5
Healthcare Practitioner and Technical Occupations	4	2.0	Registered Nurses	4	2.0
Installation, Maintenance, and Repair Occupations	3	1.5	Automotive Body and Related Repairs	1	0.5
			Automotive Service Technicians and Mechanics	2	1.0
Management Occupations	13	6.6	Financial Managers	3	1.5
			Human Resources Managers, All Other	1	0.5
			Managers, All Other	9	4.6
Office and Administrative Support Occupations	27	13.7	Bookkeeping, Accounting, and Auditing Clerks	7	3.6
			Customer Service Representatives	2	1.0
			Information and Record Clerks, All Other	1	0.5
			Office and Administrative Support Workers, All Other	9	4.6
			Office Clerks, General	4	2.0
			Receptionists and Information Clerks	1	0.5
			Tellers	3	1.5
Other	6	3.0	Advocate	1	0.5
			Consultant	1	0.5
			Inventory Inspection	1	0.5
			Safety Specialist	1	0.5
			Technologist	1	0.5
			Warehouse	1	0.5
Personal Care and Service Occupations	11	5.6	Child Care Workers	1	0.5
			Children's Fitness Instructors	3	1.5
			Fitness Trainers and Aerobics Instructors	3	1.5
			Hairdressers, Hairstylists, and Cosmetologists	4	2.0
Protective Service Occupations	1	0.5	Security Guards	1	0.5

Table 13. *Occupation of the Subjects (cont.)*

Occupation Categories	Category Totals	Category %	Subcategories	Sub Totals	Sub %
Sales and Related Occupations	27	13.7	Bookseller	1	0.5
			Cashiers	1	0.5
			First-Line Supervisors/Managers of Retail Sales Workers	1	0.5
			Real Estate Sales Agents	3	1.5
			Retail Salesperson	1	0.5
			Sales and Related Workers, All Other	19	9.6
			Sales Representative, Services, All Other	1	0.5
Self Employed	3	1.5	Self Employed	3	1.5
Student	34	17.3	Graduate	4	2.0
			Postdoctoral Research Associate	1	0.5
			Undergraduate	29	14.7
Transportation and Material Moving Occupations	3	1.5	Captains, Mates, and Pilots of Water Vessels	1	0.5
			Dock Attendant	1	0.5
			Lot Attendant	1	0.5
Unemployed	16	8.1	Disabled	1	0.5
			Housewife	1	0.5
			Mom	1	0.5
			Retired	12	6.1
			Unemployed	1	0.5

Note. Categories were guided by the Bureau of Labor Statistics Occupational Groups reported in the May 2007 National Occupational Employment and Wage Estimates.

Subjects were asked how much they spend on clothing per year, for themselves. Figure 7 displays, in U.S. dollars, what subjects' perceived they spend on clothing per year. As commonly thought in our society, female subjects spend more on clothing per year than males.

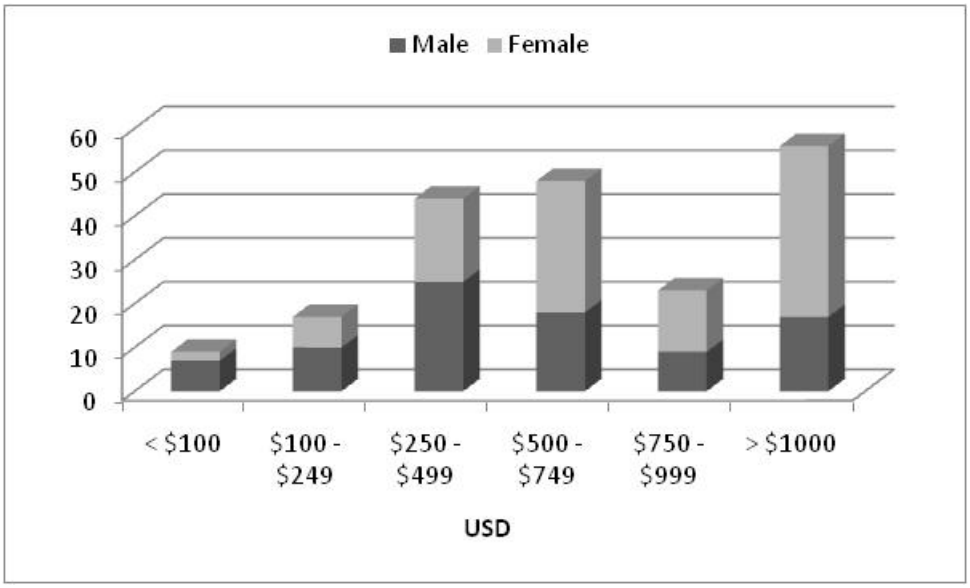


Figure 7. Dollar amount subjects spend on clothing per year.

To determine city of recidency, subjects were asked to provide their zip code. The sample included subjects from 35 different cities within North Carolina. Slightly over 60% of the subjects resided in Raleigh, North Carolina while the remaining subjects recided within other cities throughout North Carolina (see Table 14). Over 75% of the subjects resided in Wake County with the next largest represented county was Johnston County with 6.6%.

Table 14. *Residency of the Subjects*

Total	%	City	County	Zip Code
2	1.0	Apex	Wake	27502
1	0.5	Benson	Johnston	27504
1	0.5	Carrborro	Orange	27510
7	3.6	Cary	Wake	27511, 27513, 27518, 27519
2	1.0	Chapel Hill	Orange	27514
1	0.5	Charlotte	Mecklenburg	28226
12	6.1	Clayton	Johnston	27520, 27527
1	0.5	Clyde	Haywood	28721
1	0.5	Creedmoor	Granville	27522
5	2.5	Durham	Durham	27703, 27705, 27713
1	0.5	Eden	Rockingham	27288
1	0.5	Elon College	Alamance	27244
1	0.5	Franklinton	Franklin	27525
3	1.5	Fuquay Varina	Wake	27526
5	2.5	Garner	Wake	27529
1	0.5	Gastonia	Gaston	28056
2	1.0	Goldsboro	Wayne	27530
1	0.5	Greensboro	Guilford	27410
1	0.5	Henderson	Vance	27537
2	1.0	Hickory	Catawba	28601
1	0.5	Holly Springs	Wake	27540
2	1.0	Knightdale	Wake	27545
2	1.0	Leasburg	Caswell	27291
1	0.5	Lexington	Davidson	27292
2	1.0	Louisburg	Franklin	27549
1	0.5	Oak Ridge	Guilford	27310
119	60.4	Raleigh	Wake	27603, 27604, 27606, 27607, 27608, 27609, 27610, 27612, 27613, 27614, 27615, 27616, 27617, 27658
1	0.5	Rocky Point	Pender	28457
1	0.5	Roxboro	Person	27574
1	0.5	Sanford	Lee	27330
6	3.0	Wake Forest	Wake	27587
1	0.5	Wendell	Wake	27591
3	1.5	Willow Spring	Wake	27592
4	2.0	Wilmington	New Hanover	28403, 28405, 28411
1	0.5	Zebulon	Wake	27597

Part I: Rating Results

In order to evaluate consumer acceptance of nonwoven fabrics in apparel and accessories, Part I of the methodology asked consumers to rate each of the six fabrics for comfort and five attributes which included cool/warm, smooth/rough, thin/thick, flexible/stiff, and tight/stretchy. To determine the attribute levels for each fabric, the median of each attribute rating for each fabric was calculated for all subjects (see Table 15) and by gender (see Table 19). Using the statistical software JMP, the Wilcoxon Signed Rank test was performed to determine if the difference between attribute ratings for each fabric was statistically significantly different. This information was used to determine how the nonwoven fabrics rate in comparison to the woven fabrics, how the nonwoven fabrics rate among one another, and how the woven fabrics rate among one another. The Wilcoxon Rank Sum test was run to determine if there was a difference between the male and female attribute ratings for each fabric in order to determine if gender had an influence on fabric ratings. Spearman's Correlation Coefficient was run to determine if age had an influence on how the subjects rated the fabric. This test was also used to determine if there was a relationship between comfort and the five attributes, as well as among the five attributes. All statistical tests were analyzed at a 95 % confidence level, and therefore, a p-value of 0.05 or less is significant.

Attribute Ratings of Nonwoven Fabrics in Comparison to Woven Fabrics

Comfort

The median comfort rating of woven Fabric A was not significantly different from nonwoven Fabric D (see Table 16). Subject median ratings for woven Fabric A and nonwoven Fabric D was slightly comfortable (see Table 15). However, the comfort rating for woven Fabric A was significantly different than nonwoven fabrics E and T. Fabric A was rated slightly comfortable, Fabric E was rated neither comfortable nor uncomfortable, and Fabric T was rated slightly uncomfortable.

The median comfort rating of woven Fabric B was significantly different than the rating of nonwoven Fabric D (see Table 16). Woven Fabric B was rated less comfortable than nonwoven Fabric D; Fabric B was slightly uncomfortable and Fabric D was slightly comfortable (see Table 15). However, the comfort rating of woven Fabric B was not significantly different than nonwoven fabrics E and T. These fabrics were perceived to have the same comfort level.

The median comfort rating of woven Fabric C was significantly different from nonwoven fabrics D and T (see Table 16). Nonwoven Fabric D was rated slightly comfortable, and therefore, perceived to be more comfortable than woven Fabric C; rated neither comfortable nor uncomfortable. Nonwoven Fabric T was rated slightly uncomfortable, and therefore, perceived to be less comfortable than woven Fabric C (see Table 15). The comfort rating of woven Fabric C was not significantly different from nonwoven Fabric E indicating that subjects perceived these fabrics to have the same level of comfort, neither comfortable nor uncomfortable.

Cool/Warm

The median cool/warm ratings of the woven fabrics (A, B, C) were significantly different than the cool/warm ratings of the nonwoven fabric (D, E, T) (see Table 16). The nonwoven fabrics were perceived to be warmer than the woven fabrics (see Table 15). While the medians of BD, BT, CD, and CT are the same, looking at the box plots, and the 10% and 90% quantiles, the nonwoven fabrics are slightly warmer than the woven fabrics (see APPENDIX G).

Smooth/Rough

The median smooth/rough ratings of the woven fabrics (A, B, C) were significantly different than the nonwoven fabrics (D, E, T), except for the comparison of woven Fabric C and nonwoven Fabric E which were not significantly different (see Table 16). Woven Fabric A was rated neither smooth nor rough, and therefore, perceived to be a rougher than nonwoven fabrics D and E which were rated slightly smooth. However, nonwoven Fabric T was rated slightly rough, and therefore, perceived to be rougher than woven Fabric A. Woven Fabric B was rated slightly rough, and therefore, like Fabric A, it was perceived to be rougher than nonwoven fabrics D and E. Fabric B and Fabric T had the same medians even though these fabrics were significantly different. Looking at the box plots (see APPENDIX H), Fabric T was heavier on ratings of six, indicating that Fabric T was rougher than Fabric B. Woven Fabric C was perceived to be rougher than nonwoven Fabric D, but smoother than nonwoven Fabric T. Note that Fabric C and Fabric D had the same median, but the box plots indicated Fabric C was heavier on the rougher ratings than Fabric D. Fabric C and nonwoven Fabric E were not significantly different, and perceived to be slightly smooth (see Table 15).

Thin/Thick

The median thin/thick ratings of woven fabrics A and B were significantly different than the nonwoven fabrics (D, E, T) (see Table 16). Woven fabrics A and B were perceived to be thinner than the nonwoven fabrics (D, E, T). The median rating of Fabric A was thin, Fabric B was slightly thin, and the median of the nonwoven fabrics was neither thin nor thick (see Table 15). Woven Fabric C was not significantly different from the nonwoven fabrics (D, E, T) indicating that the subjects perceived woven Fabric C and the nonwoven fabrics (D, E, T) to have the same thickness. The median rating of these fabrics was neither thin nor thick.

Flexible/Stiff

The median flexible/stiff rating of woven Fabric A was significantly different than the nonwoven fabrics (D, E, T) (see Table 16). Fabric A was perceived to be less stiff than the nonwoven fabrics. Note that the medians of AD and AT were the same, but the box plots indicate fabrics D and T had more ratings related to stiffness (see APPENDIX H). Woven Fabric B was not significantly different than the nonwoven fabrics (D, E, T), indicating the subjects perceived the fabrics to be of the same flexibility. Woven Fabric C was not significantly different than nonwoven fabrics D and T; they were perceived to be slightly flexible. However, woven Fabric C was significantly different than nonwoven Fabric E. Woven Fabric C had a median rating of three, indicating the fabric was perceived to be slightly flexible. Nonwoven Fabric E had a median rating of four, indicating the fabric was perceived to be neither flexible nor stiff.

Tight/Stretchy

The median tight/stretchy ratings of woven fabrics A and C were significantly different than the nonwoven fabrics (D, E, T) (see Table 16). The median rating of woven Fabric A was three, slightly tight, and the median rating of nonwoven fabrics D and T was five, slightly stretchy. This indicates that Fabric A was perceived to be less stretchy than nonwoven fabrics D and T (see Table 15). However, nonwoven Fabric E was rated tight, and therefore, perceived to be tighter than woven Fabric A. Woven Fabric C was perceived to be slightly stretchy while nonwoven Fabric E was perceived to be tight. Nonwoven fabrics D and T were significantly different than woven Fabric C, but they had the same medians. The box plots indicate woven Fabric C was stretchier than nonwoven fabrics D and T (see APPENDIX H). Woven Fabric B was significantly different than nonwoven fabrics D and T, but not significantly different than nonwoven Fabric E. Fabric B was perceived to be tight, and fabrics D and T were perceived to be slightly stretchy. The median ratings for Fabric B and Fabric E was two, indicating subjects perceived the fabrics to be tight.

Table 15. *Median Attribute Ratings for all Subjects*

Fabrics / Attributes	Woven			Nonwoven		
	A	B	C	D	E	T
Comfort	5	3	4	5	4	3
Cool/Warm	3	4	4	4	5	4
Smooth/Rough	4	5	3	3	3	5
Thin/Thick	2	3	4	4	4	4
Flexible/Stiff	3	3	3	3	4	3
Tight/Stretchy	3	2	5	5	2	5

Note. For comfort, 1= very uncomfortable, 2= uncomfortable, 3= slightly uncomfortable, 4= neither comfortable nor uncomfortable, 5= slightly comfortable, 6= comfortable, 7= very comfortable. Similar for remaining attributes.

Table 16. *Wilcoxon Signed Rank Test: Comparison of Median Ratings between Woven and Nonwoven Fabrics for all Subjects*

Fabrics / Attribute	AD		AE		AT		BD		BE		BT		CD		CE		CT	
	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|
Comfort	-574.5	0.3139	1371.5	**0.0147***	2782.0	**<.0001***	-3110.5	**<.0001***	-1082.5	0.0671	282.5	0.6128	-1843.0	**0.0008***	197.0	0.7580	1539.5	**0.0065***
Cool/Warm	-3826.5	**<.0001***	-4595.0	**<.0001***	-3841.5	**<.0001***	-2269.5	**<.0001***	-3318.0	**<.0001***	-1615.5	**0.0004***	-2366.5	**<.0001***	-2850.5	**<.0001***	-1938.5	**0.0002***
Smooth/Rough	4070.0	**<.0001***	1302.0	**0.0070***	-3150.5	**<.0001***	5970.0	**<.0001***	3078.0	**<.0001***	-1816.5	**<.0001***	2617.0	**<.0001***	60.0	0.9131	-4991.0	**<.0001***
Thin/Thick	-5592.5	**<.0001***	-6120.0	**<.0001***	-4828.5	**<.0001***	-3682.5	**<.0001***	-3456.0	**<.0001***	-2748.0	**<.0001***	-58.5	0.8924	87.5	0.8449	635.0	0.1556
Flexible/Stiff	-2172.5	**<.0001***	-3460.0	**<.0001***	-2810.0	**<.0001***	901.0	0.0519	-712.0	0.1139	110.5	0.8066	32.5	0.9473	-1532.0	**0.0014***	-733.0	0.1061
Tight/Stretchy	-2785.5	**<.0001***	3110.5	**<.0001***	-3419.0	**<.0001***	-4923.0	**<.0001***	517.0	0.1876	-5570.5	**<.0001***	2217.5	**<.0001***	7521.0	**<.0001***	1296.5	**0.0040***

Note. * indicates significance at a 95% confidence level. Fabrics A, B, and C a woven fabrics. Fabrics D, E, and T are nonwoven fabrics.

Attribute Ratings among Nonwoven Fabrics

Comfort

The median comfort ratings between the nonwoven fabrics (D, E, T) was significantly different (see Table 17). This indicates subjects perceived the three nonwoven fabrics to have different levels of comfort. Fabric D was perceived to be slightly comfortable, Fabric E was perceived to be neither comfortable nor uncomfortable, and Fabric T was perceived to be slightly uncomfortable (see Table 15).

Cool/Warm

The median cool/warm rating of Fabric E was significantly different than fabrics D and T (see Table 17). Fabric E was perceived to slightly warm, and fabrics D and T were perceived to be neither cool nor warm (see Table 15). Fabric D and Fabric T were not significantly different, indicating the subjects perceived the two fabrics to have the same level of thermal character.

Smooth/Rough

The median smooth/rough ratings between the nonwoven fabrics (D, E, T) was significantly different, indicating subjects perceived the fabrics to have different levels of smoothness (see Table 17). Fabric D was perceived as slightly smooth, and Fabric T was perceived as slightly rough (see Table 15). Fabric E had the same median as Fabric D (slightly smooth), but the Wilcoxon Signed Rank test reports a statistically significance. This indicates subjects perceived the fabrics to have a different level of smoothness. The box plots indicate Fabric E has more ratings on the rougher side; indicating Fabric E was perceived to be rougher than Fabric D, but not as rough as Fabric T (see APPENDIX HAPPENDIX H).

Thin/Thick

The median thin/thick ratings between the nonwoven fabrics (D, E, T) was not significantly different (see Table 17). This indicates subjects perceived all nonwoven fabrics to have the same thickness. The median rating for these fabrics was four, neither thin nor thick (see Table 15).

Flexible/Stiff

The median flexible/stiff ratings between Fabric D and Fabric E were significantly different (see Table 17). Subjects perceived Fabric D to be slightly flexible, and Fabric E to be neither flexible nor stiff (see Table 15). However, fabrics D and T were not significantly different, and neither was fabrics E and T. This indicates these fabrics were perceived to have the same level of stiffness.

Tight/Stretchy

The median tight/stretchy rating of Fabric E was significantly different than fabrics D and T (see Table 17). Fabrics D and T were perceived to be slightly stretchy, and Fabric E was perceived to be tight (see Table 15). Fabrics D and T were not significantly different. This indicates subjects perceived these fabrics to have the same level of stretch, slightly stretchy.

Table 17. *Wilcoxon Signed Rank Test: Comparison of Median Ratings among Nonwoven Fabrics for all Subjects*

Fabrics / Attribute	DE		DT		ET	
	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|
Comfort	1783.5	**0.0002***	2965.5	**<.0001***	1391.0	**0.0160***
Cool/Warm	-1024.0	**0.0225***	379.0	0.4218	1220.0	**0.0025***
Smooth/Rough	-2250.5	**<.0001***	-7559.0	**<.0001***	-4768.5	**<.0001***
Thin/Thick	81.5	0.8308	655.0	0.1013	463.0	0.2854
Flexible/Stiff	-1687.5	**0.0002***	-962.5	0.0502	858.0	0.0711
Tight/Stretchy	5546.5	**<.0001***	-676.5	0.1333	-6128.5	**<.0001***

Note. * indicates significance at a 95% confidence level.

Attribute Ratings among Woven Fabrics

Comfort

The median comfort ratings for the three woven fabrics (A, B, C) were significantly different, indicating subjects perceived the three fabrics to have different comfort levels (see Table 18). Subjects perceived Fabric A to be slightly comfortable, Fabric B to be slightly uncomfortable, and Fabric C to be neither comfortable nor uncomfortable (see Table 15).

Cool/Warm

The median cool/warm rating of Fabric A was significantly different than fabrics B and C (see Table 18). Fabric A was perceived to be slightly cool, and fabrics B and C were perceived to be neither cool nor warm (see Table 15). The median ratings between fabrics B and C were not significantly different.

Smooth/Rough

The median smooth/rough ratings for the three woven fabrics (A, B, C) were significantly different, indicating the subjects perceived the three fabrics to have a different

surface textures (see Table 18). Fabric A was neither smooth nor rough, Fabric B was slightly rough, and Fabric C was slightly smooth (see Table 15).

Thin/Thick

The median thin/thick ratings for the three woven fabrics (A, B, C) were significantly different indicating the subjects perceived the three fabrics to have different levels of thickness (see Table 18). Fabric A was rated thin, Fabric B was rated slightly thin, and Fabric C was rated neither thin nor thick (see Table 15).

Flexible/Stiff

The median flexible/stiff rating of Fabric A was significantly different than fabrics B and C (see Table 18). Statistical significance indicates the subjects perceived these fabrics to have different levels of stiffness; however, the medians were not different. The box plots indicate Fabric B and Fabric C were stiffer than Fabric A (see APPENDIX H). The median flexible/stiff ratings between fabrics B and C were not significantly different, indicating subjects perceived the fabrics to have the same level of flexibility, slightly flexible (see Table 18).

Tight/Stretchy

The median tight/stretchy ratings for the three woven fabrics (A, B, C) were significantly different, indicating the subjects perceived the three fabrics to have different levels of stretch (see Table 18). Fabric A was rated slightly tight, Fabric B was rated tight, and Fabric C was rated slightly stretchy (see Table 15).

Table 18. *Wilcoxon Signed Rank Test: Comparison of Median Ratings among Woven Fabrics for all Subjects*

Fabrics / Attribute	AB		AC		BC	
	t	Prob>|t|	T	Prob>|t|	t	Prob>|t|
Comfort	2581.0	**<.0001***	1199.5	**0.0052***	-1202.5	**0.0106***
Cool/Warm	-1738.0	**<.0001***	-1625.0	**0.0009***	234.0	0.6075
Smooth/Rough	-2023.0	**<.0001***	1376.0	**0.0013***	3271.0	**<.0001***
Thin/Thick	-2472.5	**<.0001***	-5781.0	**<.0001***	-3277.0	**<.0001***
Flexible/Stiff	-2777.0	**<.0001***	-1841.0	**<.0001***	746.5	0.1325
Tight/Stretchy	2366.0	**<.0001***	-5161.0	**<.0001***	-6746.5	**<.0001***

Note. * indicates significance at a 95% confidence level.

Influence of Gender on Fabric Ratings

Comfort

The male subjects' median comfort rating for woven Fabric B was significantly different than the female subjects' median comfort rating for Fabric B (see Table 20). Males perceived Fabric B to be neither comfortable nor uncomfortable, while females perceived Fabric B to be slightly uncomfortable (see Table 19). The male and female comfort ratings were not significantly different for woven fabrics A and C, and nonwoven fabrics D, E, and T. This indicates male and female subjects rated the comfort of Fabric A the same; similar for fabrics C, D, E, and T.

Cool/Warm

The median cool/warm ratings for woven fabrics A and B, and nonwoven Fabric T, were not significantly different between genders (see Table 20). Males and females rated Fabric A as slight cool, and fabrics B and T as neither cool nor warm (see Table 19). However, the males' median cool/warm ratings for woven Fabric C, and nonwoven fabrics D

and E, were significantly different from the females' median cool/warm. Male subjects perceived Fabric C to be slightly cool, and female subjects perceived Fabric C to be neither cool nor warm. Males perceived nonwoven fabrics D and E to be neither cool nor warm, and females perceived fabrics D and E to be slightly warm.

Smooth/Rough

The median smooth/rough ratings were not significantly different between gender for all fabrics (A, B, C, D, E, T) (see Table 20). This indicates male and female subjects perceived the same fabric to have the same level of smoothness or roughness.

Thin/Thick

The males' median thin/thick ratings were not significantly different from the females' median ratings for all fabrics (A, B, C, D, E, T) (see Table 20). This indicates male and female subjects perceived the same fabric to have the same level of thickness.

Flexible/Stiff

The males' median flexible/stiff ratings were not significantly different from the females' median flexible/stiff ratings for all fabrics (A, B, C, D, E), except nonwoven Fabric T (see Table 20). This indicates male and female subjects rated the same fabric at the same level of flexibility or stiffness. There was a significant difference between the male and female median flexible/stiff ratings for Fabric T. The males perceived Fabric T to be slightly flexible, and the females perceived Fabric T to be neither flexible nor stiff (see Table 19).

Tight/Stretchy

The males' median tight/stretchy ratings were not significantly different from the females' median tight/stretchy ratings for all fabrics (A, B, C, D, E, T) (see Table 20). For each fabric, they perceived the fabric to have the same level of stretchiness or tightness.

Table 19. *Median Attribute Ratings by Gender*

	Male						Female					
Fabrics / Attributes	Woven			Nonwoven			Woven			Nonwoven		
	A	B	C	D	E	T	A	B	C	D	E	T
Comfort	5	4	4	5	4	4	5	3	4	5	4	3
Cool/Warm	3	4	3	4	4	4	3	4	4	5	5	4
Smooth/Rough	4	5	3	3	3	5	4	5	3	2	3	5
Thin/Thick	2	3	4	4	4	4	2	3	4	4	4	3
Flexible/Stiff	2	3	3	3	4	3	3	4	3	3	4	4
Tight/Stretchy	3	2	5	5	2	5	3	2	5	5	2	5

Note. For comfort, 1= very uncomfortable, 2= uncomfortable, 3= slightly uncomfortable, 4= neither comfortable nor uncomfortable, 5= slightly comfortable, 6= comfortable, 7= very comfortable. Similar for remaining attributes.

Table 20. *Wilcoxon Rank-Sum Test: Comparison of Median Ratings between Genders*

	Woven						Nonwoven					
Attribute	Fabric A		Fabric B		Fabric C		Fabric D		Fabric E		Fabric T	
	Z	Prob>|Z|	Z	Prob>|Z|	Z	Prob>|Z|	Z	Prob>|Z|	Z	Prob>|Z|	Z	Prob>|Z|
Comfort	0.6650	0.5061	2.9480	**0.0032***	-0.7317	0.4644	0.2609	0.7942	0.6693	0.5033	1.9453	0.0517
Cool/Warm	0.3944	0.6933	-0.8578	0.3910	-3.5479	**0.0004***	-2.2918	**0.0219***	-2.9101	**0.0036***	-0.6215	0.5343
Smooth/Rough	0.6493	0.5161	-1.6693	0.0951	0.8626	0.3884	1.5328	0.1253	1.7144	0.0865	1.5210	0.1283
Thin/Thick	0.2963	0.7670	-0.5446	0.5860	0.3284	0.7426	0.3125	0.7547	-0.5626	0.5737	1.6035	0.1088
Flexible/Stiff	-0.5701	0.5686	-1.8828	0.0597	-0.5325	0.5944	-1.4101	0.1585	0.1356	0.8921	-2.8164	**0.0049***
Tight/Stretchy	0.8367	0.4028	-1.3748	0.1692	-0.0999	0.9204	-0.4220	0.6730	1.4406	0.1497	1.6386	0.1013

Note. * indicates significance at a 95% confidence level.

Influence of Age on Fabric Ratings

Comfort

Age was significantly correlated to woven fabrics A, B, and C, and nonwoven Fabric E, when rating the fabrics for comfort (see Table 21). The positive relationship between age and fabrics A, B, and C, indicates the older the subject, the more comfortable they perceived these fabrics. The negative relationship between age and nonwoven Fabric E, indicates the older the subject, the less comfortable they perceived this fabric. However, the correlations of 0.3118, 0.2904, 0.1944, and -0.1666 indicate a weak association between age and the comfort ratings of fabrics A, B, C, and E. This weak relationship may be due to other relationships, aside from age, that were influencing comfort ratings. There was no significant correlation between age and nonwoven fabrics D and T, indicating that age had no association to the chosen comfort ratings of Fabric D or Fabric T.

Cool/Warm

Age was significantly correlated to nonwoven Fabric E when rating the fabric for the cool/warm attribute (see Table 21). The negative relationship between age and Fabric E indicates the older the subject, the cooler they perceived Fabric E. However, the correlation of -0.1943 indicates a weak association between age and the cool/warm rating of Fabric E. There was no significant correlation between age and woven fabrics A, B, and C, and nonwoven fabrics D and T, indicating that age had no association to the chosen cool/warm rating of these fabrics.

Smooth/Rough

Age was significantly correlated to woven fabrics A and B, and nonwoven fabrics E and T, when rating the fabrics for the smooth/rough attribute (see Table 21). The negative relationship between age and fabrics A, B, and T indicates the older the subject, the smoother they perceived these fabrics. The positive relationship between age and Fabric E indicates the older the subject, the rougher they perceived Fabric E. However, the correlations of -0.2049, -0.3325, 0.2301, and -0.1942 indicate a weak association between age and the smooth/rough rating of these fabrics. There was no significant correlation between age and woven Fabric C, and nonwoven Fabric D, indicating that age had no association to the chosen smooth/rough rating of fabrics C and D.

Thin/Thick

Age was significantly correlated to woven Fabric A and nonwoven Fabric B when rating the fabrics for the thin/thick attribute (see Table 21). The positive relationship between age and fabrics A and B indicates the older the subject, the thicker they perceived the fabrics. However, the correlations of 0.2090 and 0.1658 indicate a weak association between age and the thin/thick rating of fabrics A and B. There was no significant correlation between age and woven Fabric C, and nonwoven fabrics D, E, and T, indicating that age had no association to the chosen thin/thick rating of these fabrics.

Flexible/Stiff

There were no significant correlations between age and the fabrics for the flexible/stiff rating (see Table 21). This indicates age was not associated with the chosen flexible/stiff rating of fabrics A, B, C, D, E, or T.

Tight/Stretchy

Age was significantly correlated to woven Fabric B when rating the fabric for the tight/stretchy attribute (see Table 21). The positive relationship between age and Fabric B indicates the older the subject, the stretchier they perceived this fabric. However, the correlation of 0.2365 indicates a weak association between age and the tight/stretchy rating. There was no significant correlation between age and woven fabrics A and C, and nonwoven fabrics D, E, and T, indicating that age had no association to the chosen tight/stretchy rating of these fabrics.

Table 21. *Spearman's Correlation Coefficient: Relationship between Age and Fabric Ratings*

By age for the following attributes:	Fabric A		Fabric B		Fabric C		Fabric D		Fabric E		Fabric T	
	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|
Comfort	0.3118	**<.0001***	0.2904	**<.0001***	0.1944	**0.0062***	0.0247	0.7309	-0.1666	**0.0193***	0.1336	0.0612
Cool/Warm	0.0732	0.3069	-0.0229	0.7499	0.0122	0.8644	-0.0793	0.2678	-0.1943	**0.0062***	-0.0554	0.4391
Smooth/Rough	-0.2049	**0.0039***	-0.3325	**<.0001***	-0.1215	0.0891	0.0455	0.5255	0.2301	**0.0011***	-0.1942	**0.0063***
Thin/Thick	0.2090	**0.0032***	0.1658	**0.0199***	0.0570	0.4263	0.0609	0.3953	0.1226	0.0862	0.1058	0.1389
Flexible/Stiff	-0.0413	0.5646	-0.0588	0.4121	-0.0344	0.6311	-0.0120	0.8667	-0.0240	0.7377	-0.0288	0.6879
Tight/Stretchy	-0.0348	0.6270	0.2365	**0.0008***	0.0200	0.7806	-0.0629	0.3796	0.1038	0.1465	-0.0099	0.8906

Note. * indicates significance at a 95% confidence level. Fabric A, B, and C are woven fabrics. Fabric D, E, and T are nonwoven fabrics.

Relationship between Comfort and the Attribute Ratings

Cool/Warm

There was no significant correlation found between comfort and the cool/warm attribute for any of the fabrics (A, B, C, D, E, T) (see Table 22). This indicates comfort was not associated to the cool/warm attribute.

Smooth/Rough

The smooth/rough attribute was significantly correlated to comfort for every fabric (A, B, C, D, E, T) (see Table 22). The negative relationship between the two variables indicates the more comfortable the subject perceived the fabrics, the smoother they perceived the fabrics. However, the correlations of -0.4784, -0.4939, -0.5680, -0.3727, -0.5271, and -0.3783 indicate a moderate association between comfort and smooth/rough.

Thin/Thick

There was no significant correlation found between comfort and the thin/thick attribute for any of the fabrics (A, B, C, D, E, T) (see Table 22). This indicates comfort was not associated to the thin/thick attribute.

Flexible/Stiff

The flexible/stiff attribute was significantly correlated to comfort for four of the six fabrics; woven fabrics A and C, and nonwoven fabrics D and T (see Table 22). The negative relationship between comfort and flexible/stiff indicates the more comfortable the subject perceived these fabrics, the more flexible they perceived the fabrics. However, the correlations of -0.1834, -0.3179, -0.2067, and -0.2851 indicate a weak relationship between comfort and flexible/stiff. This may be due to other factors also influencing the fabric ratings.

Tight/Stretchy

The tight/stretchy attribute was significantly correlated to comfort for only nonwoven Fabric T (see Table 22). The positive relationship between comfort and tight/stretchy indicates the more comfortable the subject perceived Fabric T, the stretchier they perceived the fabric.

Relationship between the Attribute Ratings

The cool/warm sensory attribute was significantly correlated to the smooth/rough attribute for Fabric A (see Table 22). The positive relationship between the two variables indicates the warmer the subject perceived this fabric, the rougher they perceived the fabric. However, the correlation of 0.1893 indicates a weak association between cool/warm and smooth/rough for Fabric A. The cool/warm attribute was significantly correlated to the thin/thick attribute for the nonwoven fabrics (D, E, T). The positive relationship between the two attributes indicates the warmer the subject perceived these fabric, the thicker they perceived these fabric. However, the correlations of 0.1529, 0.1729, and 0.2431 indicate a weak association between cool/warm and thin/thick for nonwoven fabrics D, E, and T. There was no significant correlation found between cool/warm and flexible/stiff, or cool/warm and tight/stretchy.

The smooth/rough attribute was significantly correlated to the thin/thick attribute for nonwoven Fabric E. The positive relationship between the two attributes indicates the rougher the subject perceived this fabric, the thicker they perceived the fabric. However, the correlation of 0.1722 indicates a weak association between smooth/rough and thin/thick for Fabric E. The smooth/rough attribute was significantly correlated to the flexible/stiff attribute

for woven Fabric C and nonwoven Fabric E. The positive relationship between the two attributes indicates the rougher the subject perceived these fabrics, the stiffer they perceived the fabrics. However, the correlations of 0.2725 and 0.1677 indicate a weak association between smooth/rough and flexible/stiff. The smooth/rough attribute was significantly correlated to the tight/stretchy attribute for Fabric C. The negative relationship between the two attributes indicates the rougher the subject perceived the fabric, the stretchier they perceived the fabric. However, the correlation of -0.1454 indicates a very association between smooth/rough and tight/stretchy.

The thin/thick attribute was significantly correlated to the flexible/stiff attribute for woven fabrics A, B, and C, and nonwoven fabrics D and T. The positive relationship between the two attributes indicates the thicker the subject perceived these fabrics, the stiffer they perceived these fabrics. However, the correlations of 0.1710, 0.1855, 0.2524, 0.1908, and 0.2380 indicate a weak association between thin/thick and flexible/stiff. The thin/thick attribute was significantly correlated to the tight/stretchy attribute for woven fabrics B and C. The positive relationship between the two attributes indicates the thicker these fabrics were perceived, the stretchier these fabrics were perceived. However, the correlations of 0.2218 and 0.1611 indicate a weak association between the thin/thick and tight/stretchy attributes.

The flexible/stiff attribute was significantly related to the tight/stretchy attribute for woven Fabric C. The negative relationship between the two attributes indicates the more flexible the subject perceived Fabric C, the tighter they perceived the fabric. However, the correlation of -0.1741 indicates a weak association between the flexible/stiff and tight/stretchy attributes.

Table 22. *Spearman's Correlation Coefficient: Relationship between Comfort and Fabric Attributes*

Fabric A	**Cool/Warm**		**Smooth/Rough**		**Thin/Thick**		**Flexible/Stiff**		**Tight/Stretchy**	
	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|
Comfort	0.0533	0.4565	-0.4784	**<.0001***	-0.0074	0.9181	-0.1834	**0.0099***	0.0085	0.9059
Cool/Warm	1.0000	-	0.1893	**0.0077***	0.0742	0.3000	-0.0121	0.8655	0.0790	0.2699
Smooth/Rough	-	-	1.0000	-	0.1159	0.1047	0.1257	0.0784	-0.0245	0.7326
Thin/Thick	-	-	-	-	1.0000	-	0.1710	**0.0163***	0.0447	0.5324
Flexible/Stiff	-	-	-	-	-	-	1.0000	-	-0.1047	0.1430
Fabric B	**Cool/Warm**		**Smooth/Rough**		**Thin/Thick**		**Flexible/Stiff**		**Tight/Stretchy**	
	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|
Comfort	0.0252	0.7252	-0.4939	**<.0001***	-0.0145	0.8396	-0.1334	0.0616	0.0575	0.4224
Cool/Warm	1.0000	-	0.0612	0.3926	0.1397	0.0502	0.0248	0.7293	0.0607	0.3967
Smooth/Rough	-	-	1.0000	-	0.0595	0.4063	0.0425	0.5533	-0.0685	0.3389
Thin/Thick	-	-	-	-	1.0000	-	0.1855	**0.0091***	0.2218	**0.0017***
Flexible/Stiff	-	-	-	-	-	-	1.0000	-	0.0488	0.4963
Fabric C	**Cool/Warm**		**Smooth/Rough**		**Thin/Thick**		**Flexible/Stiff**		**Tight/Stretchy**	
	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|
Comfort	-0.0580	0.4178	-0.5680	**<.0001***	-0.1214	0.0893	-0.3179	**<.0001***	0.1160	0.1046
Cool/Warm	1.0000	-	0.1213	0.0896	0.1304	0.0677	0.0805	0.2610	0.0033	0.9636
Smooth/Rough	-	-	1.0000	-	0.1014	0.1563	0.2725	**0.0001***	-0.1454	**0.0415***
Thin/Thick	-	-	-	-	1.0000	-	0.2524	**0.0003***	0.1611	**0.0237***
Flexible/Stiff	-	-	-	-	-	-	1.0000	-	-0.1741	**0.0144***
Fabric D	**Cool/Warm**		**Smooth/Rough**		**Thin/Thick**		**Flexible/Stiff**		**Tight/Stretchy**	
	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|
Comfort	0.0024	0.9734	-0.3727	**<.0001***	0.0293	0.6825	-0.2067	**0.0036***	0.0465	0.5161
Cool/Warm	1.0000	-	-0.0273	0.7029	0.1529	**0.0320***	0.1198	0.0936	0.0356	0.6193
Smooth/Rough	-	-	1.0000	-	-0.0052	0.9427	0.0739	0.3020	-0.1130	0.1138
Thin/Thick	-	-	-	-	1.0000	-	0.1908	**0.0072***	0.0571	0.4257
Flexible/Stiff	-	-	-	-	-	-	1.0000	-	-0.0576	0.4217
Fabric E	**Cool/Warm**		**Smooth/Rough**		**Thin/Thick**		**Flexible/Stiff**		**Tight/Stretchy**	
	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|
Comfort	0.1199	0.0932	-0.5271	**<.0001***	-0.0080	0.9113	-0.0674	0.3464	0.0338	0.6375
Cool/Warm	1.0000	-	0.0129	0.8576	0.1729	**0.0151***	0.0517	0.4709	-0.0855	0.2323
Smooth/Rough	-	-	1.0000	-	0.1722	**0.0155***	0.1677	**0.0185***	0.0503	0.4828
Thin/Thick	-	-	-	-	1.0000	-	0.1047	0.1432	-0.0311	0.6649
Flexible/Stiff	-	-	-	-	-	-	1.0000	-	-0.1192	0.0952
Fabric T	**Cool/Warm**		**Smooth/Rough**		**Thin/Thick**		**Flexible/Stiff**		**Tight/Stretchy**	
	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|
Comfort	0.0677	0.3447	-0.3783	**<.0001***	-0.0324	0.6511	-0.2851	**<.0001***	0.2619	**0.0002***
Cool/Warm	1.0000	-	0.1199	0.0933	0.2431	**0.0006***	0.1021	0.1533	-0.1335	0.0615
Smooth/Rough	-	-	1.0000	-	0.1389	0.0516	0.1335	0.0615	0.0354	0.6218
Thin/Thick	-	-	-	-	1.0000	-	0.2380	**0.0008***	-0.0457	0.5236
Flexible/Stiff	-	-	-	-	-	-	1.0000	-	-0.0828	0.2474

Note. * indicates significance at a 95% confidence level. Fabric A, B, and C are woven fabrics. Fabrics D, E, and T are nonwoven fabrics.

Part II: Ranking Results

Part II of the methodology asked subjects to rank the six fabrics in order of preference (1=best, 6=worst) for four different products. The products included a long sleeve shirt, a short sleeve shirt, a pair of shorts, and a tote bag. To determine the ranking of each fabric, the median of each fabric, for each product, was calculated for all subjects (see Table 23) and by gender (see Table 27). Using the statistical software JMP, the Wilcoxon Signed Rank test was run to determine if the fabric rankings were statistically significantly different. The information was used to determine how the nonwoven fabrics ranked in comparison to the woven fabric, how the nonwoven fabrics ranked among one another, and how the woven fabrics ranked among one another. This test was also used to determine if the fabrics were ranked differently for each product. To determine if gender had an influence on rankings, the Wilcoxon Rank-Sum test was performed to determine if there was a difference between the males' ranking and the females' rankings. Spearman's Correlation Coefficient was run to determine if age had an influence on how the subjects ranked the fabrics. This test was also used to determine if there was a relationship between comfort, as well as the five fabric attribute ratings, and the fabric rankings for the four products. All statistical tests were run at a 95% confidence level, and therefore, a p-value of 0.05 of less is significant.

Fabric Rankings of Nonwoven Fabrics in Comparison to Woven Fabrics

Long Sleeve Shirt

The median ranking of woven *Fabric A* was significantly different from the nonwoven fabrics (D, E, T) (see Table 24). Fabric A was preferred over the nonwoven

fabrics for a long sleeve button-down collared shirt (see Table 23). The median ranking of woven *Fabric B* was not significantly different from the median ranking of nonwoven Fabric D, indicating that subjects preferred these fabrics the same for a long sleeve shirt. However, woven Fabric B was significantly different from nonwoven fabrics E and T. Fabric B was preferred over nonwoven fabrics E and T for a long sleeve shirt. The median ranking of woven *Fabric C* was not significantly different from nonwoven Fabric D; indicating subjects did not prefer one fabric over the other when considering the fabrics for a long sleeve shirt. However, the medians for these two fabrics were different (see Table 23). Note that the p-value, 0.0590, is very close to significance, and therefore, Fabric C and Fabric D may be perceived to have different rankings. The median ranking of Fabric C was significantly different than the median rankings of nonwoven fabrics E and T. The subjects preferred woven Fabric C over nonwoven fabrics E and T.

Short Sleeve Shirt

The median rankings of the woven fabrics (A, B, C) were significantly different than the median rankings of the nonwovens fabrics (D, E, T) (see Table 24). The subjects preferred the woven fabrics over the nonwoven fabrics for a short sleeve button-down collared shirt (see Table 23).

Shorts

The median rankings of the woven fabrics (A, B, C) were significantly different than the nonwoven fabrics (D, E, T), except for fabrics A and D (see Table 24). The subjects preferred the woven fabrics over the nonwoven fabrics, except for woven Fabric A and nonwoven Fabric D; these fabrics were equally preferred for a pair of shorts (see Table 23).

Bag

The median ranking of *Fabric A* was significantly different than the median rankings of the nonwoven fabrics (D, E, T) (see Table 24). The subjects preferred the nonwoven fabrics over woven Fabric A for a tote bag (see Table 23). The median ranking of woven *Fabric B* was not significantly different than the median ranking of nonwoven Fabric E, indicating subjects did not prefer one fabric over the other for a tote bag. However, there was a significant difference between woven Fabric B and nonwoven fabrics D and T. The subjects preferred nonwoven fabrics D and T over woven Fabric B for a tote bag. The median ranking of woven *Fabric C* was significantly different than nonwoven fabrics D and E. Subjects preferred woven Fabric C over nonwoven fabrics D and E. The median ranking of woven Fabric C was not significantly different from nonwoven Fabric T, indicating subjects did not prefer one fabric over the other when considering the fabrics for a tote bag. The medians, however, for these two fabrics were different. Note that the p-value, 0.0588, is very close to significance (see Table 24). Therefore, woven Fabric C may be preferred over nonwoven Fabric T.

Table 23. *Median Fabric Rankings for all Subjects*

Fabrics / Attributes	Woven			Nonwoven		
	A	B	C	D	E	T
Long Sleeve	2	3	3	4	4	5
Short Sleeve	1	2	3	4	4	5
Shorts	3	3	2	3	4	5
Bag	6	4	2	3	3	3

Note. 1 = best, 6 = worst

Table 24. *Wilcoxon Signed Rank Test: Comparison of Median Rankings between Woven and Nonwoven Fabrics for all Subjects*

Fabrics / Attribute	AD		AE		AT		BD		BE		BT		CD		CE		CT	
	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|
Long Sleeve	-3199.5	**<.0001***	-3792.0	**<.0001***	-6542.5	**<.0001***	-1376.5	0.0833	-2148.5	**0.0066***	-5744.0	**<.0001***	-1496.5	0.0590	-2119.0	**0.0073***	-5257.5	**<.0001***
Short Sleeve	-6362.5	**<.0001***	-7173.5	**<.0001***	-7614.0	**<.0001***	-3859.0	**<.0001***	-4959.5	**<.0001***	-6048.5	**<.0001***	-2737.5	**0.0005***	-4002.5	**<.0001***	-4889.5	**<.0001***
Shorts	777.5	0.3296	-1565.5	**0.0484***	-1930.0	**0.0149***	-1766.0	**0.0259***	-3973.0	**<.0001***	-4205.0	**<.0001***	-3741.5	**<.0001***	-5697.0	**<.0001***	-5463.0	**<.0001***
Bag	6215.0	**<.0001***	5446.5	**<.0001***	6767.0	**<.0001***	2413.0	**0.0022***	1288.0	0.1054	3797.5	**<.0001***	-3323.0	**<.0001***	-4199.0	**<.0001***	-1499.5	0.0588

Note. * indicates significance at a 95% confidence level. Fabrics A, B, and C are woven fabrics. Fabrics D, E, and T are nonwoven fabrics.

Fabric Rankings among Nonwoven Fabrics

Long Sleeve Shirt

The median ranking of Fabric D was not significantly different than the median ranking of Fabric E (see Table 25). This indicates subjects did not have a preference for one fabric over the other when considering the fabrics for a long sleeve shirt. The median ranking of Fabric T was significantly different than the median ranking of fabrics D and E. This indicates subjects had a preference for one fabric over the other when considering the fabrics for a long sleeve shirt. Fabrics D and E were preferred over Fabric T for a long sleeve shirt (see Table 23).

Short Sleeve Shirt

The median rankings of Fabric D and Fabric E were not significantly different (see Table 25). Also, the median rankings of fabrics E and T were not significantly different. This indicates subjects did not have a preference for one fabric over the other when considering these fabrics for a short sleeve shirt. However, there was a significant difference between the median rankings of Fabric D and Fabric T. Fabric D was preferred over Fabric T for a short sleeve shirt (see Table 23).

Shorts

The median ranking of Fabric E was not significantly different than the median ranking of Fabric T (see Table 25). This indicates subjects did not have a preference for one fabric over the other when considering the fabrics for a pair of shorts. However, Fabric D was significantly different than fabrics E and T. Fabric D was preferred over fabrics E and T for a pair of shorts (see Table 23).

Bag

The median rankings of Fabric D and Fabric T were not significantly different, indicating subjects did not have a preference for one fabric over the other when considering the fabrics for a tote bag (see Table 25). However, the median rankings of fabrics D and T were significantly different from Fabric E. This indicates subjects had a preference when ranking these fabrics for a tote bag; however, the median rankings were the same for these fabrics (see Table 23). The box plots indicated fabrics D and T were preferred over Fabric E (see APPENDIX H).

Table 25. *Wilcoxon Signed Rank Test: Comparison of Median Ratings among Nonwoven Fabrics for all Subjects*

Fabrics / Product	DE		DT		ET	
	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|
Long Sleeve	-992.5	0.2002	-4209.5	**<.0001***	-3687.0	**<.0001***
Short Sleeve	-1321.0	0.0851	-2365.5	**0.0026***	-1282.0	0.1050
Shorts	-3051.0	**<.0001***	-2467.5	**0.0017***	-379.0	0.6332
Bag	-1654.0	**0.0316***	1374.5	0.0820	2694.5	**0.0006***

Note. * indicates significance at a 95% confidence level.

Fabric Rankings among Woven Fabrics

Long Sleeve Shirt

The median ranking of Fabric B was not significantly different than the median ranking of Fabric C (see Table 26). This indicates subjects did not have a preference for one fabric over the other when considering the fabrics for a long sleeve shirt. The median ranking of Fabric A was significantly different than the median rankings of fabrics B and C. Fabric A

was preferred over fabrics B and C for a long sleeve button-down collared shirt (see Table 23).

Short Sleeve Shirt

The median rankings of all the woven fabrics (A, B, C) were significantly different, indicating subjects had a preference for one fabric over the other when considering a short sleeve button-down collared shirt (see Table 26). Fabric A was the most preferred, followed by Fabric B. Fabric C was least preferred (see Table 23).

Shorts

The median rankings of all woven fabrics (A, B, C) were significantly different, indicating subjects had a preference for one fabric over the other when considering a pair of shorts (see Table 26). Fabric C was preferred over fabrics A and B. Fabric A and Fabric B were significantly different, however, the median rankings were the same (see Table 23). The box plots indicated Fabric A had more rankings that were less desirable than Fabric B (see APPENDIX H). This indicates that Fabric B was preferred over Fabric A for a pair of shorts.

Bag

The median rankings of the woven fabrics (A, B, C) were significantly different, indicating subjects had a preference for one fabric over the other when considering a tote bag (see Table 26). Fabric C was most preferred, followed by Fabric B. Fabric A was least preferred for a tote bag.

Table 26. *Wilcoxon Signed Rank Test: Comparison of Median Rankings among Woven Fabrics for all Subjects*

Fabrics / Product	AB		AC		BC	
	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|
Long Sleeve	-2847.5	**0.0002***	-2529.0	**0.0013***	-482.5	0.5421
Short Sleeve	-4999.5	**<.0001***	-5807.0	**<.0001***	-2196.5	**0.0048***
Shorts	3675.0	**<.0001***	4345.0	**<.0001***	2006.5	**0.0106***
Bag	5850.5	**<.0001***	8540.5	**<.0001***	6258.0	**<.0001***

Note. * indicates significance at a 95% confidence level.

Influence of Gender on Fabric Rankings

Long Sleeve Shirt

The median rankings were not significantly different between genders for all fabrics (A, B, C, D, E, T) (see Table 28). This indicates male and female subjects ranked the fabrics in the same order of preference when considering the fabrics for a long sleeve button-down collared shirt.

Short Sleeve Shirt

The males' median rankings were significantly different from the females' median rankings for woven fabrics A and C (see Table 28). This indicates females preferred Fabric A more than the males for a short sleeve shirt (see Table 27). The median rankings were significantly different between genders for Fabric C, but the medians were the same. The box plots indicated males preferred Fabric C more than females for a short sleeve shirt (see APPENDIX H). The median ranking between genders were not significantly different for woven Fabric B, and nonwoven fabrics D, E, and T. This indicates males and females ranked

these fabrics in the same order of preference when considering the fabrics for a short sleeve shirt.

Shorts

The males' median rankings were not significantly different from the females' median rankings for all fabrics (A, B, C, D, E, T) (see Table 28). This indicates males and females ranked the fabrics in the same order of preference when considering the fabrics for a pair of shorts.

Bag

The median rankings between genders were significantly different for woven Fabric A and nonwoven Fabric E (see Table 28). This indicates males and females preferred these fabrics differently when considering them for a tote bag. The males preferred Fabric A more than the females (see Table 27). The females preferred Fabric E more than the males. The median rankings between genders were not significantly different for woven fabrics B and C, and nonwoven fabrics D and T (see Table 28). This indicates males and females ranked these fabrics in the same order of preference when considering the fabrics for a tote bag.

Table 27. *Median Fabric Rankings by Gender*

	Male						Female					
Fabrics / Attributes	Woven			Nonwoven			Woven			Nonwoven		
	A	B	C	D	E	T	A	B	C	D	E	T
Long Sleeve	2	3	3	4	4	5	2	3	3	4	4	5
Short Sleeve	1.5	3	3	4	4	5	1	2	3	4	4	5
Shorts	3	3	3	3	5	5	4	2	2	4	4	4
Bag	5	4	2	3	4	3	6	4	2	3	3	3

Note. 1 = best, 6 = worst

Table 28. *Wilcoxon Rank-Sum Test: Comparison of Median Rankings between Genders*

	Woven						Nonwoven					
Product	Fabric A		Fabric B		Fabric C		Fabric D		Fabric E		Fabric T	
	Z	Prob>|Z|	Z	Prob>|Z|	Z	Prob>|Z|	Z	Prob>|Z|	Z	Prob>|Z|	Z	Prob>|Z|
Long Sleeve	0.8494	0.3957	-0.6203	0.5351	-1.7286	0.0839	0.3463	0.7291	1.2702	0.2040	-0.1787	0.8582
Short Sleeve	2.2430	**0.0249***	0.9476	0.3433	-1.9969	**0.0458***	-0.2236	0.8231	-0.1445	0.8851	-0.3314	0.7403
Shorts	-0.7622	0.4460	0.8062	0.4201	0.9303	0.3522	-1.6669	0.0955	0.7199	0.4716	0.5669	0.5708
Bag	-2.4221	**0.0154***	-0.0340	0.9729	-0.1845	0.8536	-0.1067	0.9150	2.2904	**0.0220***	-0.0828	0.9340

Note. * indicates significance at a 95% confidence level.

Influence of Age on Fabric Rankings

Long Sleeve Shirt

Age was not significantly correlated to any of the fabric rankings (see Table 29). This indicates the age of the subject was not associated to how the subject ranked the fabrics for a long sleeve button-down collared shirt.

Short Sleeve Shirt

Age was not significantly correlated to any of the fabric rankings (see Table 29). This indicates the age of the subject was not associated to how the subject ranked the fabrics for a short sleeve button-down collared shirt.

Shorts

Age was significantly correlated to the rankings of woven Fabric B, and nonwoven fabrics D and E (see Table 29). The positive relationship between age and woven Fabric B indicates the older the subject, the less they preferred Fabric B for a pair of shorts. The negative relationship between age and nonwoven fabrics D and E, indicates the older the subject, the more they preferred fabrics D and E for a pair of shorts. However, the correlations of 0.1597, -0.2575, and -0.1559 indicate a weak association between age and the rankings of Fabric B, Fabric D, and Fabric E for a pair of shorts. There was no significant correlation between age and the rankings of woven fabrics A and C, and nonwoven Fabric T, indicating age was not associated with the ranking of these fabrics for a pair of shorts.

Bag

Age was significantly correlated to the rankings of woven fabrics A and B, and nonwoven Fabric T (see Table 29). The positive relationship between age and woven fabrics

A and B indicates the older the subject, the less they preferred these fabrics for a tote bag. The negative relationship between age and nonwoven Fabric T indicates the older the subject, the more they preferred nonwoven Fabric T for a tote bag. There was no significant correlation between age and the rankings of woven Fabric C, and nonwoven fabrics D and E. This indicates age was not associated with how the subjects ranked these fabrics for a tote bag.

Table 29. *Spearman's Correlation Coefficient: Relationship between Age and Fabric Rankings*

	Woven						Nonwoven					
By age for the following products:	**Fabric A**		**Fabric B**		**Fabric C**		**Fabric D**		**Fabric E**		**Fabric T**	
	ρ	**Prob>|ρ|**	**ρ**	**Prob>|ρ|**	**ρ**	**Prob>|ρ|**	**ρ**	**Prob>|ρ|**	**ρ**	**Prob>|ρ|**	**ρ**	**Prob>|ρ|**
Long Sleeve	-0.0459	0.5223	-0.0102	0.8873	0.0852	0.2340	-0.0319	0.6565	0.0264	0.7130	-0.0477	0.5056
Short Sleeve	-0.0968	0.1759	-0.0052	0.9419	0.1202	0.0926	-0.0463	0.5183	-0.0005	0.9947	0.0749	0.2953
Shorts	0.1219	0.0879	0.1597	**0.0249***	0.0955	0.1617	-0.2575	**0.0003***	-0.1559	**0.0287***	0.0683	0.3402
Bag	0.1408	**0.0484***	0.2635	**0.0002***	-0.0446	0.5336	-0.0665	0.3530	-0.0997	0.1635	-0.1480	**0.0380***

Note. * indicates significance at a 95% confidence level.

Fabric Rankings among Products

Fabric A

The median ranking of woven Fabric A was significantly different for each product (see Table 30). This indicates Fabric A was ranked differently for a long sleeve shirt, a short sleeve shirt, a pair of shorts, and a bag. Fabric A was ranked the most desirable for both a long sleeve and short sleeve shirt. The median ranking of the long sleeve shirt was two, and the median of the short sleeve shirt was one. Since this test showed statistical significance between the long sleeve and the short sleeve shirts, Fabric A was more preferred for a short sleeve shirt than for a long sleeve shirt. This fabric was ranked third for a pair of shorts, and was least desirable fabric for a tote bag (see Table 23).

Fabric B

The median ranking of woven Fabric B for a long sleeve and short sleeve shirt was not significantly different than the median ranking for a pair of shorts (see Table 30). There was, however, a significant difference between the median ranking of woven fabric B for a short sleeve shirt and a long sleeve shirt. Fabric B was perceived to be more desirable for a short sleeve shirt than for a long sleeve shirt (see Table 23). The median rankings of the apparel products were significantly different than the median ranking of the bag. Fabric B was perceived to be more desirable for the apparel products than for a tote bag.

Fabric C

The median ranking of woven Fabric C for a long sleeve and short sleeve shirt was significantly different than the median ranking of Fabric C for pair of shorts and tote bag (see Table 30). Subjects perceived Fabric C to be more desirable for a pair of shorts and a tote

bag, than for a long sleeve or short sleeve shirt (see Table 23). There was no significant difference in the median ranking of Fabric C for a long sleeve shirt and short sleeve shirt. There was also no significant difference between a pair of shorts and a tote bag.

Fabric D

The median ranking of nonwoven Fabric D for a long sleeve shirt was significantly different than the median ranking of the short sleeve shirt (see Table 30). However, the median ranking of Fabric D for a long sleeve shirt was the same as the median ranking of Fabric D for a short sleeve shirt. The box plots indicated Fabric D was more desirable for a long sleeve shirt than for a short sleeve shirt (see APPENDIX H). The median ranking of Fabric D for a long sleeve shirt was not significantly different than the median ranking a pair of shorts. However, the median ranking of Fabric D for a short sleeve shirt was significantly different than the median ranking for a pair of shorts. Fabric D was perceived to be more desirable for a pair of shorts than for a short sleeve shirt (see Table 23). The median ranking of Fabric D for a tote bag was significantly different than the median rankings of a short sleeve and long sleeve shirt. Fabric D was perceived to be more desirable for a tote bag than for a shirt. The median ranking of Fabric D for a pair of shorts was not significantly different than the median ranking of Fabric D for a tote bag, indicating that subjects perceived these fabrics to be equally desirable for both products.

Fabric E

The median ranking of nonwoven Fabric E for a long sleeve shirt was significantly different than the median ranking of Fabric E for a short sleeve shirt and shorts (see Table 30). However, the median rankings were not different. The box plots indicated Fabric E was

perceived to be more desirable for a long sleeve shirt than for a short sleeve shirt or shorts (see APPENDIX H). The median ranking of Fabric E for a long sleeve shirt was not significantly different than for a tote bag. The median ranking of Fabric E for a short sleeve shirt was not significantly different than for shorts. However, the median ranking of Fabric E was significantly different for a short sleeve shirt and a bag, as well as for shorts and a bag. This indicates subjects perceived Fabric E to be better suited for a tote bag than for a short sleeve shirt or shorts (see Table 23).

Fabric T

The median ranking of nonwoven Fabric T was not significantly different between a long sleeve shirt and short sleeve shirt (see Table 30). This indicates subjects perceived this fabric to be equally suitable for either product. The median ranking of Fabric T for a long sleeve shirt was significantly different than the median ranking of Fabric T for shorts and a tote bag. However, the median ranking for the long sleeve shirt was the same for the shorts and the box plots offer no indication to of fabric preference for one product over the other (see APPENDIX H). The subjects perceived Fabric T to be better suited for a tote bag than for a long sleeve shirt (see Table 23). The median ranking of Fabric T for a short sleeve shirt was significantly difference than the median ranking of Fabric T for a pair of shorts or a tote bag. However, the median ranking of Fabric T was the same for the short sleeve shirt and the shorts and the box plots offer no indication to fabric preference for one product over the other. The subjects perceived Fabric T to be better suited for a tote bag than for a short sleeve shirt. The median ranking of Fabric T was significantly different between the shorts and the bag. Subjects perceived Fabric T to be better suited for a tote bag than for shorts.

Table 30. *Wilcoxon Signed Rank Test: Comparison of Median Rankings by Products for all Subjects*

Products / Fabric ID	LS-SS		LS-SH		LS-B		SS-SH		SS-B		SH-B	
	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|	t	Prob>|t|
A	1627.0	**<.0001***	-3239.5	**<.0001***	-6135.0	**<.0001***	-5109.5	**<.0001***	-7329.5	**<.0001***	-4090.5	**<.0001***
B	865.0	**0.0251***	568.5	0.2986	-2344.5	**<.0001***	-515.0	0.2972	-3462.5	**<.0001***	-3108.0	**<.0001***
C	-382.0	0.4083	2355.0	**<.0001***	2534.0	**<.0001***	2842.5	**<.0001***	3231.5	**<.0001***	125.0	0.8149
D	-1345.0	**0.0069***	332.0	0.5501	1293.5	**0.0242***	1861.0	**0.0006***	3010.0	**<.0001***	963.0	0.0656
E	-1734.5	**0.0001***	-1266.0	**0.0174***	683.0	0.2413	552.5	0.2885	2467.5	**<.0001***	2166.5	**0.0001***
T	274.0	0.4283	1226.0	**0.0073***	4977.0	**<.0001***	1025.0	**0.0223***	4755.5	**<.0001***	3740.0	**<.0001***

Note. * indicates significance at a 95% confidence level. LS = long sleeve shirt, SS = short sleeve shirt, SH = shorts, B = bag.

Relationship between Attribute Ratings and Fabric Rankings

Comfort and Fabric Rankings

The comfort rating was significantly correlated to the ranking of woven fabrics A and B and nonwoven Fabric E for a *long sleeve button-down collared shirt* (see Table 31). The negative relationship between the two variables indicates the more comfortable the subject perceived these fabrics, the better they ranked them for a long sleeve shirt. However, the correlations of -0.1562, -0.1483, and -0.1757 indicate a weak association between the comfort rating and the fabric ranking for a long sleeve shirt.

The comfort rating was significantly correlated to the ranking of woven Fabric A for a *short sleeve button-down collared shirt*. The negative relationship between the two variables indicates the more comfortable the subject perceived Fabric A, the better they ranked Fabric A for a short sleeve shirt. However, the correlation of -0.2085 indicates a weak association between the comfort rating and the fabric ranking for a short sleeve shirt.

The comfort rating was significantly correlated to the ranking of woven Fabric C and nonwoven Fabric T for *shorts*. The negative relationship between the two variables indicates the more comfortable the subject perceived the fabrics, the better they ranked the fabrics for shorts. However, the correlations of -0.1456 and -0.1757 indicate a weak association between the comfort rating and the fabric ranking for shorts.

The comfort rating was significantly correlated to the ranking of woven Fabric A for a tote *bag*. The positive relationship between the two variables indicates the more comfortable the subject perceived Fabric A, the worse they ranked the fabric for a tote bag.

However, the correlation of 0.1446 indicates a weak association between the comfort rating and the fabric ranking for a tote bag.

Cool/Warm and Fabric Rankings

The cool/warm rating was not significantly correlated to the ranking of the fabrics (A, B, C, D, E, or T) for any of the four products. This indicates that subjects did not rank the products based on the thermal character of the fabric.

Smooth/Rough and Fabric Rankings

The smooth/rough rating was significantly correlated to the ranking of woven Fabric B and nonwoven Fabric T for a *long sleeve shirt*. The positive relationship between the two variables indicates the rougher the subject perceived the fabrics, the worse they ranked the fabrics for a long sleeve shirt. However, the correlations of 0.1576 and 0.1608 indicate a weak association between the smooth/rough rating and the fabrics ranking for a long sleeve shirt.

The smooth/rough rating was significantly correlated to the ranking of nonwoven Fabric T for a *short sleeve shirt*. The positive relationship between the two variables indicates the rougher the subject perceived Fabric T, the worse they ranked the fabric for a short sleeve shirt. However, the correlation of 0.1793 indicates a weak association between the smooth/rough rating and the fabric ranking for a short sleeve shirt.

The smooth/rough rating was significantly correlated to the ranking of nonwoven Fabric T for *shorts*. The positive relationship between the two variables indicates the rougher the subject perceived Fabric T, the worse they ranked the fabric for shorts. However, the

correlation of 0.1792 indicates a weak association between the smooth/rough rating and the fabric ranking for shorts.

The smooth/rough rating was significantly correlated to the ranking of woven Fabric C for a tote *bag.* The positive relationship between the two variables indicates the rougher the subject perceived Fabric C, the worse they ranked the fabric for a tote bag. However, the correlation of 0.1715 indicates a weak association between the smooth/rough rating and the fabric ranking for a tote bag.

Thin/Thick and Fabric Rankings

The thin/thick rating was not significantly correlated to the ranking of any fabrics (A, B, C, D, E, or T) for a *long sleeve shirt*. This indicates the subjects were not significantly influenced by the thin/thick attribute when ranking fabrics for a long sleeve shirt.

The thin/thick rating was significantly correlated to the ranking of nonwoven Fabric T for a *short sleeve shirt*. The positive relationship between the two variables indicates the thicker the subject perceived Fabric T, the worse they ranked the fabric for a short sleeve shirt. However, the correlation of 0.2094 indicates a weak association between the thin/thick rating and the fabric ranking for a short sleeve shirt.

The thin/thick rating was significantly correlated to the ranking of nonwoven Fabric T for *shorts*. The positive relationship between the two variables indicates the thicker the subject perceived Fabric T, the worse they ranked the fabric for shorts. However, the correlation of 0.1441 indicates a weak association between the thin/thick rating and the fabric ranking for shorts.

The thin/thick rating was not significantly correlated to the ranking of any fabrics (A, B, C, D, E, or T) for a tote *bag*. This indicates the subjects were not significantly influenced by the thin/thick attribute when ranking fabrics for a tote bag.

Flexible/Stiff and Fabric Ratings

The flexible/stiff rating was significantly correlated to the ranking of nonwoven Fabric E for *long sleeve shirt*. The positive relationship between the two variables indicates the stiffer the subject perceived Fabric E, the worse they ranked the fabric for a long sleeve shirt. However, the correlation of 0.1622 indicates a weak association between the flexible/stiff rating and the fabric ranking for a long sleeve shirt.

The flexible/stiff rating was significantly correlated to the ranking of woven Fabric C for a *short sleeve shirt*. The positive relationship between the two variables indicates the stiffer the subject perceived Fabric C, the worse they ranked the fabric for a short sleeve shirt. However, the correlation of 0.1482 indicated a weak association between the flexible/stiff rating and the fabric ranking for a short sleeve shirt.

The flexible/stiff rating was not significantly correlated to the ranking of any fabrics (A, B, C, D, E, or T) for *shorts* or a tote *bag*. This indicates the subjects were not significantly influenced by the flexible/stiff attribute when ranking fabrics for shorts or a tote bag.

Tight/Stretchy and Fabric Rankings

The tight/stretchy rating was not significantly correlated to the ranking of any fabrics (A, B, C, D, E, or T) for a *long sleeve shirt*. This indicates the subjects were not significantly influenced by the tight/stretchy attribute when ranking fabrics for a long sleeve shirt.

The tight/stretchy rating was significantly correlated to the ranking of woven Fabric B for a *short sleeve shirt*. The negative relationship between the two variables indicates the tighter the subject perceived Fabric B, the worse they ranked the fabric for a short sleeve shirt. However, the correlation of -0.1488 indicates a weak association between the tight/stretchy rating and the fabric ranking for a short sleeve shirt.

The tight/stretchy rating was significantly correlated to the ranking of woven Fabric C for *shorts*. The negative relationship between the two variables indicates the stretchier the subject perceived Fabric C, the better they ranked the fabric for shorts. However, the correlation of -0.1756 indicates a weak association between the tight/stretchy rating and the fabric ranking for shorts.

The tight/stretchy rating was not significantly correlated to the ranking of any fabrics (A, B, C, D, E, or T) for a tote *bag*. This indicates the subjects were not significantly influenced by the tight/stretchy attribute when ranking fabrics for a tote bag.

Table 31. *Spearman's Correlation Coefficient: Relationship between Attribute Ratings and Fabric Rankings*

Fabric A	**Long Sleeve**		**Short Sleeve**		**Shorts**		**Bag**	
	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|
Comfort	-0.1562	**0.0284***	-0.2085	**0.0033***	0.0845	0.2375	0.1446	**0.0427***
Cool/Warm	-0.0087	0.9036	-0.1215	0.0889	-0.0209	0.7703	-0.0179	0.8030
Smooth/Rough	0.0628	0.3805	0.1344	0.0597	-0.0239	0.7384	-0.0709	0.3222
Thin/Thick	0.0831	0.2459	-0.0392	0.5841	0.0897	0.2102	0.0526	0.4633
Flexible/Stiff	0.0123	0.8639	0.0561	0.4338	0.0696	0.3311	-0.0671	0.3487
Tight/Stretchy	-0.0166	0.8166	-0.0246	0.7320	0.0304	0.6711	-0.0734	0.3054
Fabric B	**Long Sleeve**		**Short Sleeve**		**Shorts**		**Bag**	
	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|
Comfort	-0.1483	**0.0376***	-0.1315	0.0654	0.0527	0.4623	0.0960	0.1796
Cool/Warm	0.0187	0.7947	-0.0162	0.8215	-0.0306	0.6692	-0.1235	0.0839
Smooth/Rough	0.1576	**0.0270***	0.1271	0.0751	-0.0930	0.1938	-0.0829	0.2467
Thin/Thick	-0.0189	0.7916	-0.1038	0.1465	-0.0379	0.5970	-0.0523	0.4658
Flexible/Stiff	0.1060	0.1382	0.0228	0.7500	0.0343	0.6323	-0.0175	0.8076
Tight/Stretchy	-0.0152	0.8321	-0.1488	**0.0369***	0.0119	0.8679	0.0179	0.8028
Fabric C	**Long Sleeve**		**Short Sleeve**		**Shorts**		**Bag**	
	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|
Comfort	-0.1009	0.1583	-0.1138	0.1113	-0.1456	**0.0412***	-0.1359	0.0569
Cool/Warm	0.1299	0.0688	0.1013	0.1567	-0.0074	0.9181	-0.0275	0.7016
Smooth/Rough	0.0931	0.1930	0.1261	0.0776	0.1243	0.0818	0.1715	**0.0160***
Thin/Thick	0.0578	0.4199	0.0643	0.3691	-0.0816	0.2542	-0.0165	0.8178
Flexible/Stiff	0.0826	0.2485	0.1482	**0.0377***	0.0616	0.3897	0.1001	0.1617
Tight/Stretchy	-0.0008	0.9908	-0.0213	0.7660	-0.1756	**0.0136***	-0.0308	0.6671
Fabric D	**Long Sleeve**		**Short Sleeve**		**Shorts**		**Bag**	
	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|
Comfort	-0.0645	0.3678	-0.1434	**0.0443***	0.0109	0.8786	0.0636	0.3746
Cool/Warm	0.0762	0.2875	-0.1105	0.1220	0.0243	0.7341	0.0794	0.2677
Smooth/Rough	0.0908	0.2044	0.1279	0.0732	0.0499	0.4859	0.0770	0.2821
Thin/Thick	0.0013	0.9853	0.0941	0.1885	0.1223	0.0870	-0.0551	0.4418
Flexible/Stiff	0.1179	0.0990	-0.0428	0.5507	-0.0312	0.6634	0.0728	0.3092
Tight/Stretchy	-0.0459	0.5221	0.0264	0.7124	0.0561	0.4339	-0.0231	0.7474
Fabric E	**Long Sleeve**		**Short Sleeve**		**Shorts**		**Bag**	
	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|
Comfort	-0.1757	**0.0135***	-0.0832	0.2453	-0.0658	0.3581	-0.0706	0.3242
Cool/Warm	0.0036	0.9603	0.0412	0.5657	0.0096	0.8933	0.0636	0.3744
Smooth/Rough	0.1374	0.0541	0.0837	0.2420	0.0401	0.5754	0.1128	0.1144
Thin/Thick	0.0865	0.2270	-0.0416	0.5621	-0.1018	0.1547	0.0636	0.3749
Flexible/Stiff	0.1622	**0.0228***	0.0310	0.6657	-0.0962	0.1789	-0.0204	0.7764
Tight/Stretchy	-0.0445	0.5349	-0.0241	0.7369	0.0432	0.5468	-0.0142	0.8434

Table 31. *Spearman's Correlation Coefficient: Relationship between Attribute Ratings and Fabric Rankings (cont.)*

Fabric T	Long Sleeve		Short Sleeve		Shorts		Bag	
	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|	ρ	Prob>|ρ|
Comfort	-0.1264	0.0768	-0.1324	0.0636	-0.1757	**0.0135***	0.0025	0.9727
Cool/Warm	-0.0381	0.5953	-0.0395	0.5820	0.0260	0.7173	-0.1152	0.1069
Smooth/Rough	0.1608	**0.0240***	0.1793	**0.0117***	0.1792	**0.0118***	-0.0587	0.4124
Thin/Thick	0.0360	0.6150	0.2094	**0.0032***	0.1441	**0.0434***	-0.0776	0.2782
Flexible/Stiff	-0.0276	0.7001	0.0738	0.3024	0.0967	0.1765	0.0610	0.3942
Tight/Stretchy	0.0754	0.2921	0.0509	0.4777	0.0686	0.3384	-0.0386	0.5901

Note. * indicates significance at a 95% confidence level. Fabrics A, B, and C are woven fabrics. Fabrics D, E, and T are nonwoven fabrics.

Summary of Results

Part I: Rating Summary Results

Summary of Fabric Ratings by Attribute

Using the results from the following three sections – Attribute Ratings of Nonwoven Fabrics in Comparison to Woven Fabrics, Attribute Ratings among Nonwoven Fabrics, and Attribute Ratings among Woven Fabrics – the information was gathered into tables, by attribute. The following six tables consolidate the information to show the difference between fabrics for each attribute. Each letter is given a symbol. Letters with the same symbol are not statistically significant. Letters with different symbols are significantly different. The fabrics without shading are woven fabrics; fabrics with light gray shading are nonwoven fabrics.

Comfort. Nonwoven Fabric D and woven Fabric A were rated the most comfortable and are significantly different from the other fabrics in terms of comfort (see Table 32). Woven Fabric C was not significantly different than nonwoven Fabric E. Also, nonwoven Fabric E was not significantly different than woven Fabric B. Woven Fabric B was not significantly different than nonwoven Fabric T.

Table 32. *Difference between Fabric Ratings for Comfort*

Fabric	Levels				Median Rating	
T	●				3	Slightly Uncomfortable
B	●	■			3	Slightly Uncomfortable
E		■	✸		4	Neither Comfortable nor Uncomfortable
C			✸		4	Neither Comfortable nor Uncomfortable
A				♦	5	Slightly Comfortable
D				♦	5	Slightly Comfortable

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.

Cool/Warm. Woven Fabric A was significantly different than the other fabrics and considered to be the coolest fabric among the six fabric samples (see Table 33). Woven fabrics C and B were not significantly different. Nonwoven fabrics T and D were also not significantly different. Nonwoven Fabric E was significantly different than all other fabrics in terms of the cool/warm rating. Fabric E was perceived to be the warmest fabric. In this case, the table clearly shows the woven fabrics are significantly different than the nonwoven fabrics. The nonwoven fabrics are perceived to be warmer than the woven fabrics.

Table 33. *Difference between Fabric Ratings for Cool/Warm*

Fabric	Levels				Median Rating†	
A	●				3	Slightly Cool
B		■			4	Neither Cool nor Warm
C		■			4	Neither Cool nor Warm
D			✸		4	Neither Cool nor Warm
T			✸		4	Neither Cool nor Warm
E				♦	5	Slightly Warm

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.
† The box plots were used to determine order when medians were the same but ratings were significantly different.

Smooth/Rough. Nonwoven Fabric D was significantly different than all other fabrics in terms of the smooth/rough rating (see Table 34). Woven Fabric C and nonwoven Fabric E were not significantly different and were perceived to have the same level of smoothness. These two fabrics were significantly different than the other four fabrics. Woven fabrics A and B were significantly different than all other fabrics. Nonwoven Fabric T was significantly different than all other fabrics and was rated the roughest of the fabrics.

Table 34. *Difference between Fabric Ratings for Smooth/Rough*

Fabric	Levels					Median Rating†	
D	●					3	Slightly Smooth
C		■				3	Slightly Smooth
E		■				3	Slightly Smooth
A			✸			4	Neither Smooth nor Rough
B				♦		5	Slightly Rough
T					▲	5	Slightly Rough

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.
† The box plots were used to determine order when medians were the same but ratings were significantly different.

Thin/Thick. Woven Fabric A was significantly different than all other fabrics in terms of the thin/thick rating (see Table 35). Fabric A was perceived to be the thinnest fabric among the six fabrics in the sample. Woven Fabric B was also significantly different than all other fabrics. However, woven Fabric C and nonwoven fabrics D, E, and T were not significantly different from one another indicating that subjects perceived these four fabrics to be of the same thickness. The table clearly shows that the nonwoven fabrics are significantly different than woven fabrics A and B but equal in thickness to woven Fabric C.

Table 35. *Difference between Fabric Ratings for Thin/Thick*

Fabric	Levels			Median Rating	
A	●			2	Thin
B		■		3	Slightly Thin
C			✸	4	Neither Thin nor Thick
D			✸	4	Neither Thin nor Thick
E			✸	4	Neither Thin nor Thick
T			✸	4	Neither Thin nor Thick

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.

Flexible/Stiff. Woven Fabric A was significantly different than all other fabrics indicating the fabric was perceived to be more flexible than the other five fabrics (see Table 36). Note woven Fabric B and nonwoven Fabric D are borderline significant with a p-value of 0.0519. They were treated as significantly different for this attribute. Also, nonwoven fabrics D and T were borderline significant with a p-value of 0.0502. These fabrics were also treated as significantly different. Therefore, nonwoven Fabric D and woven Fabric C were not significantly different. However, Fabric D was significantly different from nonwoven

fabrics E and T, but fabrics E and T were perceived to be equal. Woven Fabric C was equal to nonwoven T, but significantly different than nonwoven E. Woven Fabric B was equal to nonwoven fabrics E and T.

Table 36. *Difference between Fabric Ratings for Flexible/Stiff*

Fabric	Levels				Median Rating†	
A	●				3	Slightly Flexible
D		■			3	Slightly Flexible
C		■	✸		3	Slightly Flexible
B			✸	♦	3	Slightly Flexible
T			✸	♦	3	Slightly Flexible
E				♦	4	Neither Flexible nor Stiff

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.
† The box plots were used to determine order when medians were the same but ratings were significantly different.

Tight/Stretchy. Woven Fabric B was not significantly different than nonwoven Fabric E (see Table 37). Subjects perceived these fabrics to be the least stretchy among the six fabric samples. Woven Fabric A was significantly different from all other fabrics and perceived to be less tight than fabrics B and E. Nonwoven fabrics D and T were not significantly different, and therefore, perceived to be the same level of stretchiness. Woven Fabric C was significantly different than the other five fabrics and was perceived to be the stretchiest fabric.

Table 37. *Difference between Fabric Ratings for Tight/Stretchy*

Fabric	Levels				Median Rating†	
B	●				2	Tight
E	●				2	Tight
A		■			3	Slightly Tight
D			✸		5	Slightly Stretchy
T			✸		5	Slightly Stretchy
C				♦	5	Slightly Stretchy

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.
† The box plots were used to determine order when medians were the same but ratings were significantly different.

Summary of Gender Influence on Fabric Ratings

Male and female subject comfort ratings were not significantly different for five of the six fabrics. Woven Fabric B was the only fabric rated differently based on gender. Females perceived Fabric B to be slightly less comfortable than the males. Gender had more of an influence on the cool/warm rating where statistical significance occurred for half of the fabrics. The females rated woven Fabric C, and nonwoven fabrics D and E, warmer than the males. However, gender did not influence the smooth/rough, thin/thick, or tight/stretchy ratings for any of the six fabrics. Gender was related to the flexible/stiff ratings for only one fabric, nonwoven Fabric T. Females perceived Fabric T to be stiffer than the male subjects. Gender does not have an overwhelming significant influence on the chosen ratings for comfort and the five attributes included in this study.

Summary of Age Influence on Fabric Ratings

Age was significantly related to the comfort rating for four of the six fabrics in the study, woven fabrics A, B, and C and nonwoven Fabric E. The older the subject, the more

comfortable they perceived the woven fabrics and less comfortable they perceived Fabric E. Age was also significantly related to the smooth/rough rating for four of the six fabrics, woven fabrics A and B, and nonwoven fabrics E and T. The older the subject, the smoother they perceived fabrics A, B, and T, and the rougher they perceived Fabric E. However, age was only significantly related to thin/thick for woven fabrics A and B, in which the older the subject the thicker they perceived these two fabrics. Nonwoven Fabric E showed the only significant correlation between age and the cool/warm rating. The older the subject, the cooler they perceived Fabric E. Woven Fabric B was the only significant correlation between age and the tight/stretchy rating, in which the older the subject the stretchier Fabric B was perceived. There was no significant relation between age and the flexible/stiff fabric rating. While age appeared to have more influence on ratings than gender did, overall, age was not overwhelmingly associated with fabric ratings.

Summary of Relationships between Attributes

Comfort was not significantly related to cool/warm or thin/thick. However, comfort was negatively significantly related to the smooth/rough attribute for all fabrics. Comfort was negatively significantly related to flexible/stiff for four of the six sample fabrics, woven fabrics A and C and nonwoven fabrics D and T. Comfort was positively significantly related to tight/stretchy for only nonwoven Fabric T. The results indicated certain attributes influence the perception of comfort more than other attributes.

The cool/warm attribute was not significantly related to the flexible/stiff or tight/stretchy attributes. Cool/warm was positively significantly related to smooth/rough, but only for woven Fabric A. There was a positive significant correlation between cool/warm and

thin/thick indicating the warmer the fabrics were perceived, the thicker they were perceived. However, this was only significant for the nonwoven fabrics (D, E, T). There was a positive significant correlation between smooth/rough and thin/thick for nonwoven Fabric E. Smooth/rough was positively significantly related to flexible/stiff but only for woven Fabric C and nonwoven Fabric E. There was a negative significant correlation between smooth/rough and tight/stretchy but only for woven Fabric C. The thin/thick attribute and the flexible/stiff attribute were positively significantly related for all fabrics, except for nonwoven Fabric E. The thin/thick attribute was positively significantly related to tight/stretchy for woven fabrics B and C. Finally, flexible/stiff and tight/stretchy were negatively significantly related, but only for woven Fabric C.

Part II: Ranking Summary Results

Summary of Fabric Rankings by Product

Using the results from the following three sections – Fabric Rankings of Nonwoven Fabrics in Comparison to Woven Fabrics, Fabric Rankings among Nonwoven Fabrics, and Fabric Rankings among Woven Fabrics – the information was gathered into tables, by product. The following four tables consolidate the information to show the differences between fabrics for each attribute. Each letter is given a symbol. Letters with the same symbol are not statistically significant. Letters with different symbols are significantly different. The fabrics without shading are the woven fabrics while the fabrics with light gray shading are the nonwoven fabrics.

Long Sleeve Shirt. Woven Fabric A was significantly different than the other five fabrics and perceived to be the best fabric for a long sleeve button-down collared shirt (see Table 38). Woven fabrics B and C and nonwoven Fabric D were not significantly different indicating subjects perceived these to be equally liked for a long sleeve shirt. Nonwoven fabrics D and E were not significantly different. However, nonwoven Fabric T was significantly different than all other fabrics and was perceived to be the least preferred fabric for a long sleeve button-down collared shirt.

Table 38. *Difference between Fabric Rankings for a Long Sleeve Shirt*

Fabric	Levels				Ranking	
A	●				2	Best
B		■			3	
C		■			3	
D		■	✸		4	
E			✸		4	
T				♦	5	Worst

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.

Short Sleeve Shirt. Woven Fabric A was significantly different than all other fabrics when ranking for a short sleeve button-down collared shirt (see Table 39). Fabric A was perceived to be the best fabric for a short sleeve shirt. Woven Fabric B was also significantly different than all other fabrics and ranked second best for a short sleeve shirt. Woven Fabric C was significantly different than all other fabrics as well. However, nonwoven fabrics D and E were not significantly different and were ranked equally. Nonwoven fabric E and T were also not significantly different. The table clearly shows the nonwoven fabrics were

significantly different from woven fabrics, indicating the subjects preferred woven fabrics over nonwoven fabrics for a short sleeve shirt.

Table 39. *Difference between Fabric Rankings for a Short Sleeve Shirt*

Fabric	Levels					Ranking	
A	●					1	Best
B		■				2	
C			✸			3	
D				♦		4	
E				♦	▲	4	
T					▲	5	Worst

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.

Shorts. Woven Fabric C was significantly different than the other fabrics when ranking for a pair of shorts (see Table 40). Fabric C was perceived to be the best fabric for a pair of shorts. Woven Fabric B was also significantly different than the other fabrics and was perceived to be the second best fabric for a pair of shorts. Nonwoven Fabric D and woven Fabric A were not significantly different indicating they were equally preferred for a pair of shorts. Nonwoven fabrics E and T were also not significantly different. They were the least preferred fabrics for a pair of shorts.

Table 40. *Difference between Fabric Rankings for a pair of Shorts*

Fabric	Levels				Ranking†	
C	●				2	Best
B		■			3	
D			✸		3	
A			✸		3	
E				♦	4	
T				♦	5	Worst

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.
† The box plots were used to determine order when medians were the same but rankings were significantly different.

Bag. Woven Fabric C and nonwoven Fabric T were not significantly different and preferred equally (see Table 41). These fabrics were preferred over the other fabrics for a tote bag. Nonwoven fabrics T and D were not significantly different and nonwoven Fabric E was not significantly different than woven Fabric B. However, woven Fabric A was significantly different than the other five fabrics and perceived to be the worst fabric for a tote bag.

Table 41. *Difference between Fabric Rankings for a Bag*

Fabric	Levels				Ranking	
C	●				2	Best
T	●	■			3	
D		■			3	
E			✸		3	
B			✸		4	
A				♦	6	Worst

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.

Summary of Gender Influence on Fabric Rankings

Gender was not significantly related to the choice of fabric rankings for a long sleeve button-down collared shirt or a pair of shorts. When ranking fabrics for a short sleeve button-down collard shirt and a tote bag, gender was significantly related to the fabric rankings for only two fabrics. In the case of the short sleeve shirt, gender was associated with the rankings of woven fabric A and C. Female subjects perceived Fabric A to be better for a short sleeve shirt than the male subjects, but the females perceived Fabric C to be worse than the males. As for the tote bag, gender was associated to the ranking choices for only woven Fabric A and nonwoven Fabric E. With regard to the tote bag, the females perceived Fabric A to be worse than the males, but the females perceived Fabric E to be better than the males. Overall, gender did not have an association to the fabric ranking choices for the four general products.

Summary of Age Influence on Fabric Rankings

Age was not significantly related to the fabric rankings for a long sleeve shirt or short sleeve shirt. With regard to shorts, however, age was significantly related to half of the fabric, woven Fabric B, and nonwoven fabrics D and E. The older the subject, the worse they ranked woven Fabric B, but the better they ranked nonwoven fabrics D and E. Age was also significantly related to half of the fabric rankings for a tote bag, woven fabrics A and B, and nonwoven Fabric T. The older the subject, the worse they ranked woven fabrics A and B, but the better they ranked nonwoven Fabric T. Age did not influence the fabric rankings of the shirts, but did appear to have a slight influence on the shorts and tote bag.

Summary of Fabric Rankings between Products

Table 42 displays a summary of the results from the "Fabric Rankings among Products" section. If products are labeled with the same symbol, than the fabric ranking for those products were not significantly different. Woven Fabric A was the only fabric that was ranked differently for each product. Fabric A was more preferred for top weights and not perceived as suitable material for a tote bag. Woven Fabric B was not preferred for a bag and perceived as slightly better for apparel items. The ranking of woven Fabric C was not significantly different for the long sleeve and short sleeve shirts. However, the shirt rankings were significantly different than the shorts and bag rankings. Fabric C was preferred more for a pair of shorts and a bag than it was for a shirt. Nonwoven Fabric D ranking for a short sleeve shirt was a significantly different ranking than for the other three products. Fabric D was ranked mid-range for all products and was not highly preferred for one product or another. Nonwoven Fabric E was also ranked mid-range and not highly preferred for one product or another. The long sleeve shirt and short sleeve shirt rankings of nonwoven Fabric T were not significantly different, indicating Fabric T was equally ranked for the shirts. Subjects did not perceive Fabric T to be suitable for apparel and was perceived to be more suitable for a tote bag.

Table 42. *Summary of Fabric Rankings between Products*

Fabric A	Levels				Median Ranking
Long Sleeve	●				2
Short Sleeve		■			1
Shorts			✸		3
Bag				♦	6
Fabric B					
Long Sleeve	●				3
Short Sleeve		■			2
Shorts	●	■			3
Bag			✸		4
Fabric C					
Long Sleeve	●				3
Short Sleeve	●				3
Shorts		■			2
Bag		■			2
Fabric D					
Long Sleeve	●				4
Short Sleeve			✸		4
Shorts	●	■			3
Bag		■			3
Fabric E					
Long Sleeve	●				4
Short Sleeve		■			4
Shorts		■			4
Bag	●				3
Fabric T					
Long Sleeve	●				5
Short Sleeve	●				5
Shorts		■			5
Bag			✸		3

Note. Levels not connected by the same symbol are significantly different. 1=best, 6=worst.

Summary of Relationships between Attributes and Products

Comfort was significantly related to the long sleeve shirt for half the fabrics, woven fabrics A and B and nonwoven Fabric E. Comfort was significantly related to shorts for two

of the six fabrics, woven Fabric C and nonwoven Fabric T. Comfort was significantly related to the short sleeve shirt and the bag for only one fabric, woven Fabric A. The cool/warm attribute was not significantly related to the fabric rankings for any of the products. The smooth/rough attribute was not overwhelmingly related to the ranking of the fabrics. The attribute was significantly related to the rankings of woven Fabric B and nonwoven Fabric T for a long sleeve shirt. The smooth/rough rating was significantly related to the short sleeve shirt and the pair of shorts for only one fabric, nonwoven Fabric T. The attribute was also significantly related to a bag, but only for woven Fabric C. The thin/thick attribute was not related to a long sleeve shirt or a tote bag. The thin/thick attribute was significantly related to the short sleeve shirt and shorts for only one fabric, nonwoven Fabric T. The flexible/stiff attribute was not significantly related to a pair of shorts or to a bag. The attribute was significantly related to the long sleeve and short sleeve shirts for only one of the six fabrics, nonwoven E and nonwoven C, respectfully. Similar to the thin/thick attribute, tight/stretchy was not significantly related to the long sleeve shirt or to a tote bag. The tight/stretchy attribute was, however, significantly related to the short sleeve shirt for woven Fabric B and to the pair of shorts for woven Fabric C.

CHAPTER V: SUMMARY, CONCLUSIONS, & FUTURE RESEARCH

Summary

Technological advancements have made great strides in the development of nonwoven fabrics. New generations of nonwoven fabrics are more durable, have better drape, are stretchable, and overall have a better hand than past generations of nonwoven fabrics. With these advancements come new product development opportunities. One possible opportunity is expansion into the apparel and accessories market, not as a support fabric, but as the shell (visible, outside) fabric.

The purpose of this study was to determine the consumer's acceptance of nonwoven fabrics for apparel and accessory end-uses through the use of subjective fabric hand evaluation. The research questions were as follows:

1. How do nonwoven fabrics compare to woven fabrics?
    a. How do nonwoven fabrics *rate* in comparison to woven fabrics for comfort and fabric attributes (cool/warm, smooth/rough, thin/thick, flexible/stiff, tight/stretchy)?
    b. How do nonwoven fabrics *rank* in comparison to woven fabrics for general apparel and accessory products (long sleeve button-down shirt, short sleeve button-down shirt, pleated shorts, bag)?
2. How do nonwoven fabrics compare to one another?

a. How do nonwoven fabrics *rate* among one another for comfort and fabric attributes (cool/warm, smooth/rough, thin/thick, flexible/stiff, tight/stretchy)?

b. How do nonwoven fabrics *rank* among one another for general apparel and accessory products (long sleeve button-down shirt, short sleeve button-down shirt, pleated shorts, bag)?

3. Does gender and age affect consumer acceptance of nonwoven fabrics?

    a. Does *gender* influence fabric rating and ranking responses?

    b. Does *age* influence fabric rating and ranking responses?

A review of the literature was conducted to guide the development of an appropriate subjective fabric hand evaluation method to study the average consumer's acceptance of traditional woven fabrics versus spunlaced (spunbond and hydroentangled) nonwoven fabrics. With no one subjective fabric hand method being considered the standard, it is not a surprise that literature showed researchers have used numerous methods. However, Bishop (1996) has noted six key elements to consider when developing a subjective fabric hand evaluation methodology. In the development of this study, these six elements were considered, in addition to three key publications: Civille and Dus (1990); Cardello, Witherhalter, and Schutz (2003); and the AATCC Evaluation Procedure 5: Guidelines for the Subjective Evaluation of Fabric Hand (2006).

Prior to conducting the experiment, the fabrics were chosen and prepared for testing. Three woven fabrics were chosen based on their common and wide spread use in apparel products. Three spunlaced nonwoven fabrics were chosen, one because it was a commercial

product and the other two because they represent the most recent generation of nonwoven fabrics. A pretest was conducted to finalize experimental design and fabric selection. To emulate the dying process of the woven fabrics, the nonwoven fabrics were run through a blank dye cycle, dried, and ironed using a laminator set on low heat. All six samples were cut to 8 x 8 inches (20.3cm x 20.3cm), labeled with a permanent marker, ironed, and lint rolled before subject evaluation.

The experiment was comprised of two parts, a rating and a ranking section, which were conducted simultaneously. In Part I of the experiment, the subjects were asked to rate each of the six fabrics for comfort and five different attributes – cool/warm, smooth/rough, thin/thick, flexible/stiff, and tight/stretchy. The samples were presented to the subjects, one at time, in random order, and kept from their view.

In Part II of the experiment, the subjects conducted a simple ranking procedure. They were shown four images, one a time, in random order. The four images included a short sleeve button-down collared shirt, a long sleeve button-down collared shirt, a pair of pleated shorts, and a bag. Once the subjects were shown an image, they were asked to put on a blindfold to prevent them from seeing the fabric. The six fabric samples were placed in front of the subjects in random order, on a non-textured, non-metal table. The subjects were asked to rank the fabrics in order from the most desirable (best) fabric to the least desirable (worst) fabric for the image. Through the use of the statistical software JMP, nonparametric statistics were conducted to analyze the data and respond to the research questions.

Summary of Results

RQ 1: How do nonwoven fabrics compare to woven fabrics?

RQ 1a. How do nonwoven fabrics *rate* in comparison to woven fabrics for comfort and each attribute (cool/warm, smooth/rough, thin/thick, flexible/stiff, tight/stretchy)?

Comfort depended more on the fabric and not necessarily whether the fabric was a woven or nonwoven. Nonwoven Fabric D was equally or more comfortable than the woven fabrics and nonwoven fabrics E and T were equally or less comfortable than the woven fabrics. Woven Fabric A and nonwoven Fabric D were of equal comfort, but Fabric D was better than the other two woven fabrics, B and C. Woven Fabric A was more comfortable than nonwovens E and T, but woven Fabric B was equally comfortable to nonwovens E and T. As for woven Fabric C, nonwoven Fabric E was equally comfortable, and nonwoven Fabric T was less comfortable than woven Fabric C.

The nonwoven fabrics were perceived to be *warmer* than the woven fabrics. In terms of the *smooth/rough* attribute, the woven fabrics were different than the nonwoven fabrics, except for woven Fabric C and nonwoven Fabric E, which were perceived to be equal in smoothness. Overall, nonwoven fabrics D and E were perceived to be smoother than the woven fabrics while nonwoven Fabric T was perceived to be rougher than the woven fabrics. As for the *thin/thick* attribute, woven fabrics A and B were thinner than the nonwoven fabrics; however, woven Fabric C was equal in thickness to the nonwoven fabrics. When rated for the *flexible/stiff* attribute, woven Fabric A was more flexible than the nonwoven fabrics, but woven Fabric B was equal to the nonwoven fabrics. Woven Fabric C was equally as flexible as nonwoven fabrics D and T and more flexible than nonwoven Fabric E. When

rating for the *tight/stretchy* attribute, the woven and nonwoven fabrics were different except for woven Fabric B and nonwoven Fabric E which were rated equally. Nonwoven Fabric E was tighter than woven Fabric A, but Fabric A was tighter than nonwoven fabrics D and T, which were perceived to be slightly stretchy. Woven Fabric B was also tight in comparison to nonwoven fabrics D and T. However, woven Fabric C was stretchier than the nonwoven fabrics.

RQ 1b. How do nonwoven fabrics *rank* in comparison to woven fabrics for general apparel and accessory products (long sleeve shirt, short sleeve short, shorts, bag)?

Overall, woven fabrics were preferred over nonwoven fabrics for apparel. There appears to be an opportunity for nonwoven fabrics in accessory products. For a *long sleeve shirt*, the woven fabrics were preferred over the nonwoven fabrics, except for nonwoven Fabric D, which was equally preferred to woven fabrics B and C. Woven Fabric A was perceived to be better than all nonwoven fabrics for a long sleeve shirt. Nonwoven Fabric T was the least preferred. The woven fabrics were preferred over the nonwoven fabrics for a *short sleeve shirt*. Woven fabrics were also preferred over nonwoven fabrics for a pair of *shorts*, except for fabrics A and D, which were equally preferred for a pair of shorts. Nonwoven fabrics E and T were least preferred.

The tote *bag* results showed a different trend than the three garments. All three nonwovens were preferred over woven Fabric A for a tote bag. Also, nonwoven fabrics D and T were preferred over woven Fabric B, but nonwoven Fabric E was equally preferred to woven Fabric B. Woven Fabric C was the only woven fabric perceived to be better than the nonwovens for a tote bag; except for nonwoven Fabric T, which was equally preferred to

woven Fabric C. Overall, there appears to be a market opportunity for nonwoven fabrics in a tote bag or similar accessory products.

RQ 2: How do nonwoven fabrics compare to one another?

RQ 2a. How do nonwoven fabrics *rate* among one another for comfort and each attribute (cool/warm, smooth/rough, thin/thick, flexible/stiff, tight/stretchy)?

The nonwoven fabrics similarities and differences varied among attributes. Subjects perceived the nonwovens to be the same for only one attribute, *thin/thick*. The fabrics were all perceived to be different for *comfort* and for the *smooth/rough* attribute with Fabric D being the most comfortable and the smoothest, and Fabric T being the least comfortable and the roughest. Fabrics D and T were perceived to be the same for *cool/warm* and *tight/stretchy*. In this case, subjects perceived Fabric E to be warmer and tighter. Finally, Fabric D was perceived to be more *flexible* than fabrics E and T, but note, the significance between fabrics D and T were borderline with a p-value of 0.0502.

RQ 2b. How do nonwoven fabrics *rank* among one another for general apparel and accessory products (long sleeve shirt, short sleeve short, shorts, bag)?

Fabrics D and E were equally ranked for a *long sleeve* and *short sleeve shirt*. Fabric T was ranked worse than fabrics D and E for a long sleeve shirt and worse than Fabric D for a short sleeve shirt. Fabrics E and T were ranked worse than Fabric D for a pair of *shorts*. Fabric E was ranked worse than fabrics D and T for a tote *bag*.

RQ 3: Does gender and age affect consumer acceptance of nonwoven fabrics?

RQ 3a. Does gender influence fabric rating and ranking responses?

i. Does *gender* influence fabric *rating* responses?

Overall, gender did not influence the rating of fabrics for comfort and various attributes. Gender did not influence the fabric ratings for *smooth/rough*, *thin/thick*, or *tight/stretchy*. However, females perceived woven Fabric B to be slightly less *comfortable*, and nonwoven Fabric T to be slightly *stiffer* than the males perceived these fabrics. *Cool/Warm* was the only attribute where gender appeared to have a slight influence on fabric ratings. For three of the six fabrics, males and females rated the fabrics differently. For woven Fabric C, and nonwoven fabrics D and E, the females perceived the fabrics to be warmer than the males perceived the fabrics.

ii. Does *gender* influence fabric *ranking* responses?

Overall, gender did not influence the ranking of fabrics. Gender did not influence the ranking of fabrics for a *long sleeve button-down collared shirt* and a pair of *shorts*. Gender did have an influence on only two fabric rankings for a *short sleeve button-down collared shirt*. Females perceived woven Fabric C to be worse for a short sleeve shirt than males. Females perceived woven Fabric A to be better for a short sleeve shirt than males. Gender also had an influence on two fabric rankings for a tote *bag*. The females perceived woven Fabric A to be worse for a tote bag than males. Females perceived nonwoven Fabric E to be better for the tote bag than males.

RQ 3b. Does age influence fabric rating and ranking responses?

i. Does *age* influence fabric *rating* responses?

Overall, age did not have much influence on fabric ratings, but age did appear to have a slight influence on the *comfort* and *smooth/rough* ratings. The older the subject the more comfortable they perceived woven fabrics A, B, and C but the less comfortable they perceived nonwoven Fabric E. Also, the older the subject the smoother they perceived woven fabrics A and B, and nonwoven Fabric T, but the rougher they perceived nonwoven Fabric E. Age had less of an influence on the *thin/thick* rating with only two fabrics being significantly related. The older the subject, the thicker they perceived woven fabrics A and B. The *cool/warm* and *tight/stretchy* attributes were significantly related to age for only one fabric. The older the subject the cooler they perceived nonwoven Fabric E and the stretchier they perceived woven Fabric B. There was no correlation between age and the *flexible/stiff* rating.

ii. Does *age* influence fabric *ranking* responses?

Age did not influence the fabric rankings for *long sleeve* or *short sleeve shirt*, but age did have a slight influence on the *shorts* and tote *bag*. The older the subject, the worse they ranked woven Fabric B for a pair of shorts, but the better they ranked nonwoven fabrics D and E. As for a tote bag, the older the subject, the worse they ranked woven fabrics A and B but the better they ranked nonwoven Fabric T.

Conclusion

Part I: Rating

Fabric Attribute Ratings

Comfort. Table 43 displays the fabric rankings based on perception of comfort level. The nonwoven and woven fabrics were intermixed. The nonwoven fabrics had significantly different comfort ratings with Fabric D being most comfortable, followed by Fabric E, and Fabric T being the least comfortable of the nonwovens. The comfort ratings were negatively significantly correlated to the smooth/rough attribute for all fabrics; indicating the smoother the fabric the more comfortable the fabric was perceived. However, woven Fabric A was ranked out of order from the relation to smoothness. This may be due to the comfort rating of Fabric A also being related to the flexible/stiff attribute. Since Fabric A was rated the most flexible fabric, it may explain why Fabric A was rated more comfortable than it was smooth.

Table 43. *Comfort Fabric Ratings*

Fabric	Levels				Median Rating	
T	●				3	Slightly Uncomfortable
B	●	■			3	Slightly Uncomfortable
E		■	✸		4	Neither Comfortable nor Uncomfortable
C			✸		4	Neither Comfortable nor Uncomfortable
A				♦	5	Slightly Comfortable
D				♦	5	Slightly Comfortable

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.

Cool/Warm. The nonwoven fabrics were significantly warmer than the woven fabrics (see Table 44). Nonwoven fabrics D and T were significantly different than nonwoven Fabric E, which was perceived to be slightly warmer. The cool/warm ratings were positively significantly related to the thin/thick attribute for fabrics B, D, E, and T, indicating that the thicker the fabric, the warmer the fabric was perceived. The cool/warm rating order follows the thin/thick rating order. Other contributing factors to the difference between the woven and nonwoven fabrics could be that the woven fabrics are a cotton blend. None of the nonwoven fabrics contain cotton.

Table 44. *Cool/Warm Fabric Ratings*

Fabric	Levels				Median Rating†	
A	●				3	Slightly Cool
B		■			4	Neither Cool nor Warm
C		■			4	Neither Cool nor Warm
D			✸		4	Neither Cool nor Warm
T			✸		4	Neither Cool nor Warm
E				♦	5	Slightly Warm

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.
† The box plots were used to determine order when medians were the same but ratings were significantly different.

Smooth/Rough. The nonwoven fabrics were intermixed with the woven fabrics. However, the nonwoven fabrics were all significantly different. Fabric D was the smoothest of the nonwoven fabrics, followed by Fabric E. Fabric T was the least smooth, or roughest. The smooth/rough ratings were not overwhelmingly significantly related to another attribute that was included in this study. However, fabric structure could explain the order of the

ratings. Woven fabric D was the smoothest of the fabrics. The structure of a spunlaced nonwoven is smoother than the natural texture of a woven fabric. Nonwoven fabric E is also a spunlaced nonwoven but may be perceived to be rougher than Fabric D because of the difference in fiber structure. Fabric D is an island-in-the-sea structure; the fibers are split during hydroentangling, creating round and smooth microfibers. However, Fabric E is a segmented pie structure; when the fibers split, the microfibers are pointed like a pie slice and can produce a "grabby" feeling that "picks" at ones skin, especially if the skin is dry. Woven Fabric C is a sateen weave, while woven fabrics A and B are a plain weave. Why Fabric A was perceived to be smoother than Fabric B is unknown. However, there could be several structural reasons including, fiber quality, yarn type, yarn denier, picks per inch. Nonwoven Fabric T was rated the roughest fabric. This fabric was a spunlaced fabric like the other nonwovens, but a texture was added during the hydroentangling process. This made the texture on the fabric surface much more pronounced in comparison to the other five fabrics in the study.

Table 45. *Smooth/Rough Fabric Ratings*

Fabric	Levels					Median Rating†	
D	●					3	Slightly Smooth
C		■				3	Slightly Smooth
E		■				3	Slightly Smooth
A			✸			4	Neither Smooth nor Rough
B				♦		5	Slightly Rough
T					▲	5	Slightly Rough

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.
† The box plots were used to determine order when medians were the same but ratings were significantly different.

Thin/Thick. The nonwoven fabrics were rated differently than the woven fabrics, except for woven Fabric C which was rated equally as thick as the nonwoven fabrics. The nonwoven fabrics were equally rated in thickness. The thin/thick attribute is positively significantly related to the flexible/stiff attribute for all but nonwoven Fabric E. Indicating that the thin/thick fabric ratings were heavily influenced by the flexibility of the fabrics. The more flexible the fabric, the thinner the fabric was perceived. Subject thickness ratings were also in line with the objective thickness measures. Fabric A was the thinnest fabric, 0.30mm, Fabric B was slightly thicker, 0.36mm, and fabrics C, D, E, and T are as follows, 0.44mm, 0.58mm, 0.60mm, and 0.49mm. However, the difference between the thickness of fabrics A and B indicates that subjects would be able to determine a difference between Fabric C and the nonwoven fabrics, indicating that other factors are influencing the thin/thick rating, or at a certain thickness, subjects can not perceive a difference. These results indicated that fabric buyers could not go by traditional apparel fabrics weights when purchasing nonwoven fabrics. For example, a spunlaced nonwoven with the same weight as a woven would be considerably thicker than a woven fabric.

Table 46. *Thin/Thick Fabric Ratings*

Fabric	Levels			Median Rating	
A	●			2	Thin
B		■		3	Slightly Thin
C			✸	4	Neither Thin nor Thick
D			✸	4	Neither Thin nor Thick
E			✸	4	Neither Thin nor Thick
T			✸	4	Neither Thin nor Thick

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.

Flexible/Stiff. The woven fabrics were intermixed with the nonwoven fabrics. Nonwoven D was significantly different than nonwoven fabrics E and T. The flexible/stiff ratings were positively significantly related to the thin/thick attribute for all fabrics except nonwoven Fabric E. However, a weak correlation indicates there are other factors, outside of the factors included in this study, which are contributing the flexible/stiff ratings. This may explain why the rating order is not the same as the thin/thick rating order.

Table 47. *Flexible/Stiff Fabric Ratings*

Fabric	Levels				Median Rating†	
A	●				3	Slightly Flexible
D		■			3	Slightly Flexible
C		■	✸		3	Slightly Flexible
B			✸	♦	3	Slightly Flexible
T			✸	♦	3	Slightly Flexible
E				♦	4	Neither Flexible nor Stiff

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.
† The box plots were used to determine order when medians were the same but ratings were significantly different.

Tight/Stretchy. The woven and nonwoven fabrics were intermixed. Nonwoven Fabric E was perceived to be tight while nonwoven fabrics D and T were perceived to be equally stretchy. The tight/stretchy ratings were not overwhelming significantly related to another attributes included in this study. However, other factors, such as fiber content and fabric construction could be influencing the ratings. For example, nonwoven Fabric T contains an elastomer, as well as woven Fabric C which contains spandex.

Table 48. *Tight/Stretchy Fabric Ratings*

Fabric	Levels				Median Rating†	
B	●				2	Tight
E	●				2	Tight
A		■			3	Slightly Tight
D			✸		5	Slightly Stretchy
T			✸		5	Slightly Stretchy
C				♦	5	Slightly Stretchy

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.
† The box plots were used to determine order when medians were the same but ratings were significantly different.

Gender Influence

Overall, gender did not have a significant influence on comfort and the five fabric attribute ratings. Gender did not influence fabric ratings for the *smooth/rough*, *thin/thick*, or *tight/stretchy* attributes. However, *cool/warm* ratings and gender were significantly different for three of the six fabrics, woven Fabric C and nonwoven fabrics D and E. Females perceived these three fabrics to be warmer than the male subjects perceived these fabrics. Gender was significantly related to the *flexible/stiff* attribute, but only for nonwoven Fabric T; females perceived the fabric to be stiffer than the males. *Comfort* ratings were significantly different between genders, but only for woven Fabric B, which was perceived to be less comfortable by the females than by the males. The "Relationship between Comfort and Attribute Ratings" result section indicates that comfort and the smooth/rough attribute are related. However, the gender ratings were not different for smooth/rough. Since, males and females perceived Fabric B to have the same roughness, but the females perceived Fabric B to be less comfortable, it may be concluded that females find rougher fabrics less

comfortable than the males. However, this was only significant for one fabric, and while Fabric T was borderline significant at p-value of 0.0517. There are not enough gender ratings that are significantly different to confidently state that gender influences comfort ratings.

Age Influences

Overall, age did not influence the ratings of the attributes used in this study, except for the comfort and smooth/rough ratings. Therefore, it appears that age affected only the attributes that involved the surface of the fabrics. If the fabric had a texture, for instance the natural texture of the woven fabrics (A, B, C) and the intentional texture added to nonwoven Fabric T, the older the subject, the smoother they perceived the fabric. This may also explain why the older the subject, the more comfortable they perceived woven fabrics (A, B, C). Age significantly influenced the thin/thick rating, but only for woven fabrics A and B. The older the subject, the thicker they perceived these fabrics to be. The cool/warm and tight/stretchy attributes were also significantly related to age, but only for one fabric. The older the subject, the cooler they perceived nonwoven Fabric E, and the stretchier they perceived woven Fabric B.

Attribute Relationships

Certain attributes influence the perception of comfort more than others. The *smooth/rough* attribute was the only attribute that was significantly related to comfort for all six fabrics. The negative relation indicates the smoother the subject perceived the fabric, the more comfortable they perceived the fabric. Comfort also showed a relation to the *flexible/stiff* attribute with four of the six fabrics (A, C, D, T) being negatively significantly correlated. Overall, it appears that when a subject was rating comfort, which they rated first

for each fabric, they were heavily influenced by the smoothness or roughness of the fabric. Note that these relationships were weak, indicating other factors could be influencing the comfort rating. Since, flexible/stiff was correlated to smooth/rough for only woven Fabric C, it appears the weak relationship between smooth/rough and comfort is due to factors that were not part of this study. Furthermore, individual differences in a human's "sense of touch" and their personal opinion could explain a weak relationship.

In terms of the five attributes used in this research, cool/warm and thin/thick, as well as thin/thick and flexible/stiff, were, overall, related. A positive correlation indicates the warmer the subject perceived the fabric, the thicker they perceived the fabric. This follows logical sense that a thicker fabric would be perceived to provide more warmth. The attributes were significantly correlated for the nonwoven fabrics (D, E, T). As for the relationship between the thin/thick and flexible/stiff attributes, a positive significant correlation indicates the thicker the subject perceived the fabric, the stiffer they perceived the fabric. Not surprisingly, five of the six fabrics were significantly related; as a fabric increases in thickness, so does the stiffness. However, while significant, the correlations were weak, which is not unexpected for human subjects, especially those consumers who are not trained in fabric hand evaluation. It is possible, as untrained subjects, that they were allowing other factors to influence their rating responses even though they were rating one attribute at a time. This was supported in the literature (Bishop, 1996; Brand, 1964; Philippe et al., 2003; Zeng & Koehl, 2003).

Part II: Ranking

Fabric Rankings

Long Sleeve Shirt. Except for nonwoven Fabric D, the woven fabrics were preferred over the nonwoven fabrics for a long sleeve shirt. Nonwoven fabrics D and E were equally preferred. Nonwoven T was least preferred. There were no overwhelmingly significantly related attributes to explain the fabric rankings. However, woven fabrics A and B, and nonwoven Fabric E, was negatively significantly related to comfort. Woven Fabric B, and nonwoven fabrics E and T, were positively significantly related to smoothness. Based on these results and the fabric medians, woven Fabric B and nonwoven Fabric E should have been ranked more similarly. A further review of the data indicated the ranking of Fabric E was significantly related to the stiffness of the fabric. However, Fabric B was not significantly different than Fabric E in stiffness. Therefore, other factors not included in this study are influencing the ranking of these fabrics.

Table 49. *Long Sleeve Shirt Fabric Rankings*

Fabric	Levels				Ranking	
A	●				2	Best
B		■			3	
C		■			3	
D		■	✸		4	
E			✸		4	
T				♦	5	Worst

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.

Short Sleeve Shirt. The woven fabrics were preferred over the nonwoven fabrics for a short sleeve shirt. Nonwoven fabrics D and T were significantly different. Fabric D was preferred more for a short sleeve shirt than was Fabric T. However, nonwoven fabrics D and E, and nonwoven fabrics E and T, were not significantly different. There was a combination of attributes that were significantly related to the fabric rankings. However, these attributes were only related to one or two of the fabrics. Comfort was negatively significantly related to woven Fabric A and nonwoven Fabric D, indicating the more comfortable the fabric the more preferred the fabric. However, Fabric D was less preferred for a short sleeve shirt than was Fabric A. The smooth/rough and flexible/stiff attributes were negatively significantly related to the comfort attribute. These attributes influenced the comfort ratings for fabrics A and D, and therefore, influenced the fabric rankings. Fabric D was smoother, and therefore, should have been ranked better than Fabric A. Fabric A was more flexible, and therefore, should have been ranked better than Fabric D. These contradictions indicated there were other factors contributing to the fabric rankings. Future studies include a wear trial to determine subject preference for Fabric D as a shirting fabric, since it was perceived as comfortable as Fabric A which was accepted as a shirting fabric. Subjects may be accustomed to the feel of a woven fabric. Therefore, Fabric D may be less preferred because it does not feel like a woven, even though subjects rated these fabrics equally comfortable.

Table 50. *Short Sleeve Shirt Fabric Rankings*

Fabric	Levels					Ranking	
A	●					1	Best
B		■				2	
C			✸			3	
D				♦		4	
E				♦	▲	4	
T					▲	5	Worst

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.

Shorts. Woven fabrics C and B were preferred over woven Fabric A and the nonwoven fabrics for shorts. Woven Fabric A was equally preferred to nonwoven Fabric D. Nonwoven fabrics E and T were least preferred. There were no significantly related attributes to clearly explain the order of the fabric rankings. Woven Fabric C and nonwoven Fabric T were stretchy fabrics but ranked opposite. Woven Fabric C and nonwoven Fabric T were negatively significantly related to comfort. Additionally, comfort was related to the smooth/rough attribute. Fabric C was rated slightly smooth while Fabric T was rated slightly rough. This indicates Fabric T was too rough to be considered for shorts.

Table 51. *Short Fabric Rankings*

Fabric	Levels				Ranking†	
C	●				2	Best
B		■			3	
D			✸		3	
A			✸		3	
E				♦	4	
T				♦	5	Worst

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.
† The box plots were used to determine order when medians were the same but rankings were significantly different.

Bag. Woven Fabric C and nonwoven fabric T and D were preferred more than nonwoven Fabric E and woven Fabrics B. Woven Fabric A was least preferred for a tote bag. There were no attributes that were clearly related to the fabric rankings for a tote bag. However, comfort was significantly related to woven Fabrics A and C. The median of these fabrics were similar in comfort, but the fabrics were ranked opposite for a tote bag. Since comfort was negatively significantly related to these fabrics for the flexible/stiff attribute, suggest why Fabric C was preferred over Fabric A; Fabric C was stiffer.

Table 52. *Tote Bag Fabric Rankings*

Fabric	Levels				Ranking	
C	●				2	Best
T	●	■			3	
D		■			3	
E			✸		3	
B			✸		4	
A				♦	6	Worst

Note. Levels not connected by the same symbol are significantly different. Light gray shading indicates a nonwoven fabric.

Gender Influences

Overall, gender does not influence fabric rankings. Males and females did not rank fabrics differently for a *long sleeve shirt* or *shorts*. For a *short sleeve shirt*, males and females ranked woven fabrics A and C differently. The females perceived Fabric A to be better for a short sleeve shirt, but perceived Fabric C to be worse than the males perceived Fabric C for a short sleeve shirt. Rating data by gender, section "Influence of Gender on Fabric Ratings", was studied to see if the data could explain why these two fabrics were ranked at different

levels. There were no significant relationships between the studied attributes and Fabric A that would address why females ranked Fabric A better. However, cool/warm was significantly related to the ranking of Fabric C, in which females perceived Fabric C to be warmer. The perception of the warmth of Fabric C is one possible explanation as to why females perceived Fabric C to be less desirable for a short sleeve shirt than the males' perception.

There were only two significantly different rankings for the *bag*, woven Fabric A and nonwoven Fabric E. The females, unlike males, perceived Fabric A to be worse for a tote bag, and perceived Fabric E to be better for the tote bag. As previously stated, there was no significant difference between gender and the attributes for Fabric A. The only difference between genders ratings for Fabric E was the cool/warm attribute; the females perceived Fabric E to be warmer. However, there is no explanation as to why the cool/warm sensation would influence fabric choice for a tote bag. While the median ranking for these fabrics were different, the males and females did rank all six fabrics in the same order. There does not appear to be enough data to explain why females and males ranked these fabrics at different levels. Further studies in this area should address the wants and needs of the individual, with regard to the end purpose of the bag, which may be impacted by gender.

Age Influence

Age did not influence the ranking of fabrics for a *long sleeve* or *short sleeve shirt*. However, age did appear to have some influence on the fabric rankings of a pair of *shorts* and a tote *bag* with three of the six fabrics resulting in statistical significance. For a pair of *shorts*, the ranking of woven Fabric B and nonwoven fabrics D and E were significantly

related to age. The ranking of woven fabrics A and B and nonwoven Fabric T were significantly related to age for a tote *bag*. For both products, the nonwoven fabrics were negatively correlated to age indicating the older the subject, the better they ranked the nonwoven fabrics. Due to the sample size of the study, the order in which younger and older subjects ranked all six fabrics is not known. Therefore, they may have ranked the fabrics in the same order, but the older subjects may have just preferred the nonwoven fabrics slightly more than the younger subjects. It this case, no specific age may have preferred nonwoven fabrics over woven fabrics. Since the correlations indicate a weak association between age and fabric rankings, other factors not included in this study, may have influenced the consumers ranking choices. Further research, with a focus on specific age groups, would need to be conducted in order to better understand the influence of age on fabric rankings.

Fabric Rankings among Products

Overall, woven fabrics were preferred over nonwoven fabrics for apparel products while the nonwoven fabrics were preferred for the tote bag, or heavier apparel products such as the shorts and long sleeve shirt. Woven fabrics A, B, and C and nonwoven Fabric T, were clearly suited for some products over others. Woven Fabric A was perceived to be better for *shirts* than for shorts or a bag. Woven Fabric B was perceived to be better for *apparel* than for a tote bag. Woven Fabric C was perceived to be better for *shorts* and a *bag* than for shirts and nonwoven Fabric T was perceived to be better for a *bag* than for apparel. Nonwoven Fabric D was not significantly correlated to any fabric attributes and was ranked mid-range for all products. Nonwoven Fabric E was not preferred for any of the products with no

overwhelming related attributes to explain the dislike. Factors not included in this study were influencing the rankings of nonwoven fabrics D and E.

Influence of Attributes on Fabric Rankings

In an attempt to understand why fabrics were ranked the way there were for certain products, a Spearman's Correlation Coefficient was run. The results indicated which fabric attributes were significantly related to the ranking of a fabric for a specific product. Relationships between attributes and fabric rankings varied depending on the product and the fabric. There was one attribute that was not significantly related to the fabric rankings for any product, cool/warm, indicating that the thermal character of the fabric did not significantly influence the subjects when ranking the fabrics.

Woven Fabric A was perceived to be better for shirts than for the other products. The ranking of Fabric A for a long sleeve and short sleeve shirt was negatively significantly related to comfort. In which case, if the fabric was perceived to be more comfortable, it was ranked better for a shirt. However, this correlation was weak indicating other factors were contributing to the selection. Results from the "Relationship between Comfort and the Attribute Ratings" section show the comfort of Fabric A was negatively significantly related to smoothness and flexibility of Fabric A. This indicates these attributes were also influencing the ranking of Fabric A for both a long sleeve and short sleeve shirt. However, these attributes negatively impacted the ranking of Fabric A for a tote bag.

Woven Fabric B was perceived to be better for apparel products (*long sleeve* and *short sleeve shirts* and *shorts*) than for the tote bag. The ranking of Fabric B for a *long sleeve shirt* was negatively significantly related to comfort and positively significantly related to the

smooth/rough attribute. If the fabric was perceived to be more comfortable and smoother, it was ranked better for a long sleeve shirt. Fabric B, for a *short sleeve shirt*, was negatively significantly related to tight/stretchy. This indicates that the tighter the fabric was perceived, the better it was ranked for a short sleeve shirt. The tightness of Fabric B was positively significantly related to the thinness of Fabric B. This indicates that the thin/thick attribute was also influencing the ranking of Fabric B for a short sleeve shirt. The ranking of Fabric B for shorts was not significantly related to any attributes included in the study indicating there were other factors contributing to the ranking.

Woven Fabric C was perceived to be better for *shorts* and a tote *bag*. The ranking of Fabric C for *shorts* was significantly related to comfort and the tight/stretchy attribute. The more comfortable and stretchier the subjects rated Fabric C, the better they ranked the fabric for shorts. The correlations were weak, however, indicating other factors were contributing to the ranking. Referring to the results from the "Relationship between Comfort and the Attribute Ratings" section, it was found that the comfort of Fabric C was significantly related to fabric smoothness and flexibility, and stretchiness was significantly related to smoothness, flexibility, and thickness. Therefore, all these attributes may have been contributing to the ranking of Fabric C for a pair of shorts. Furthermore, the ranking of Fabric C for a tote *bag* was significantly related to the smooth/rough attribute. The smoother the subjects perceived Fabric C, the better they ranked the fabric for a tote bag. However, as with the other fabrics, the correlation was weak indicating other influencing factors. The smoothness of Fabric C was significantly related to comfort, flexibility, and stretchiness indicating that these attributes may have been a factor when subjects were ranking Fabric C for a tote bag.

Nonwoven Fabric T was perceived to be better for a *bag* than for the apparel products included in this study. The ranking of Fabric T for a long sleeve shirt was significantly related to the smooth/rough attribute. The short sleeve ranking was significantly related to the smooth/rough and thin/thick attributes. The shorts ranking was significantly related to comfort, and the smooth/rough and thin/thick attributes. Note that each of the apparel products was positively significantly related to the smooth/rough rating of Fabric T, indicating the rougher the fabric was perceived, the worse it was ranked for apparel products. The median rating of Fabric T was a five indicating the subjects perceived the fabric to be slightly rough, and the fabric was ranked worst for all of the apparel products. Since, the roughness of Fabric T was related to the uncomfortable rating of the fabric, the fabric was ultimately ranked not suitable for apparel products by the subjects. The smooth/rough attribute was not significantly related to the ranking of Fabric T for a tote bag indicating that roughness was not an influencing factor when ranking the fabric for a bag.

Future Research

Results and limitations from this study have led to the following future research opportunities:

1. Expand the geographical region
    - Explore regions outside of central North Carolina

2. Limit focus to specific apparel markets
    - Workwear (i.e. industrial clothing, uniforms)
    - Outerwear
    - Adventure wear (i.e. hunting, hiking, camping)

3. Expand focus to include interior textiles
    - Bed linens
    - Table linens
    - Curtains/Draperies
    - Upholstery
    - Decorative accessories (i.e. decorative pillows, lamp shades)

4. Expand focus of accessory products
    - Explore appropriate end-uses (i.e. gloves, scarves, hats, embellishments)
    - Explore consumer needs/wants for the accessories
    - Explore gender bias with regard to end-use

5. Explore texture technology for nonwovens
    - Textures appropriate for end-use
    - Explore age bias with regard to texture
    - Magnitude of nonwoven texture versus traditional woven texture

6. Examine comparable weight for apparel fabric purchases
    - Fabric buyers purchase by weight
    - Nonwovens considerably thicker than wovens of the same weight
    - Development of fabric buyers purchase guide by weight

7. Expand study to include wear trials
    - Educating the consumer on new fabrics
    - Overcoming traditional woven textures

In summation, this research is important to the research and development of nonwoven fabrics in the use of consumer products such as apparel and accessories. This research had several key findings which will be useful to industry and academia as they continue to develop nonwoven fabrics. Subjects found the nonwoven fabrics in this study acceptable for a tote bag, which suggests that other accessories might also be potential nonwoven products. Results indicated subjects found nonwoven Fabric D, the islands-in-the-sea polyester/nylon blend, to be equally comfortable to woven Fabric A, the plain weave

polyester/cotton blend fabric. This indicated there are potential apparel markets for this nonwoven fabric. Further research could begin to focus on specific product markets to determine the acceptable market for this nonwoven fabric. Texture, or the sensation of smoothness or roughness, appeared to have a significant influence on the perception of comfort. Nonwoven Fabric T, the textured bicomponent elastomer/polyester blend, was perceived to be too rough for apparel products. Determining acceptable textures will be critical in the success of nonwoven fabrics in the apparel market. Like many new products, consumers may need to be educated to understand the opportunities and benefits afforded by nonwoven fabrics in apparel products. While nonwoven fabrics were not overwhelmingly accepted by the subjects surveyed, there did appear to be product opportunities for the new generation of spunlaced nonwoven fabrics.

REFERENCES

Ambaye, M. (2005). *A consumer decision process model for the internet*. (Doctoral Dissertation, Brunel University).

American Association of Textile Chemists and Colorists (AATCC). (2006). Evaluation Procedure 5: Guidelines for the subjective evaluation of fabric hand. In *AATCC Technical Manual* (pp. 684-685). New York: Howes.

American Society for Testing Materials (ASTM). (2007). *D 123: Standard terminology relating to textiles*. West Conshohocken, PA: Author.

American Society for Testing Materials (ASTM). (1996). *D 3776: Standard test method for mass per unit area (weight) of fabric.* West Conshohocken, PA: Author.

American Society for Testing Materials (ASTM). (1997). *D 5729: Standard test method for thickness of nonwoven fabrics.* West Conshohocken, PA: Author.

Artificial finger designed to simulate human fabric evaluation. (2000). *Bobbin*, 42(2), 9.

Barker, R. (2002). From fabric hand to thermal comfort: the evolving role of objective measurements in explaining human comfort response to textiles. *International Journal of Clothing Science and Technology*, 14(3/4), 181-200.

Barker, R. L. and Scheininger, M. M. (1982). Predicting the hand of nonwoven fabrics from simple laboratory measurements. *Textile Research Journal*, 52, 612-620.

Behery, H. M. (Ed.). (2005). *Effects of mechanical and physical properties on fabric hand*. Washington, DC: CRC Press.

Bertaux, E., Lewandowski. M., and Derler, S. (2007). Relationship between friction and tactile properties for woven and knitted fabrics. *Textile Research Journal*, 77, 387-396.

Binns, H. (1926). The discrimination of wool fabrics by the sense of touch. *British Journal of Psychology,* 16, 238-247.

Binns, H. (1934). Tactile comparison of the cloth qualities of continental and noble combed materials. *Journal of the Textile Institute,* 25, T157-T173.

Bishop, D. P. (1996). Fabrics: Sensory and mechanical properties. *Textile Progress*, 26(3), 1-64.

Blackwell, R. D., Miniard, P. W. & Engel, J. F. (2006). *Consumer behavior* (10th ed.). Mason, OH: Thomason South-Western.

Blackwell, R. D. & Hilliker, J. S. (1978). "Clothing decisions: A decision process analysis of focused group interviews," *Advances in Consumer Research*, 5(1), 743-749.

Block, C. E. & Roering, K. J. (1976). *Essentials of consumer behavior*. Hinsdale, IL: Dryden Press.

Bogaty, H., Hollies, N. R. S., and Harris, M. (1956). The judgment of harshness of fabrics. *Textile Research Journal*, 26, 355-360.

Brand, R. H. (1964). Measurement of fabric aesthetics: Analysis of aesthetic components. *Textile Research Journal*, 34, 791-804.

Brandt, M., Skinner, E. Z., and Coleman, J. A. (1963). Texture profile method. *Journal of Food Sciences*, 28, 404-409.

Bureau of Labor Statistics. (2009). Occupational employment statistics: May 2007 national occupational employment and wage estimates. Retrieved April 13, 2009. http://www.bls.gov/oes/2007/may/oes_nat.htm#b17-0000

Byrne, M. S., Carty, P. and Scriven, K. (1998). The effect of variation in linear density of polyamide filaments on the handle of ladies' hosiery. *Journal of Sensory Studies,* 13, 175-190.

Cardello, A. V., Witherhalter, C. and Schutz, H. G. (2003). Predicting the handle and comfort of military clothing fabrics from sensory and instrumental data: Development and application of new psychophysical methods. *Textile Research Journal*, 73(3), 221-237.

Cassill, N. & Drake, M. F. (1987). "Employment orientation's influence on lifestyle and evaluative criteria for apparel," *Family and Consumer Sciences Research Journal,* 16(1), 23-35.

Chae, M., Black, C., & Heitmeyer, J. (2006). "Pre-purchase and post-purchase satisfaction and fashion involvement of female tennis wear consumers," *International Journal of Consumer Studies*, 30(1), 23-33.

Civille, G. V. and Dus, C. A. (1990). Development of terminology to describe the handfeel properties of paper and fabrics. *Journal of Sensory Studies*, 5, 19-32.

Cooper, C. L. & Argyris, C. eds. (1998). *The concise Blackwell encyclopedia of management*. Malden, MA: Blackwell Publishers.

Cotton Incorporated. Retrieved September, 25 2008. http://www.thefabricofourlives.com/View-Cotton-Commercials/#topvid.

Cowan, S. L., Tilley, R. C., and Wiczynski, M. E. (1988). Comfort factors of protective clothing: Mechanical and transport properties, subjective evaluation of comfort, in *Performance of Protective Clothing: Second Symposium, ASTM STP 989*, Mansdorf, S. Z., Sager, R., and Nielsen, A. P. (Eds.). American Society for Testing and Materials, Philadelphia, 31-42.

Dawes, V. H. and Owen, J. D. (1971a). The assessment of fabric handle part I: Stiffness and liveliness. *Journal of the Textile Institute*, 62(5), 233-244.

Dawes, V. H. and Owen, J. D. (1971b). The assessment of fabric handle part II: Smoothness. *Journal of the Textile Institute*, 62(5), 245-250.

De Boos, A. (2005). Concepts and understanding of fabric hand. In H. M. Behery (Ed.), *Effects of mechanical and physical properties on fabric hand* (pp. 11-44). Washington, DC: CRC Press.

Dockery, A. (2003). Australian partnership seeks to commercialize nonwoven wool. *Apparel Magazine*, 45(3), 12.

Dreby, E. C. (1942). Physical methods for evaluating the hand of fabrics and for determining the effects of certain textile finishing processes. *American Dyestuff Reporter*, 31, P497-504.

El Mogahzy, Y. E., Kilinc, F. S., and Hassan, M. (2005). Developments in measurement and evaluation of fabric hand. In H. M. Behery (Ed.), *Effect of mechanical and physical properties on fabric hand* (pp. 45-65). Washington, DC: CRC Press.

Elder, H. M., Fisher, S., Armstrong, K., and Hutchison, G. (1984). Fabric softness, handle, and compression. *Journal of the Textile Institute*, 75, 37-46.

Ellis, B. C. and Garnsworthy, R. K. (1980). A review of techniques for the assessment of hand. *Textile Research Journal*, 50, 231-238.

Engel, J. F., Kollat, D. T., & Blackwell, R. D. (1968). *Consumer behavior*. New York: Holt, Rinehart and Winston.

Engel, J. F. & Blackwell, R. D. (1982). *Consumer behavior* (4th ed.). New York: Dryden Press.

Erasmus, A. C., Boshoff, E., & Rousseau, G.G. (2001). "Consumer decision-making models within the discipline of consumer science: a critical approach," *Journal of Family Ecology and Consumer Sciences*, 29, 82-90.

Fabric evaluation for textiles and clothing. (1984). *International Dyer & Textile Printer*, 169(2), 8.

Forney, J. C., Park, E. J., & Brandon, L. (2005). "Effets of evaluative criteria on fashion brand extension," *Journal of Fashion Marketing and Management*, 9(2), 156-165.

Fourt, L. and Hollies, N. R. S. (1970). *Clothing: Comfort and function.* New York: Marcel Dekker.

Fuzek, J. F. and Ammons, R. L. (1977). Techniques for the subjective assessment of comfort in fabrics and garments. In N. R. S. Hollies and R. F. Goldman (Eds.), *Clothing comfort: Interaction of thermal, ventilation, construction and assessment factors* (pp. 121-130). Ann Arbor, MI: Ann Arbor Science.

Garland, G. (2009). Introduction to nonwovens. A presentation for The Nonwovens Institute. Raleigh, NC: The Nonwovens Institute. Original source: INDA market report: Worldwide outlook 2007-2012.

Griffin, M. L. and O'Neal, G. S. (1992). Critical characteristics of fabric quality. *Family and Consumer Sciences Research Journal*, 21, 173-191.

Grinevičiūtė, D. and Gutauskas, M. (2004). The comparison of methods for the evaluation of woven fabric hand. *Material Science (Medžiagotyra),* 10(1), 97-100.

Harkin, F. (2002). Frontier fashion fashion forget chainmail and silver trim, Fiona Harkin finds laboratories are stitching up the future with nonwoven fabrics, interactive fibres and nanotechnology. *The Financial Times (London, England)* [Electronic version], pp. 11. Retrieved October 21, 2004, from LexisNexis database.

Hart, C. & Dewsnap, B. (2000). "An exploratory study of the consumer decision process for intimate apparel," *Journal of Fashion Marketing and Management*, 5(2), 108-119.

Hollies, N. R. S. (1977). Psychological scaling. In N. R. S. Hollies and R. F. Goldman (Eds.), *Clothing comfort: Interaction of thermal, ventilation, construction and assessment factors* (pp. 107-120). Ann Arbor, MI: Ann Arbor Science.

Howard, J. A. (1963). *Marketing management: analysis and planning* (Revised ed.). Homewood, IL: Irwin.

Howard, J. A. & Sheth, J. N. (1969). *The theory of buyer behavior*. New York: John Wiley & Sons, Inc.

Howard, J. A. (1977). *Consumer behavior: Application of theory*. New York: McGraw-Hill.

Howard, J. A. (1989). *Consumer behavior in marketing strategy*. Englewood Cliff, NJ: Prentice-Hall.

Howorth, W. S. and Oliver, P. H. (1958). The application of multiple factor analysis to the assessment of fabric handle. *Journal of the Textile Institute*, 49(10), T540-T553.

Howorth, W. S. (1964). The handle of suiting, lingerie, and dress fabrics. *Journal of the Textile Institute*, 55, T251-260.

Hsu, H. & Burns, L. D. (2002). "Clothing evaluative criteria: A cross-national comparison of Taiwanese and United States Consumers," *Clothing and Textiles Research Journal*, 20(4), 246-252.

Hyun, S. O., Hollies, N. R. S., and Spivak, S. M. (1991). Skin sensations perceived in apparel wear Part I: Development of a new perception language. *Journal of the Textile Institute*, 82(3), 389-397.

International Organization for Standardization (ISO). http://www.iso.org/iso/home.htm.

Jarvis, C. (1997). Present and future opportunities for nonwovens in apparel. *Nonwovens Industry, 28*(5), 40-42.

Kawabata, S. (1980). *The standardization and analysis of hand evaluation* (2nd). Osaka, Japan: The Textile Machinery Society of Japan.

Kawabata, S., Niwa, M., and Wang, F. (1994). Objective hand measurement of nonwoven fabrics: Part I: Development of the equations. *Textile Research Journal*, 64, 597-610.

Kim, C. J. and Piromthamsiri, K. (1984). Sensory and physical hand properties of inherently flam-retardant sleepwear fabrics 1. *Textile Research Journal*, 54, 61-68.

Kim, C. J. and Vaughn, E. A. (1975). Physical properties associated with fabric hand. *AATCC Book of Papers National Technical Conference*, 78-95.

Kim, C. J. and Vaughn, E. A. (1979). Prediction of fabric hand from mechanical properties of woven fabrics. *Journal of the Textile Machinery Society of Japan,* 32(6), 47-56; Japanese edition, article in English.

Kim, D. O., Yoo, S., and Kim, E. A. (2005). Objective measures for perceived touch of worsted fabrics. *International Journal of Industrial Ergonomics*, 35, 1159-1169.

Laing, R. M. and Ingham, P. E. (1983). The effectiveness of Specimen Tactile Evaluation as a predictor of garment tactile acceptability for garments as a whole and on a regional basis. *Clothing and Textile Research Journal*, 2, 58-63.

Lee, M. & Burns, L. D. (1993). "Self-consciousness and clothing purchase criteria of Korean and United States college woman," *Clothing and Textiles Research Journal*, 11(4), 32-40.

Lewis, B. R. & Littler, D. (Eds.). (1999). *The Blackwell encyclopedic dictionary of marketing*. Malden, MA: Blackwell Publishers.

Lundgren, H. P. (1969). New concepts in evaluating fabric hand. *Textile Chemist and Colorist*, 1(1), 35-45.

Mahar, T. J. and Postle, R. (1989). Measuring and interpreting low-stress fabric mechanical and surface properties: Part IV: Subjective evaluation of fabric handle. *Textile Research Journal*, 59, 721-733.

Matsuo, T., Nasu, N., and Saito, M. (1971). Study on the hand part 2: the method for measuring hand. *Journal of the Textile Machinery Society of Japan*, 17(3), 92-104.

Maycumber, S. G. (2000, May 26). Important fabric innovations will come from nontraditional sources; new apparel nonwovens from several players will share the spotlight in the coming years. *Daily News Record,* pp. 56.

May-Plumlee, T. & Little, T. J. (2006). Proactive product development integrating consumer requirements. *International Journal of Clothing Science and Technology,* 18(1), 53-66.

Merkel, R. S. (1991). Comfort, hand, and drape. In *Textile product serviceability* (pp. 325-350). New York: MacMillan Publishing.

Meilgaard, M., Civille, G. V., and Carr, B. T. (1987). *Sensory evaluation techniques* (2nd Ed.). Boca Raton, FL: CRC Press.

Militký, J. (2005). Application of statistical methods in evaluation of fabric hand. In H. M. Behery (Ed.), *Effect of mechanical and physical properties on fabric hand* (pp. 66-123). Washington, DC: CRC Press.

Morris, M. A. and Prato, H. H. (1981). Consumer perception of comfort, fit and tactile characteristics of denim jeans. *Textile Chemist and Colorist*, 13(3), 24-30.

Morris, M. A., Prato, H. H., and White, N. L. (1984). Line-dried vs. machine-dried fabrics: Comparison of appearance, hand, and consumer acceptance. *Family and Consumer Sciences Research Journal*, 13, 27-35.

Nicosia, F. M. (1966). *Consumer decision processes: Marketing and advertising implications*. Englewood Cliffs, NJ.: Prentice-Hall, Inc.

Norgren, J. (2008, February). *Consumer Insight*. Presentation presented at the Graduate Seminar, College of Textiles, North Carolina State University, Raleigh, NC.

Paek, S. L. (1975). Evaluation of the hand of certain flame-retardant fabrics. *Textile Research Journal*, 45, 704-711.

Paek, S. L. (1978). Response profiles of flame-retardant fabric hand. *Textile Research Journal*, 48, 487-489.

Paek, S. L. (1979). An analysis of sensory hands as identified by selected consumers. *Textile Research Journal,* 49, 698-704.

Pan, N. (2007). Quantification and evaluation of human tactile sense towards fabrics. *International Journal of Design and Nature*, 1(1), 48-60.

Pan, N., Kaiser, S. B., Chandler, J., Dallas, M. J., Brandt, B., Cameron, B. A., et al. (1998). Fabric hand evaluation: Perception and instrumentation. *Proceedings of the International Textile and Apparel Association Annual Meeting,* Dallas, November 18-21.

Peirce, F. T. (1930). The handle of cloth as a measureable quantity. *Journal of the Textile Institute Transactions*, 21, T377-T416.

Philippe, F., Schacher, L., Adolphe, D. C., and Dacremont, C. (2003). The sensory panel applied to textile goods – a new marketing tool. *Journal of Fashion Marketing and Management*, 7(3), 235-248.

Pontrelli, G. J. (1977). Partial analysis of comfort's gestalt. In N. R. S. Hollies and R. F. Goldman (Eds.), Clothing comfort: Interaction of thermal, ventilation, construction and assessment factors (pp. 71-80). Ann Arbor, MI: Ann Arbor Science.

Pourdeyhimi, B. (2004). Nonwovens and traditional textile know-how. *Textile World, 154*(8), 42-45.

Pourdeyhimi, B., Fedorova, N., and Sharp, Stephen. (2006). *U.S. Patent Application Serial No. 11/473,534.* Washington, DC: U.S. Patent and Trademark Office.

Pourdeyhimi, B. and Sharp, S. (2008). *U.S. Patent Application Serial No. 11/769,871.* Washington, DC: U.S. Patent and Trademark Office.

Robertson, T. S. & Kassarjian, H. H. (1991). *Handbook of consumer behavior*. Englewood Cliffs, NJ: Prentice-Hall.

Scheepers, R. (2003). "Supporting the online consumer decision process: Electronic commerce in a small Australian retailer", *Proceedings of the Twelfth Australasian Conference on Information Systems*, Coffs, Harbour, NSW. Australia.

Schiffman, L. G. & Kanuk, L. L. (1978). *Consumer behavior*. Englewood Cliffs, NJ: Prentice-Hall.

Schiffman, L. G. & Kanuk, L. L. (1994). *Consumer behavior* (5th ed.). Englewood Cliffs, NJ: Prentice-Hall.

Schiffman, L. G. and Kanuk, L. L. (2000). *Consumer behavior* (7th ed.). Upper Saddle River, NJ: Prentice-Hall.

Shenai, V. A. (1989). Fundamental concepts of fabric hand: Part I. *Textile Dyer & Printer,* 22(8), 19-26.

Shin, K. (2007). Factors influencing source credibility of consumer reviews: Apparel online shopping (Master's Thesis, Oregon State University).

Smith, J. E. (1986). The comfort of clothing. *Textiles*, 15(1), 23-27.

Stearn, a. E., D'arey, R. L., Postle, R., and Mahar, T. J. (1988). A statistical analysis of subjective and objective methods of evaluating fabric handle part 2: Relationships between subjective and objective measurements. *Journal of Textile Machinery Society of Japan*, 34(2), 39-46.

Stone, H. and Sidel, J. L. (1993). *Sensory evaluation practices* (2nd ed.). New York: Academic Press.

Sülar, B. and Okur, A. (2007). Sensory evaluation methods for tactile properties of fabrics. *Journal of Sensory Studies,* 22, 1-16.

Szczesniak, A. S. and Skinner, E. Z. (1973). Meaning of texture words to the consumer. *Journal of Texture Studies*, 4, 378-384.

Szczesniak, A. S. Loew, B. J., and Skinner, E. Z. (1975). Consumer texture profile technique. *Journal of Food Science*, 40, 1253-1256.

Teo, T. S. H. & Yeong , Y. D. (2003). Assessing the consumer decision process in the digital marketplace. *The International Journal of Management Science*, 31, 349-363.

Tester, D. and De Boos, A. (1990). Get it right FAST time. *Textile Horizons*, 10, 13.

Tilin, A. (2001). Slick as teflon! Tough as kevlar! Limber as lycra! *Wired* [Electronic version], *9*(10). Available: http://www.wired.com/wired/archive/9.10/abfabs_pr.html

Vaughn, E. A. and Kim. C. J. (1975). Definition and assessment of fabric hand. *AATCC Book of Papers National Technical Conference,* 66-77.

Wallenberger, F. T. (1982). What's new in man-made fibers: Fiber-dependent garment comfort factors. *Textile Chemist and Colorist*, 14(8), 33-37.

Walters, C. G. & Paul, G. W. (1970). *Consumer behavior: An integrated framework.* Homewood, IL: Irwin.

Walzer, E. (2001). Textile makers use nonwovens, corn for material gain. *Sporting Goods Business, 34*(13), 34-35.

Winakor, G. Kim, C. J. and Wolins, L. (1980). Fabric hand: Tactile sensory assessment. *Textile Research Journal*, 50, 601-610.

Workman, J. E. and Caldwell, L. F. (2007). Centrality of visual product aesthetics, tactile and uniqueness needs of fashion consumers. *International Journal of Consumer Studies*, 31, 589-596.

Yick, K. L., Cheng, K. P. S., and How, Y. L. (1995). Subjective and objective evaluation of men's shirting fabrics. *International Journal of Clothing Science and Technology,* 7(4), 17-29.

Zeng, X. and Koehl, L. (2003). Representation of the subjective evaluation of the fabric hand using fuzzy techniques. *International Journal of Intelligent Systems*, 18, 355-366.

APPENDIX A

Pretest

A pretest was conducted to ensure the computerized survey, developed for this research, would function properly and record data correctly. Also, the pretest was conducted to ensure the subjects' understanding of the testing and evaluation procedures, and that the testing procedure would run smoothly as well as gain an understanding of the time required for subjects to compete the testing. This pretest allowed for an opportunity to conduct statistical analysis to ensure data collected could be properly analyzed.

Pretest Methodology

Subject Recruitment

Subjects were recruited by emailing students who were currently enrolled in apparel courses at the College of Textiles, North Carolina State University. Students who were interested in participating in the study responded via email and a testing time was scheduled. Students who participated in the study were compensated with five extra credit points in their apparel class.

Sample Preparation

Three woven fabrics were chosen based on their common and wide spread use in apparel products. Three spunlaced nonwoven fabrics were chosen, one because it was a commercial product and the other two because they represent the most recent generation of nonwoven fabrics. Table 53 describes the six fabrics used in the study. Basis weight and

thickness measures were obtained following ASTM methods D 3776 and D 5729 respectively. The woven fabrics and nonwoven fabric E are commercially available fabrics. Nonwoven fabrics D and F were produced in house at The Nonwovens Institute's Partners' Lab. All nonwoven fabrics were produced via the spunbond process and bonded via hydroentangling, commonly referred to as a spunlaced nonwoven. Since the woven fabrics were already dyed when purchased, the three nonwoven fabrics were placed in a Theis Jet Dye, run through a blank polyester dye cycle reaching 265ºF (130ºC) for 30 minutes, and dried. This was done so the samples would have equivalent processes to the dyed woven fabrics. Once dry, the nonwoven fabrics were run through a Stork® laminator at 175°F (80°C) with a dwell time of 27 seconds and a pressure of 35 psi to remove any wrinkles. As suggested by the literature, each sample fabric was cut into 8 x 8 inch (20.3 x 20.3 cm) samples, with edges parallel to the warp, or machine direction. The samples were labeled with a permanent marker so as not to affect the fabric surface. Each sample was marked with the fabric identification letter and an arrow to indicate the warp, or machine direction. All samples were ironed and lint rolled to remove any wrinkles or particles that would affect the surface of the fabrics which in turn could affect the testing results.

Table 53. *Pretest Fabric Samples*

Fabric ID	Fabric Construction	Fiber Content	Basis Weight (g/m^2)	Thickness (mm)
A	Plain Weave	65%/35% Polyester/Cotton	141	0.30
B	Plain Weave	65%/35% Polyester/Cotton	144	0.36
C	Sateen Weave	97%/3% Cotton/Spandex	199	0.44
D	Bicomponent Spunlaced Nonwoven	50%/50% Polyester/Nylon	131	0.58
E	Bicomponent Spunlaced Nonwoven	70%/30%* Polyester/Nylon	111	0.60
F	Bicomponent Spunlaced Nonwoven	80%/20% Polyester/Nylon	132	0.50

Note. *Fabric shipment unlabeled, typically a 70%/30% blend.

Development of Testing Procedure

While there is no industry standard for subjective fabric hand evaluation, Bishop (1996) has noted six key elements to consider when developing a subjective fabric hand evaluation methodology. These six elements have been considered and an extensive review of the literature has been conducted to help guide the development of the methodology. Three key publications have been found helpful in the development of this study: Civille and Dus (1990); Cardello, Witherhalter, and Schutz (2003); and the AATCC Evaluation Procedure 5: Guidelines for the Subjective Evaluation of Fabric Hand (2006).

The experiment was comprised of two parts, a rating and a ranking section, which were conducted simultaneously. The entire experiment was conducted as a blind study, as suggested in the literature. Due to the use of consumer subjects, the study was not conducted in a controlled environment. As suggested in the literature, subjects were required to wash their hands with non-moisturizing hand soap and dry their hands with a paper towel before

participating in the experiment. Subjects were not to expose their hands to moisture, lotions, or powders until the evaluation of all specimens were completed. This prevented any contamination to the surface of the fabric samples that would affect the sensory evaluation of the fabrics.

In Part I of the pretest experiment, the subjects were asked to rate each of the six fabrics. The samples were presented to the subjects, one at time, in random order. The samples were hidden from the subjects view by using a box and cardboard screen (see Figure 8). Holes on the side of the box, with plastic 'curtains', allowed for subjects to easily place their hands in the box to evaluate the fabric while still keeping the fabric from view. The cardboard screen allowed for the proctor to easily move fabrics in and out of the box without subjects seeing the fabric. The cardboard screen also prevented other subjects from seeing the fabrics when more than one subject was being tested at the same time.

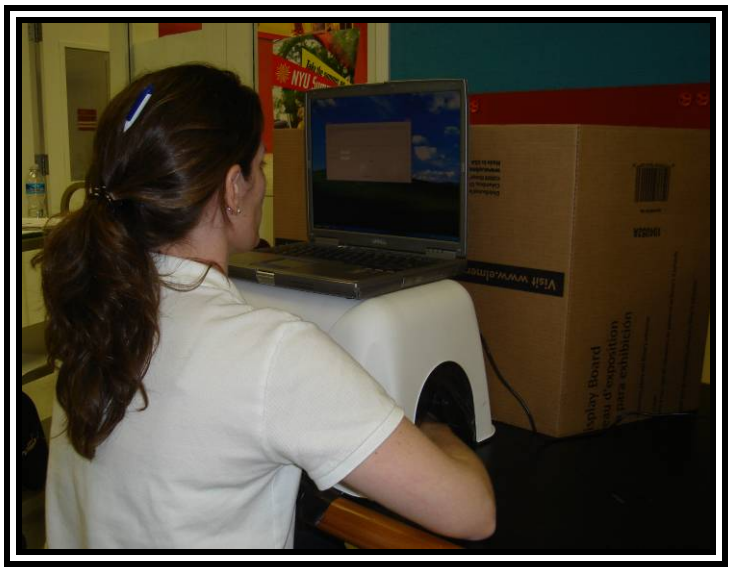


Figure 8. The experimental set-up for Pretest Part I: Rating.

The subjects were asked to rate each fabric based on comfort and seven fabric attributes; cool/warm, dry/wet, smooth/rough, bald/fuzzy, thin/thick, flexible/stiff, and tight/stretchy. For each attribute rating, a definition and evaluation procedure was provided to keep the untrained subjects consistent in their evaluation technique (see Table 54). The definitions and evaluation procedures were adopted from the Handfeel Spectrum Descriptive Analysis (HSDA) method (Civille & Dus, 1990). A 7-point category rating scale was used in the evaluation. For example, the scale for cool/warm was labeled very cool, cool, slightly cool, neither cool nor warm, slightly warm, warm, and very warm; very cool = 1 and very warm = 7. The rating evaluation was guided by a computer software program designed by a research scientist in the department. The survey was opened on a laptop which was positioned on top of the box, in front of the subject (see Figure 8). The survey was self-guided and showed only one question at a time. The questions were ordered in a manner so that the prior evaluation would not alter the fabric which could affect the following evaluations. See APPENDIX D for the complete survey as seen by the subjects. Each fabric was only evaluated once to prevent change in hand which could be caused by excessive handling.

Table 54. *Pretest Fabric Attribute Definitions and Evaluation Procedures*

Fabric Attributes	Definition	Evaluation Procedure
Cool/Warm	The difference in thermal character between the fabric and the hand.	Gather fabric into palm with fingers closed; flex fingers and squeeze sample gently for 3 seconds. Do not squeeze fabric again or longer than 3 seconds.
Dry/Wet	The amount of moistness on the surface and in the interior of the fabric.	Gather fabric into palm with fingers closed; flex fingers and squeeze sample gently for 3 seconds. Do not squeeze fabric again or longer than 3 seconds.
Smooth/Rough	The overall presence of gritty, grainy, or lumpy particles in the surface.	Lay sample flat on the table; place wrist on the table top; move index and middle fingers across the surface lightly (left to right) using weight of hand; rotate fabric to stroke along all four directions of fabric.
Bald/Fuzzy	The amount of fiber on the surface.	Lay sample flat on the table; place wrist on the table top; rotate index finger lightly on surface in small quarter size circles.
Thin/Thick	The perceived distance between thumb and fingers.	Hold corner of sample with non-dominant hand thumb, index and middle fingers; grasp sample with thumb and index finger of dominant hand just next to non-dominant hand; run dominant hand fingers over sample using light pressure; do not go off the edge.
Flexible/Stiff	The degree to which the sample feels pointed, ridged, and cracked.	Place dominant hand on top of sample; gather sample with fingers toward palm; close hand slightly and manipulate by rotating sample in palm.
Tight/Stretchy	The degree to which the sample stretches from its original shape.	Grasp opposite edges (near the edges) in hands; pull sample square across in direction 1 (left and right side) for 5 seconds; repeat for direction 2 (top and bottom side) for 5 seconds.

Note. Adopted from "Development of terminology to describe the handfeel properties of paper and fabrics," by G. C. Civille and C. A. Dus, 1990, in *Journal of Sensory Studies,* 5, 19-32.

In Part II of the pretest experiment, the subjects conducted a simple ranking procedure. The subjects were shown the four images, one a time, in random order. The four images included a short sleeve button-down collared shirt, a long sleeve button-down collared shirt, a pair of pleated shorts, and a bag (see Figure 9). These images were chosen because of their general application to apparel and accessories and were appropriate for the

fabrics used in the study. Once the subjects were shown an image, they were asked to put on a blindfold to prevent them from seeing the fabric, as suggested in literature. The six fabric samples were placed in front of the subjects in random order, on a non-textured, non-metal table (see Figure 10). The subjects were asked to rank the fabrics in order from the most desirable (best) fabric to the least desirable (worst) fabric for the image. The ranking was recorded by the proctor, the fabrics were removed from view, and the subjects were asked to remove the blindfold to see the next image. The process was repeated until the subjects had seen all four images.

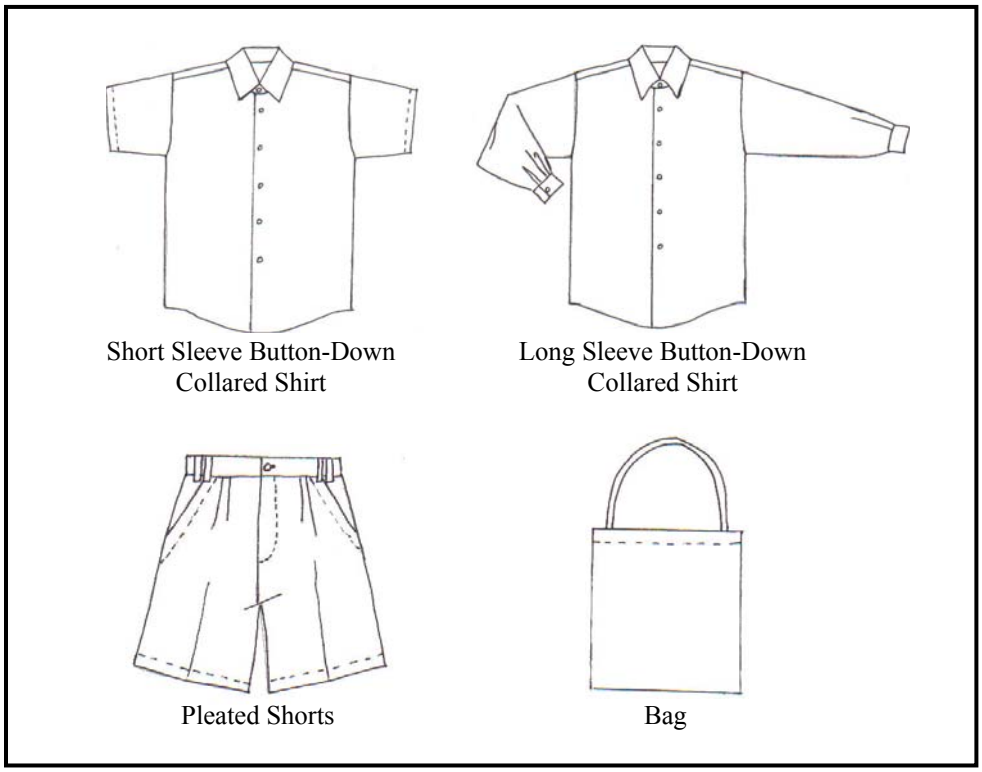


Figure 9. The four images used in Pretest Part II: Ranking.

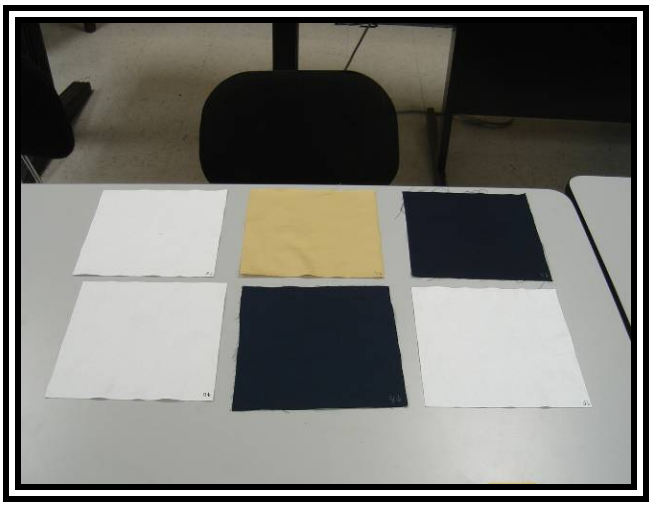


Figure 10. The experimental set-up for Pretest Part II: Ranking.

APPENDIX B

Pretest Results

Median ratings of each attribute for each fabric were calculated using Microsoft Excel. The medians were compared using the Wilcoxon rank-sum test which was performed using the statistical software JMP. This determined if there were significant differences between fabrics for each attribute rating. Results were used to determine how nonwoven fabrics rate in comparison to woven fabrics, and how nonwoven fabrics rate among one another. Spearman's Correlation of Coefficients was also calculated using JMP to compare fabric attributes and comfort, and determine if there are any significant relations between the pairs. JMP was also used to perform a Tukey test on the fabric rankings for each image (short sleeve button-down shirt, long sleeve button-down shirt, pleated shots, bag) to determine if the fabric rankings were significantly different. Results were used to determine how nonwoven fabrics rank in comparison to woven fabrics, and how nonwoven fabrics rank among one another. This information is helpful in determining the acceptance of nonwoven fabrics for general end-uses (short sleeve button-down shirts, long sleeve button-down shirts, pleated shorts, bags).

Pretest Subjects

The pre-test consisted of a convenience sampling of 36 subjects. These subjects were all female students, age 18-25, and enrolled in textile and apparel courses at the university.

Pretest Part I: Rating Results

In order to evaluate consumer acceptance of nonwoven fabrics in apparel and accessories, Part I of the methodology asked consumers to rate each fabric for comfort, cool/warm, dry/wet, smooth/rough, bald/fuzzy, thin/thick, flexible/stiff, and tight/stretchy sensory attributes. To determine the attribute levels for each fabric the median of each attribute rating for each fabric was calculated (see Table 55). The Wilcoxon rank-sum test was then used to determine if the difference between attribute ratings for each fabric was statistically significantly different (see Table 56 and Table 57). This information was used to determine how nonwoven fabrics rate in comparison to woven fabrics as well as how nonwoven fabrics rate among one another. The statistical tests were run at a 95% confidence level, and therefore, a p-value of 0.05 or less is significant.

Attribute Ratings of Nonwoven Fabrics in Comparison to Woven Fabrics

Comfort. The comfort ratings of woven fabrics A and C were not significantly different from the three nonwoven fabrics (D, E, F). Woven fabric B and nonwoven fabric F were also not significantly different in terms of comfort rating. However, the comfort rating of woven fabric B was significantly different than the comfort rating of nonwoven fabric D and E.

Cool/Warm. The cool/warm ratings of the woven fabrics were significantly different than the cool/warm ratings of the nonwoven fabrics. This was indicated by the significant p-value for comparison of medians between woven and nonwoven fabrics (see Table 56). The nonwoven fabrics were perceived to be slightly warm while the perception of the woven

fabrics leaned toward a cooler sensation. The perception of warm or cool was determined by referring to the calculated medians (see Table 55).

Dry/Wet. The dry/wet ratings of woven fabrics were not significantly different than the dry/wet ratings of the nonwoven fabrics. This was indicated by an insignificant p-value for all comparisons of woven and nonwoven medians in the Wilcoxon rank-sum test (see Table 56). Respondents perceived the fabrics to be dry rather than wet.

Smooth/Rough. The smooth/rough ratings of woven fabrics were significantly different than the smooth/rough ratings of the nonwoven fabrics. This was indicated by a significant p-value for all comparisons between woven and nonwoven fabrics, see . Woven fabrics were perceived by respondents to be rough and nonwoven fabrics are perceived to be smooth.

Bald/Fuzzy. The bald/fuzzy ratings of woven fabrics A and B are significantly different than the bald/fuzzy ratings of the nonwoven fabrics (D, E, F). This was indicated by a significant p-value for all comparisons of woven fabrics A and B to the nonwoven fabrics (see Table 56). Woven fabric C was slightly significantly different (p-value 0.0428) than nonwoven fabric F. Woven fabric C was only slightly not significantly different (p-value 0.0589) than nonwoven fabric E. Woven fabric C was not significantly different than nonwoven fabric D in terms of the bald/fuzzy rating. Woven fabrics A and B were perceived as bald while the respondents perceived the nonwoven fabrics and woven fabric C to be fuzzy.

Thin/Thick. The thin/thick rating for woven fabrics A and B were significantly different than the thin/thick ratings of the nonwoven fabrics (D, E, F). However, the

thin/thick rating of woven fabric C was not significantly different from the ratings of the nonwoven fabrics (D, E, F) (see Table 56). Woven fabrics A and B were perceived to be thinner than woven fabric C and the three nonwoven fabrics (see Table 55).

Flexible/Stiff. The flexible/stiff rating of woven fabric A was significantly different than the flexible/stiff rating of the nonwoven fabrics (D, E, F). The flexible/stiff ratings of woven fabric B were not significantly different than the nonwoven fabrics (D, E, F). Woven fabric C was not significantly different than nonwoven fabrics D and E but was significantly different than nonwoven fabric F. Woven fabric A was perceived to be more flexible than the nonwoven fabrics. Woven fabric B was perceived to be as stiff as the nonwoven fabrics. Woven fabric C was perceived to be as stiff as nonwoven fabric D and E but not as stiff as nonwoven fabric F (see Table 55).

Tight/Stretchy. Woven fabrics B and C were significantly different than nonwoven fabrics D, E, and F in terms of the tight/stretchy ratings (see Table 56). Woven fabric A was significantly different than nonwoven fabric E but woven fabric A was not significantly different than nonwoven D and F. Woven fabric B as not as stretchy as the nonwovens. Woven fabric C was stretchier than the nonwoven fabrics. Woven fabric A was perceived as stretchier than nonwoven fabric E. Woven fabric A was perceived to be as stretchy as nonwoven fabrics D and F (see Table 55).

Summary of Nonwoven and Woven Fabric Attribute Ratings

Significant difference between rating levels of woven and nonwoven fabrics varies depending on the attribute. When comfort was considered, respondents perceived woven fabrics A and C to be the same level of comfort as the nonwoven fabrics. They perceived woven fabric B to be the same level of comfort as nonwoven fabric F. However, they perceived woven fabric B to be less comfortable than nonwoven fabrics D and E. The woven fabrics were perceived to be cooler and rougher than the nonwoven fabrics. The woven fabrics were perceived to be the same dryness level as the nonwoven fabrics. Woven fabrics A and B were perceived to be less fuzzy than the nonwoven fabrics. However, woven fabric C was perceived to be the same fuzziness as nonwoven fabrics D and E and only slightly different than nonwoven fabric F. Woven fabrics A and B were perceived to be thinner than the nonwoven fabrics, but woven fabric C was perceived to be as thick as the nonwoven fabrics. Woven fabric A was perceived to be more flexible than the nonwoven fabrics, but woven fabric B was perceived to have the same stiffness of the nonwoven fabrics. Woven fabric C was perceived to be the same stiffness as nonwoven fabrics D and E, but was perceived to be less stiff than nonwoven fabric F. Woven fabrics B and C were perceived to have different levels of stretchiness than the nonwoven fabrics. Woven fabric B was perceived to be less stretchy and woven fabric C was perceived to be stretchier than the nonwoven fabrics. Woven fabric A was perceived to be stretchier than nonwoven fabric E but woven fabric A was perceived to have the same level of stretchiness as nonwoven fabrics D and F.

Attribute Ratings among Nonwoven Fabrics

Comfort. The Wilcoxon rank-sum test shows the nonwoven fabrics (D, E, F) were not significantly different in terms of comfort rating. This was indicated by a p-value of greater than 0.05 (see Table 57). The nonwoven fabrics were perceived to be comfortable, not uncomfortable (see Table 55).

Cool/Warm. The cool/warm ratings of nonwoven fabrics D and E, and E and F, were not significantly different. The cool/warm rating of fabric D was significantly different than the rating of fabric F; however, the rating was only slightly significant (p-value 0.0412) (see Table 57). The nonwoven fabrics were perceived as warm to the touch (see Table 55).

Dry/Wet. The dry/wet ratings among the nonwoven fabrics were not significantly different. All nonwoven fabrics were perceived to have the same level of dryness (see Table 55).

Smooth/Rough. The smooth/rough ratings among the nonwoven fabrics were significantly different indicating the respondents perceived a different level of smoothness between the three nonwoven fabrics.

Bald/Fuzzy. The bald/fuzzy ratings among the nonwoven fabrics were not significantly different indicating the respondents perceived the same level of fuzziness between each nonwoven fabric.

Thin/Thick. The thin/thick ratings among the nonwoven fabrics D and E, and D and F, were not significantly different indicating the respondents perceived the same level of thickness. Thin/thick ratings between nonwoven fabrics E and F were only slightly

significantly different (p-value 0.0425) indicating respondents perceived a slight difference in thickness between these two fabrics (see Table 57).

Flexible/Stiff. The flexible/stiff ratings for nonwoven fabrics D and E, and D and F, were not significantly different indicating the respondents perceived the same level of stiffness between these fabrics. Flexible/stiff ratings between nonwoven fabrics E and F were only slightly significantly different (p-value 0.0494) indicating respondents may not have perceived a difference in stiffness between the two nonwoven fabrics (see Table 57).

Tight/Stretchy. The tight/stretchy ratings for nonwoven fabrics D and E, and E and F, were significantly different. Tight/stretchy ratings for nonwoven fabric D and F were not significantly different. These results indicated that respondents perceived fabrics D and F to be stretchy and fabric E to be not stretchy.

Summary of Nonwoven Attribute Ratings

Respondents perceived the nonwoven fabrics to have the same level of comfort, dryness, and fuzziness. The difference between fabrics D and F is only slightly significant indicating the fabrics were all perceived to be the same level of warmth. The difference between fabrics E and F was only slightly significant indicating the fabrics were all perceived to be the same level of thickness and stiffness. Respondents did perceive the nonwoven fabrics to have different levels of smoothness. Fabrics D and F were perceived to have the same level of stretchiness, but fabric E was perceived to be less stretchy than fabrics D and F.

Table 55. *Pretest Median Attribute Ratings*

Fabrics / Attributes	Woven			Nonwoven		
	A	B	C	D	E	F
Comfort	3	3	4	4.5	5	4.5
Cool/Warm	3.5	4	4	5	5	5
Dry/Wet	3	3	3	3.5	2	3
Smooth/Rough	5	5	4.5	2	3	2
Bald/Fuzzy	2	3	5	5	5	5
Thin/Thick	2	3	4	5	4	5
Flexible/Stiff	3	4	4	4	5	5
Tight/Stretchy	5	2	6	5	2	5

Table 56. *Wilcoxon Rank-Sum Test: Comparison of Medians between Pretest Woven and Nonwoven Fabrics*

Fabric / Attribute	AD		AE		AF		BD		BE		BF		CD		CE		CF	
	Z	Prob > |Z|	Z	Prob> |Z|	Z	Prob> |Z|	Z	Prob> |Z|	Z	Prob> |Z|	Z	Prob> |Z|	Z	Prob> |Z|	Z	Prob> |Z|	Z	Prob> |Z|
Comfort	1.89	0.0592	1.86	0.0627	0.58	0.5650	2.73	0.0063*	2.64	0.0083*	1.39	0.1659	0.19	0.8443	0.24	0.8114	-0.86	0.3896
Cool/Warm	2.12	0.0337*	2.92	0.0035*	3.22	0.0013*	2.36	0.0181*	3.21	0.0013*	3.60	0.0003*	2.07	0.0384*	2.96	0.0030*	3.40	0.0007*
Dry/Wet	0.12	0.9081	-1.58	0.1139	-0.24	0.8127	1.40	0.1622	-0.03	0.9769	1.17	0.2404	0.49	0.6271	-1.30	0.1932	0.10	0.9168
Smooth/Rough	-5.66	<.0001*	-4.17	<.0001*	-6.74	<.0001*	-5.44	<.0001*	-4.24	<.0001*	-6.36	<.0001*	-4.62	<.0001*	-2.71	0.0067*	-6.01	<.0001*
Bald/Fuzzy	5.19	<.0001*	5.44	<.0001*	5.10	<.0001*	4.95	<.0001*	5.23	<.0001*	4.84	<.0001*	1.37	0.1694	1.89	0.0589	2.03	0.0428*
Thin/Thick	4.76	<.0001*	4.28	<.0001*	5.53	<.0001*	3.80	0.0001*	2.98	0.0029*	4.55	<.0001*	0.72	0.4689	-0.47	0.6392	1.77	0.0766
Flexible/Stiff	2.20	0.0276*	2.11	0.0347*	3.36	0.0008*	0.12	0.9070	-0.02	0.9810	1.71	0.0878	0.92	0.3572	0.72	0.4707	2.32	0.0201*
Tight/Stretchy	1.75	0.0797	-4.12	<.0001*	0.58	0.5639	3.79	0.0002*	-2.07	0.0388*	2.81	0.0050*	-3.90	<.0001*	-7.23	<.0001*	-4.84	<.0001*

Note. * indicates significance at a 95% confidence level.

Table 57. *Wilcoxon Rank-Sum Test: Comparison of Medians among Pretest Nonwoven Fabrics and among Pretest Woven Fabrics*

	Among Nonwoven Fabrics						Among Woven Fabrics					
Fabric / Attribute	DE		DF		EF		AB		AC		BC	
	Z	Prob > |Z|	Z	Prob > |Z|	Z	Prob > |Z|	Z	Prob > |Z|	Z	Prob > |Z|	Z	Prob > |Z|
Comfort	0.12	0.9067	-0.93	0.3506	-0.86	0.3879	-0.94	0.3452	1.58	0.1143	2.48	0.0132*
Cool/Warm	1.25	0.2121	2.04	0.0412*	0.84	0.4021	-0.23	0.8168	0.12	0.9030	0.39	0.6970
Dry/Wet	-1.53	0.1270	-0.22	0.8260	1.33	0.1824	-1.34	0.1803	-0.41	0.6813	1.04	0.2973
Smooth/Rough	2.49	0.0129*	-2.14	0.0324*	-4.45	<.0001*	0.86	0.3895	-1.97	0.0485*	-2.67	0.0075*
Bald/Fuzzy	0.57	0.5671	0.95	0.3411	0.47	0.6368	1.22	0.2231	4.29	<.0001*	3.82	0.0001*
Thin/Thick	-1.04	0.2975	1.08	0.2823	2.02	0.0425*	1.56	0.1180	4.56	<.0001*	3.55	0.0004*
Flexible/Stiff	-0.14	0.8864	1.63	0.1029	1.96	0.0494*	1.99	0.0463*	1.14	0.2549	-0.76	0.4497
Tight/Stretchy	-5.73	<.0001*	-1.27	0.2035	4094	<.0001*	-1.99	0.0455*	5.35	<.0001*	6.13	<.0001*

Note. * indicates significance at a 95% confidence level.

Spearman's Correlation Coefficient

Spearman's correlation coefficients were calculated to study the relationships between the seven sensory attributes and comfort, specifically, which attributes have a significant correlation, at a 95% confidence level. The results can be seen in Table 58. Smooth/rough was significantly related to comfort for all fabrics, except for nonwoven fabric F. The negative relation between comfort and smooth/rough for fabrics A – E indicated the smoother the fabric the more comfortable the fabric was perceived. Cool/warm and comfort were significantly related for woven fabrics A and C. Woven fabric A showed a negative relationship while woven fabric C showed a positive relationship, indicating opposite sensations will both give the sensation of a more comfortable fabric. Since the subjects were fashion students familiar with fabric uses in apparel products, they may have felt fabric A which is a thinner fabric and thought a summer weight fabric. In that case cooler would be more comfortable. Whereas with fabric C, a heavier weight fabric, they may have tough winter weight in which case warmer would be more comfortable. Flexible/stiff was significantly related to comfort for nonwoven fabric E. The negative relationship indicated the more flexible the fabric the more comfortable the fabric was perceived. There were no significant correlations between the attributes and comfort for nonwoven fabric F.

Table 58. *Pretest Spearman's Correlation Coefficient*

	Fabric A Comfort		Fabric B Comfort		Fabric C Comfort		Fabric D Comfort		Fabric E Comfort		Fabric F Comfort	
	ρ	Prob > |Z|	ρ	Prob > |Z|	ρ	Prob > |Z|	ρ	Prob > |Z|	ρ	Prob > |Z|	ρ	Prob > |Z|
Cool/Warm	-0.4006	0.0155*	-0.0104	0.9518	0.3307	0.0489*	0.2943	0.0814	0.1455	0.3973	0.2890	0.0874
Dry/Wet	0.1864	0.2764	-0.1261	0.4636	0.2166	0.2045	-0.1654	0.3351	-0.0389	0.8220	-0.0592	0.7315
Smooth/Rough	-0.4075	0.0136*	-0.6699	<.0001*	-0.4050	0.0143*	-0.3793	0.0225*	-0.4100	0.0130*	-0.1493	0.3848
Bald/Fuzzy	0.0336	0.8458	-0.1490	0.3857	-0.0308	0.8583	-0.0007	0.9967	-0.0641	0.7105	-0.1387	0.4200
Thin/Thick	-0.0712	0.6797	-0.1811	0.2904	0.1132	0.5110	0.0179	0.9175	-0.1245	0.4693	-0.1795	0.2949
Flexible/Stiff	-0.2796	0.0986	-0.3286	0.0504	-0.1298	0.4506	-0.1172	0.4960	-0.4805	0.0030*	-0.1403	0.4145
Tight/Stretchy	0.1572	0.3599	0.0573	0.7399	0.1094	0.5254	-0.0160	0.9263	0.2234	0.1903	0.2215	0.1941

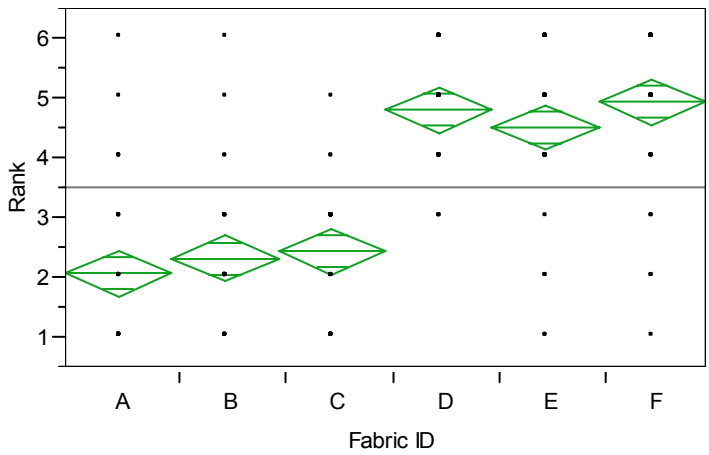
Note. * indicates significance at a 95% confidence level.

Pretest Part II: Ranking Results

Consumer acceptance of nonwoven fabrics in apparel and accessories was also evaluated by asking consumers to rank the six fabrics in order of most desirable to least desirable for four different images (short sleeve button-down shirt, long sleeve button-down shirt, pleated shorts, and a bag). The ranks were recorded for each image and analyzed using the Tukey test to determine if the mean ranks of each fabric were significantly different at a 95% confidence level. Rank 1 indicates most desirable for the image shown while rank 6 indicates least desirable for the image shown. This information was used to determine how nonwoven fabrics rank in comparison to woven fabrics, and how nonwoven fabrics rank among one another.

Short Sleeve Button-Down Shirt

Figure 11 displays the ranking results of the six test fabrics when respondents were asked to consider the desirability of a fabric for a short sleeve button-down shirt. The mean rank of the woven fabrics A, B, and C were not significantly different at a 95% confidence level. This was indicated by fabrics A, B, and C being labeled with the same letter, B. The mean rank of nonwoven fabrics E, D, and F were not significantly different at a 95% confidence level as indicated by all having the label, A. However, the mean ranks of the woven fabrics (A, B, C) were significantly different than the mean ranks of the nonwoven fabrics (D, E, F). Therefore, for a short sleeve button-down shirt, woven fabrics were preferred over the nonwoven fabrics. This result was not surprising since these are the fabrics currently in the market.



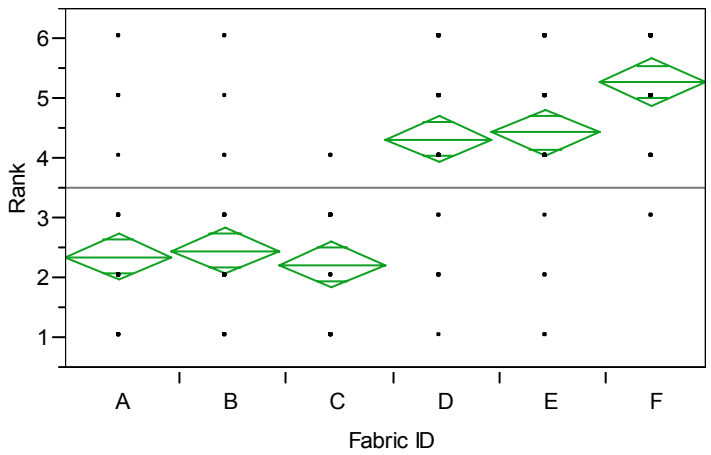
Fabric			Mean
F	A		4.9210526
D	A		4.7894737
E	A		4.5000000
C		B	2.4210526
B		B	2.3157895
A		B	2.0526316

Fabrics not connected by the same letter are significantly different.

Figure 11. Pretest Tukey test results for the short sleeve button-down shirt.

Long Sleeve Button-Down Shirt

The ranking results of the six test fabrics when respondents were asked to consider the desirability of a fabric for a long sleeve button-down shirt are shown in Figure 12. The mean rank of the woven fabrics A, B, and C were not significantly different at a 95% confidence level. The mean rank of nonwoven fabrics D and E were not significantly different; however, the mean rank of nonwoven fabric F was significantly different than the other five fabrics. The mean ranks of the woven fabrics (A, B, C) were significantly different than the mean ranks of the nonwoven fabrics (D, E, F) indicating the woven fabrics were preferred over the nonwoven fabrics for a long sleeve button-down shirt. This result was not surprising since these are the fabrics currently in the market.



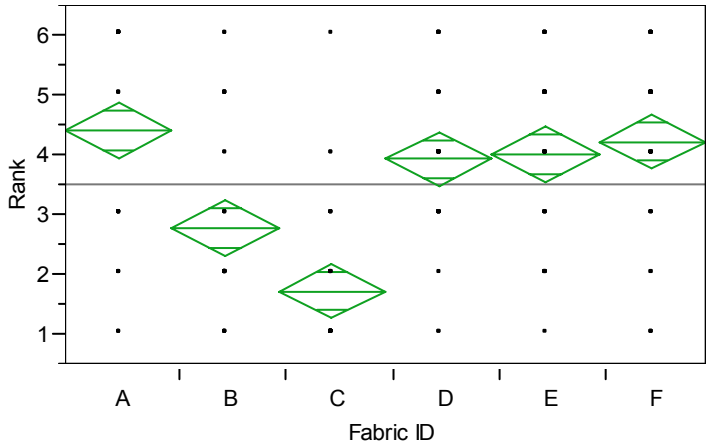
Fabric				Mean
F	A			5.2631579
E		B		4.4210526
D		B		4.3157895
B			C	2.4473684
A			C	2.3421053
C			C	2.2105263

Fabrics not connected by the same letter are significantly different.

Figure 12. Pretest Tukey test results for the long sleeve button-down shirt.

Pleated Shorts

As seen in Figure 13, woven fabric C and woven fabric B were significantly different from one another and the other fabrics. Nonwoven fabric D, E, and F and woven fabric A were not significantly different and rank less desirable than woven fabrics C and B. Therefore, woven fabrics C and B were preferred over the nonwoven fabrics for a pair of pleated shorts but woven fabric A was equally preferred to the nonwoven fabrics.



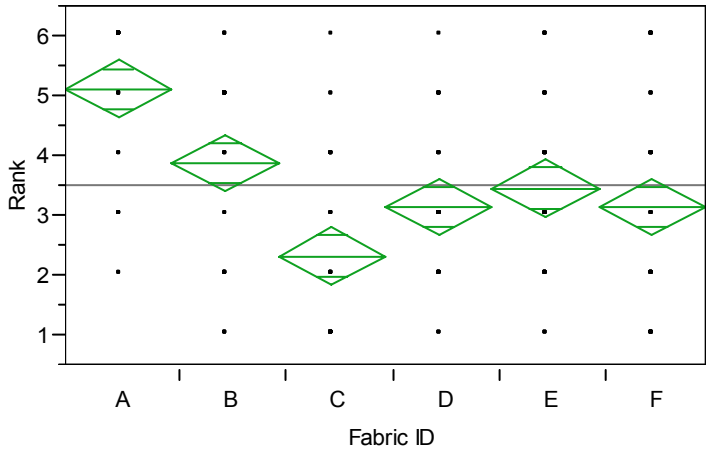
Fabric				Mean
A	A			4.3947368
F	A			4.2105263
E	A			4.0000000
D	A			3.9210526
B		B		2.7631579
C			C	1.7105263

Fabrics not connected by the same letter are significantly different.

Figure 13. Pretest Tukey test results for the pleated shorts.

Bag

Results for the bag show a different trend than the results for the three general apparel images. Woven fabric A was the only statistically significant different mean rank and ranked least desirable for a bag (see Figure 14). The mean rank among the nonwoven fabrics was not significantly different. The rank of woven fabrics B and C and the nonwoven fabrics was intermixed. The lack of statistically significant separation among ranks of the fabrics could be that a bag is not worn against the skin as with shirts and shorts. Fabrics for bags vary more than the fabrics for button-down shirts and shorts. Therefore, the fabric hand for a bag, or accessories, may not be as important to the consumer as the fabric for shirts or shorts.



Fabric				Mean
A	A			5.1052632
B		B		3.8684211
E		B		3.4473684
F		B	C	3.1315789
D		B	C	3.1315789
C			C	2.3157895

Fabrics not connected by the same letter are significantly different.

Figure 14. Pretest Tukey test results for the bag.

Summary of Fabric Rankings

For the short sleeve and long sleeve button-down shirts, the woven fabrics were preferred over the nonwoven fabrics. There was no indication of one woven fabric preferred over another for these two garments. There was no indication of one nonwoven fabric preferred over another for the short sleeve button-down shirt. There was indication that nonwoven fabric F was the least preferred of the three nonwoven fabrics for a long sleeve button-down shirt. For pleated shorts, two woven fabrics (C and B) were more preferred over nonwoven fabrics. However, woven fabric A was the least preferred of all fabrics for this garment. This may possibly be the case since this fabric is the thinnest of all six fabrics and bottom weight garments are typically a thicker or heavier weight fabric. It is clear that woven fabric A was the least preferred of all fabrics for a bag end-use. Preference for the other woven or nonwoven fabrics was not clear. As previously stated, this could be due to the fact that a bag is not worn against the skin as with shirts and shorts. Therefore, fabric hand of a bag may not be as important as the fabric hand for products worn against the skin.

Proposed Changes in Testing Procedure

Overall the pretest was successful and informative. As previously mentioned, the purpose of the pretest was to 1) ensure the computerized survey functioned properly and recorded data correctly, 2) ensure subjects' understanding of the testing and evaluation procedures, 3) test procedure for timing and methodology, and 4) determine appropriate statistics for data analysis. The computerize survey functioned and recorded data as expected. Subjects (including two subjects without a textile background) successfully completed the experiment without difficulties understanding the procedure, directions, or terminologies. There is some concern as to the time it took for respondents to complete the experiment. Respondents were averaging about 30-40 minutes to fully complete all requirements of the experiment. To avoid respondent fatigue and collect more reliable and valuable data, a testing time of 15-20 minutes is more acceptable for consumer subjects. Suggested changes to reduce the time of the study will be discussed in the following section. Statistics used to analyze the pretest are appropriate for the data collected and help answer the research questions.

Attribute Reduction

The main concern from the findings of the pretest is the time required for subjects to complete the study. Proposed changes to the methodology have been made in order to reduce the testing time. Subjects were provided with a definition and an evaluation procedure for each attribute being evaluated. A reduction in the number of attributes being evaluated can reduce the testing time and in turn user fatigue. In revisiting the literature, it was noted that

only several attributes were evaluated when researching a range of fabrics, or researching fabrics without one specific end-use product being evaluated. Studies by Howorth and Oliver (1956) and Howorth (1964) found stiffness, smoothness, thickness and/or weight to be the most significant combination of attributes to use to describe fabric hand for a variety of fabrics. While Howorth did not include warmth (thermal character) in the final list of attributes, it was part of the list of attributes that totaled 86% of the decision for total fabric hand acceptance. Therefore, researchers commonly include thermal character along with the other three attributes. Combinations of these attributes are common in literature (Laing & Ingham, 1983; Lundgren, 1969; Paek, 1975, 1978, 1979; Sülar & Okur, 2007). When studying comfort, researchers tend to include stretchiness to this list of attributes (Barker & Scheininger, 1982; Cowan et al., 1998; Fourt and Hollies, 1970). Therefore, to reduce testing time and user fatigue, the attributes dry/wet and bald/fuzzy should be removed from the survey leaving the commonly used attributes for general end-use applications, cool/warm, smooth/rough, thin/thick, flexible/stiff, and tight/stretchy.

Textured Fabric Addition

In general, the nonwoven fabrics were rated and ranked similarly indicating that the subjects were unable to distinguish between the three nonwoven fabrics. However, they were often able to distinguish between the woven and nonwoven fabrics. A nonwoven will be replaced with a textured nonwoven. This will provide an opportunity to see if a texture nonwoven is preferred over the other nonwoven fabrics, or the woven fabrics. Several textured versions are available for use (see Table 59).

Table 59. *Available Fabrics for the Study*

Fabric ID	Fabric Construction	Fiber Content	Basis Weight (g/m^2)	Thickness (mm)
A	Plain Weave	65%/35% Polyester/Cotton	141	0.30
B	Plain Weave	65%/35% Polyester/Cotton	144	0.36
C	Sateen Weave	97%/3% Cotton/Spandex	199	0.44
D	Bicomponent Spunlaced Nonwoven	50%/50% Polyester/Nylon	131	0.58
E	Bicomponent Spunlaced Nonwoven	70%/30%* Polyester/Nylon	111	0.60
F	Bicomponent Spunlaced Nonwoven	80%/20% Polyester/Nylon	132	0.50
G	Textured Bicomponent Spunlaced Nonwoven	50%/50% Polyester/Nylon	121	0.61
H	Textured Bicomponent Spunlaced Nonwoven	50%/50% Polyester/Nylon	99	0.55
I	Textured Bicomponent Spunlaced Nonwoven	50%/50% Polyester/Nylon	161	0.77

Note. *Fabric shipment unlabeled, typically 70%/30% blend.

A second, small pretest was conducted to gain an idea as to how the subjects would react to the textured nonwoven fabric. For the small pre-test, nonwoven fabric D was replaced with a textured version, labeled fabric G (see Table 60). The pre-test included eight usable subjects who were all textile and apparel students. Since the number of subjects was under 30, no statistics were used to analyze the data. Instead, the median ratings were calculated (see Table 61), and the mean, median, and mode rankings were also calculated, (see Table 62).

Table 60. *Pretest with Texture Nonwoven Fabric*

Fabric ID	Fabric Construction	Fiber Content	Basis Weight (g/m^2)	Thickness (mm)
A	Plain Weave	65%/35% Polyester/Cotton	141	0.30
B	Plain Weave	65%/35% Polyester/Cotton	144	0.36
C	Sateen Weave	97%/3% Cotton/Spandex	199	0.44
E	Bicomponent Spunbond Nonwoven	70%/30%* Polyester/Nylon	111	0.60
F	Bicomponent Spunbond Nonwoven	80%/20% Polyester/Nylon	132	0.50
G	Textured Bicomponent Spunbond Nonwoven	50%/50% Polyester/Nylon	121	0.61

Note. *Fabric shipment unlabeled, typically 70%/30% blend.

In regards to the median ratings, the texture nonwoven (G) rated similarly to the other nonwoven fabrics except for sensory attributes smooth/rough, thin/thick, and tight/stretchy (see Table 61). Nonwoven fabric G rated rougher than the nonwoven fabrics but similar to the woven fabrics. The fabric was not rated as thick as the other nonwoven fabrics and was rated stretchier than the other two nonwoven fabrics. However, without performing any statistical analysis on these numbers, one cannot tell if the ratings are significantly different from one another.

Table 61. *Medians of Fabric Ratings for Textured Pretest*

Fabrics / Attributes	A	B	C	E	F	G
Comfort	3	3	3	3	5	3.5
Cool/Warm	3	5	3.5	4.5	4.5	4
Dry/Wet	4	2.5	4	3	3	3
Smooth/Rough	3.5	5	4	3	2	5
Bald/Fuzzy	2	3	3	5	4.5	4
Thin/Thick	2.5	3	4	5	5	3.5
Flexible/Stiff	3.5	3.5	2.5	3	4.5	2.5
Tight/Stretchy	3	2.5	6	2	3	5

Table 62 displays the mean, median, and mode rankings for all six fabrics for a short sleeve button-down shirt, a long sleeve button-down shirt, a pair of pleated shorts, and a bag. Overall, the woven fabrics were ranked more desirable than the nonwoven fabrics for the apparel images (short sleeve shirt, long sleeve shirt, shorts). Fabric G, the textured nonwoven, ranked least desirable for all of the apparel images. However, when respondents were ranking the fabrics based on the image of a bag, the nonwoven fabrics were more preferred than the woven fabrics and texture nonwoven fabric G rank as one of the more desirable fabrics. However, without performing any statistical analysis on these numbers, one cannot tell if the rankings are significantly different from one another.

Table 62. *Rankings for Textured Pretest*

Short Sleeve	**Fabric A**	**Fabric B**	**Fabric C**	**Fabric E**	**Fabric F**	**Fabric G**
Mean	1.5	2.625	3.375	3.375	4.875	5.25
Median	1	2.5	3	3.5	5	5.5
Mode	1	2	3	2	5	6
Long Sleeve	**Fabric A**	**Fabric B**	**Fabric C**	**Fabric E**	**Fabric F**	**Fabric G**
Mean	2.125	3.25	2.625	3.875	4.125	5
Median	2	3	3	4	4.5	5.5
Mode	1	3	3	4	2	6
Shorts	**Fabric A**	**Fabric B**	**Fabric C**	**Fabric E**	**Fabric F**	**Fabric G**
Mean	3	2.375	2.375	3.875	4.5	4.875
Median	3	2	2.5	4.5	5	6
Mode	3	2	3	5	5	6
Bag	**Fabric A**	**Fabric B**	**Fabric C**	**Fabric E**	**Fabric F**	**Fabric G**
Mean	5.125	4.5	3.25	3.125	2.375	2.625
Median	6	5	4	3	2	1
Mode	6	5	4	2	2	1

The testing time averaged 33 minutes. When the test was completed, the following comments were made by the subjects regarding the textured nonwoven fabric G:

- *Was tricky to tell b/w a nonwoven and a woven*
- *Feels like a nonwoven*
- *Feels like a thicker nonwoven*
- *Papery*
- *Heavy, not good for against skin, hairy*
- *It has pile on the surface*
- *Rough, don't like texture, uneven texture*
- *The fabric is too bumpy and rough on the skin*
- *Okay on stretchy quality*
- *It was only stretchy in one direction*
- *Was surprised about how much stretch there was*
- *Colder than the other nonwoven fabrics*

Other Changes Based on Pre-Test Findings

Sample Preparation

Problem: Woven fabrics began to fray during the evaluation.

Solution: Cut all samples with pinking shears to prevent fraying on the woven fabrics and keep the nonwoven samples consistent with the woven samples.

Questionnaire

Problem: Limited ability to segment the subjects.

Solution: Addition of age groups, and consideration to add an income level question, and a zip code question to segment by location or city size.

Part I: Rating

Problem: Numerical labeling on the rating scales could indicate a ranking.

Solution: Remove the numbers from scale to leave only a verbally labeled categorical scale because the numbers can indicated a good/bad bias.

Part II: Ranking

Problem: Three subjects were hard to mange during the ranking section. The process took longer to manage the fabrics as well as correctly record the ranking results.

Solution: Testing will be scheduled for two subjects at a time. This will also allow for a back up computer. In case one goes down, I can still test the scheduled subject.

APPENDIX C

Pretest Questionnaire

Applicant #: _____

Survey: Qualifying Questions

1. Which hand do you consider to be your dominate hand? (Please circle one)

   ☐ Right ☐ Left

2. Gender: (Please circle one)

   ☐ Male ☐ Female

3. Age: (Please check one)

   ☐ 18 – 25
   ☐ 26 – 30
   ☐ 31 – 35
   ☐ 36 – 40
   ☐ 41 – 45
   ☐ 46 – 50

4. Race: (Please check one)

   ☐ African-American/Black
   ☐ Asian
   ☐ Caucasian/White
   ☐ Hispanic/Latino
   ☐ Native American
   ☐ Other: _____

5. Occupation:

_____

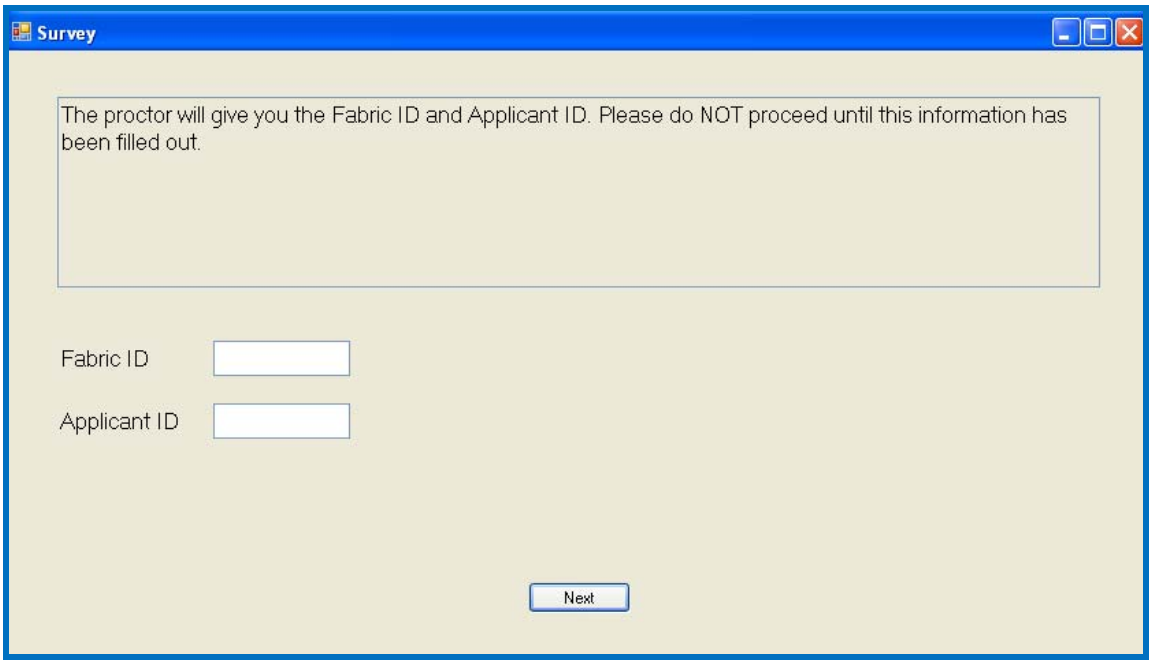
Thank You!

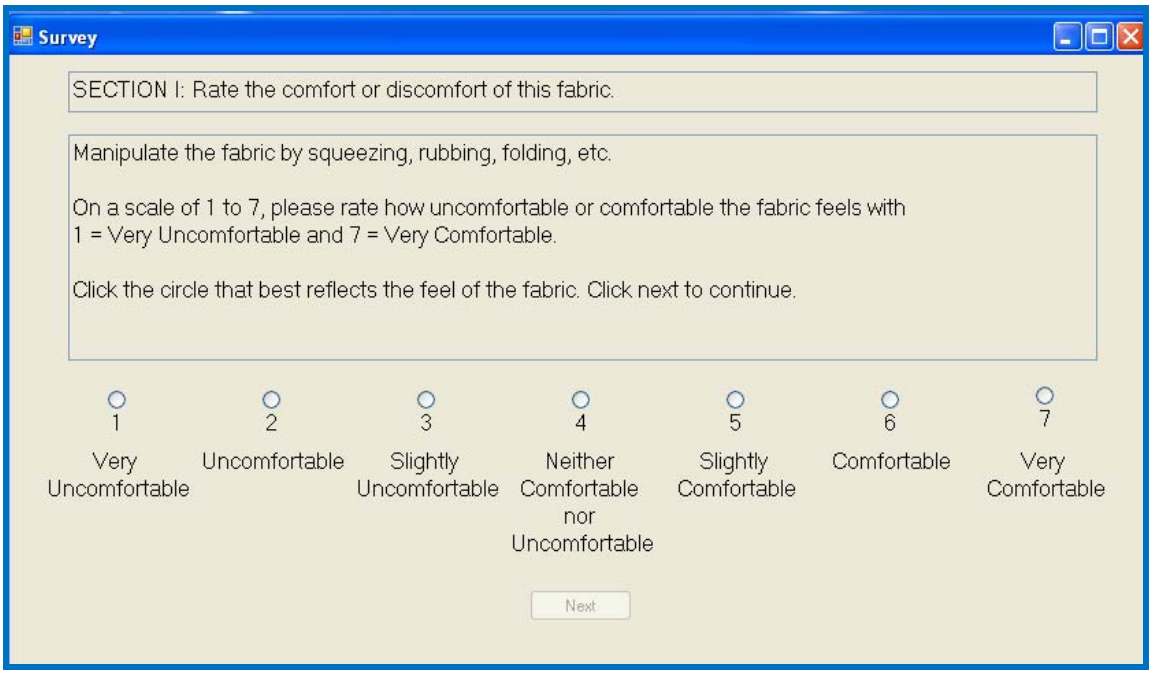
Part I: Rating - Pretest Proctor's Guide

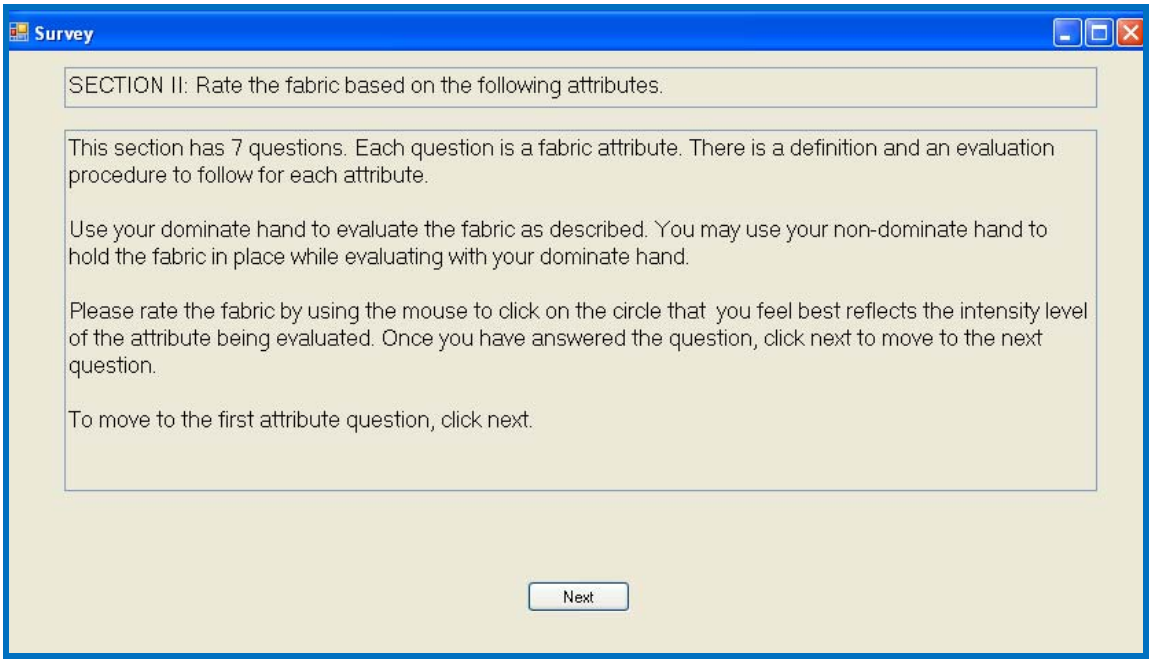
Proctor's Guide: Rating

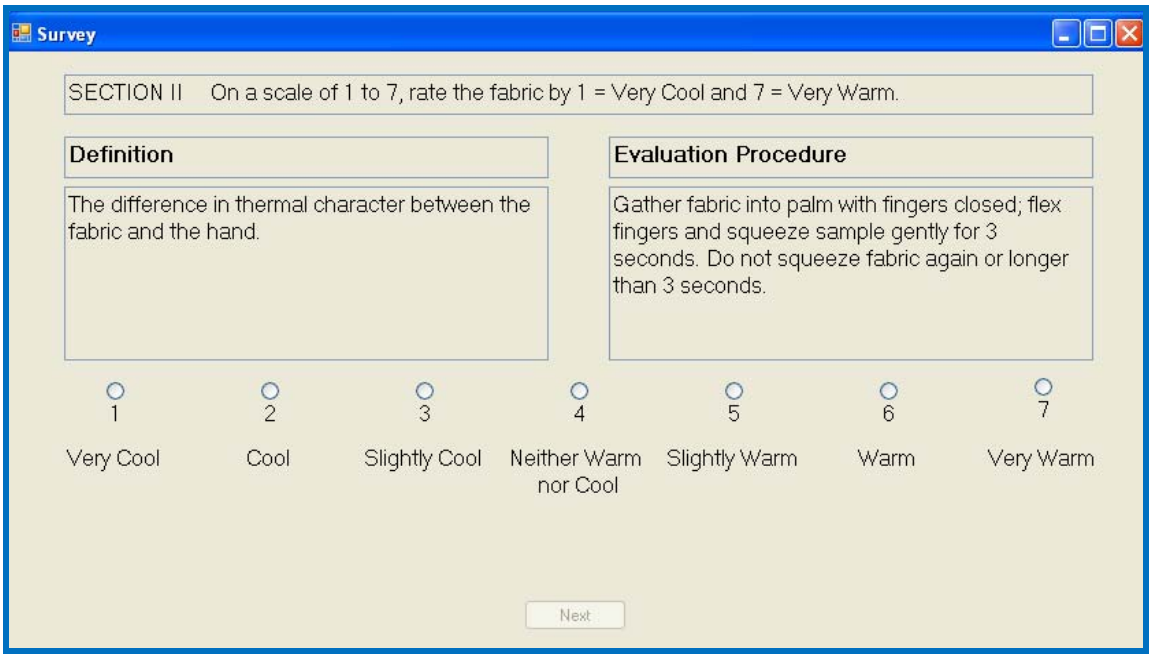
- You are here to test 6 pieces of fabric.
- You will fill out the evaluation on the computer for each fabric sample.
- Please do not look in the box at the sample because it will affect the results.
- Also, please do not share your comments about the fabric out load. We do not want one person's thoughts to affect another person's thoughts about a fabric.
- When you are done with each sample, push it back though the box to me. I will then give you a new sample. You will open up the survey and start again with the new sample.
- If you have any questions, please feel free to ask. Are there any questions before we get started?
- Warning: The first sample seems to take 3 times as long as the other samples. As you saw in your consent form, the whole session should take between 30 – 60 minutes.
- Alright, if there are no questions at this time, let's get started.

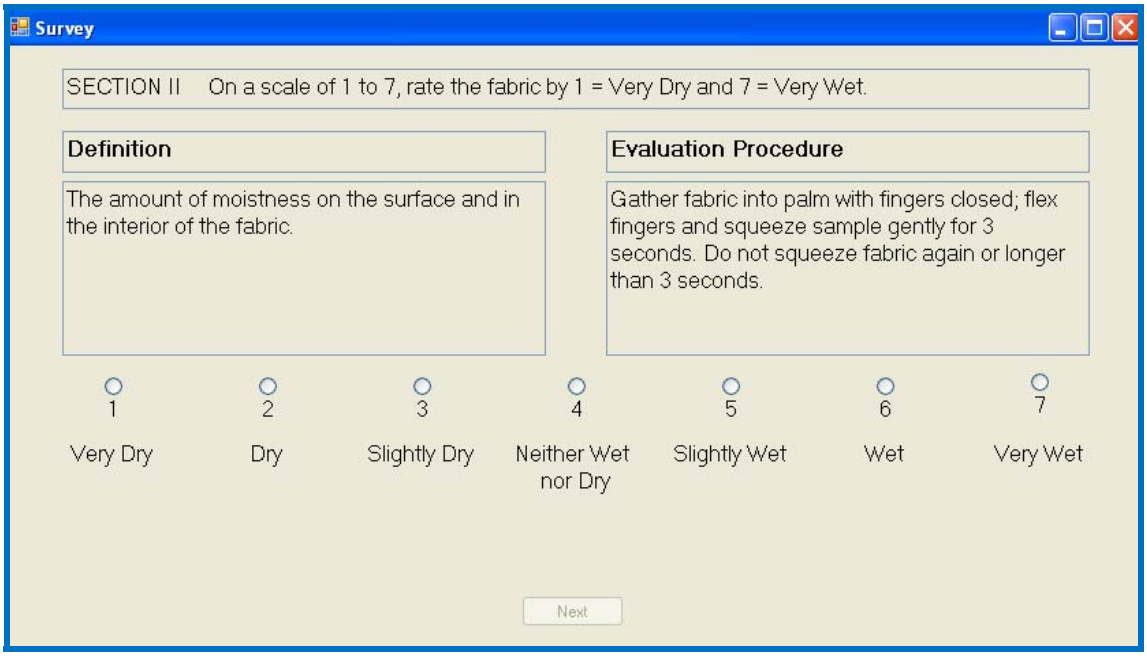
Part I: Rating - Pretest Survey

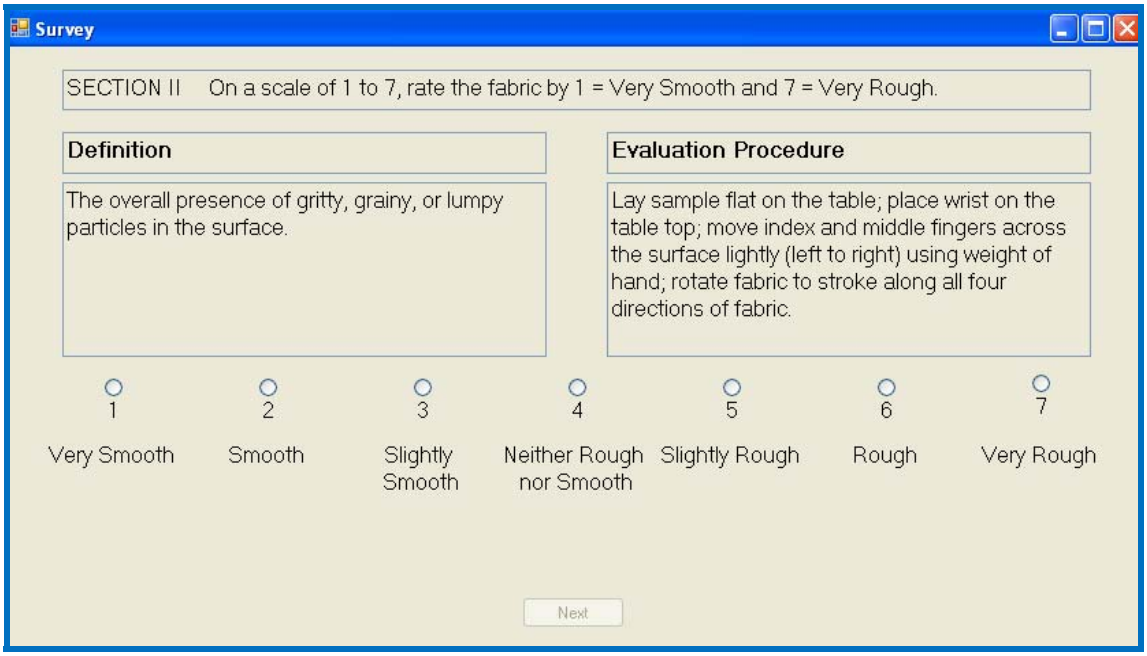


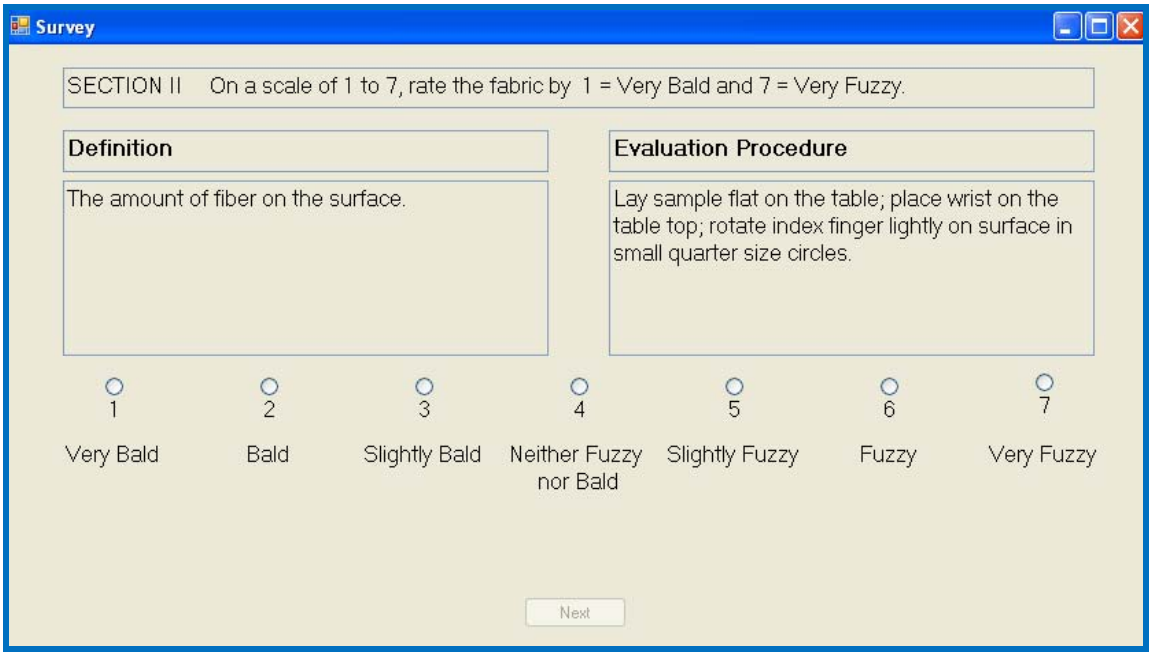


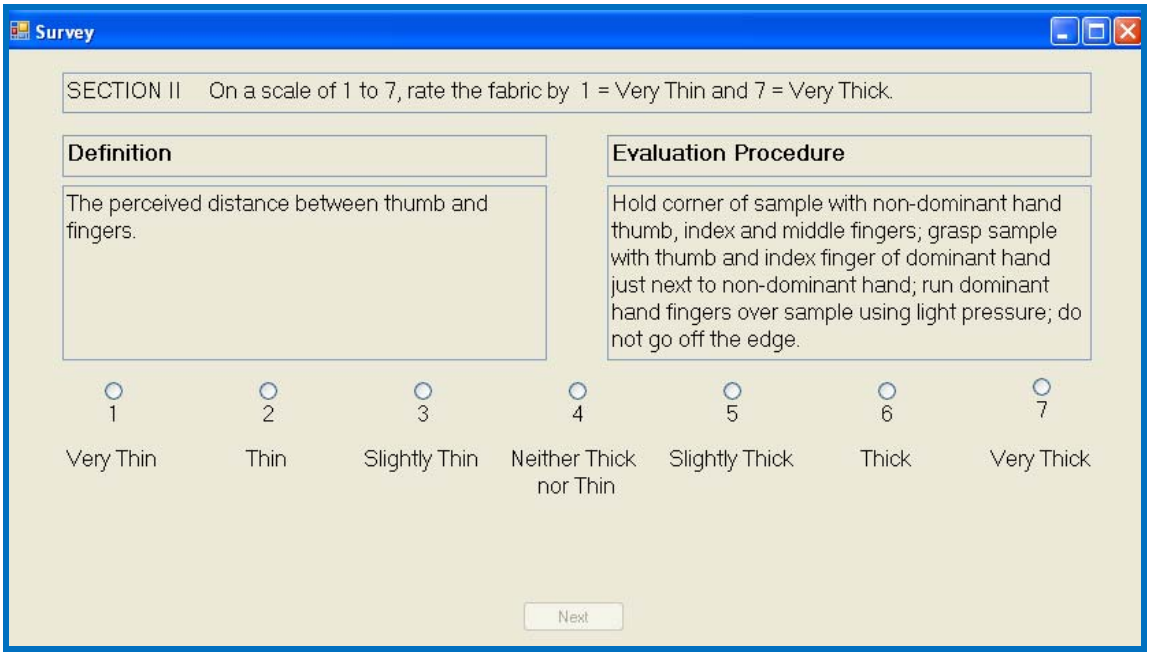

Survey
SECTION II: Rate the fabric based on the following attributes.
This section has 7 questions. Each question is a fabric attribute. There is a definition and an evaluation procedure to follow for each attribute.
Use your dominate hand to evaluate the fabric as described. You may use your non-dominate hand to hold the fabric in place while evaluating with your dominate hand.
Please rate the fabric by using the mouse to click on the circle that you feel best reflects the intensity level of the attribute being evaluated. Once you have answered the question, click next to move to the next question.
To move to the first attribute question, click next.
Next

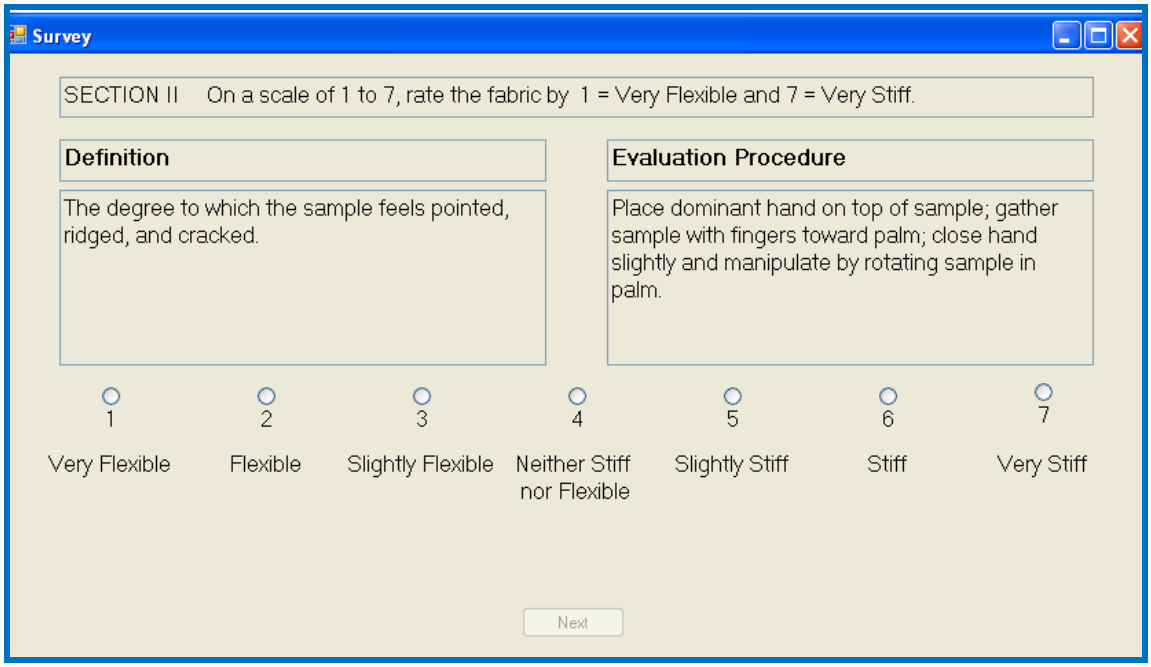

Survey
SECTION II On a scale of 1 to 7, rate the fabric by 1 = Very Cool and 7 = Very Warm.
Definition
The difference in thermal character between the fabric and the hand.
Evaluation Procedure
Gather fabric into palm with fingers closed; flex fingers and squeeze sample gently for 3 seconds. Do not squeeze fabric again or longer than 3 seconds.
1 Very Cool
2 Cool
3 Slightly Cool
4 Neither Warm nor Cool
5 Slightly Warm
6 Warm
7 Very Warm
Next

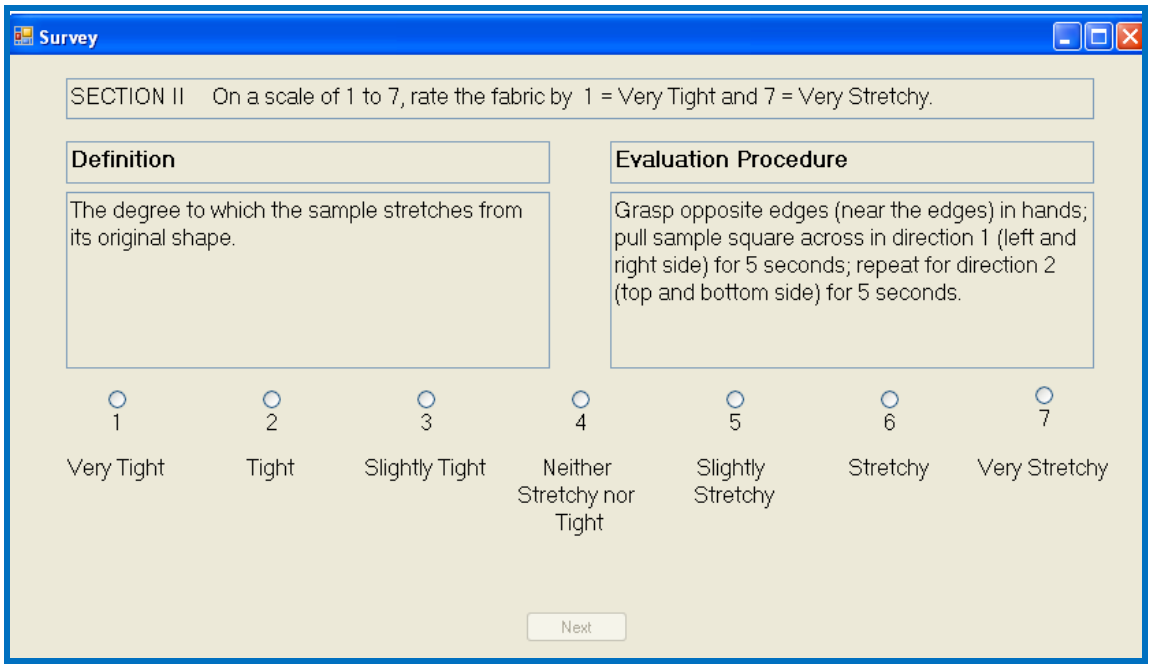

Survey
SECTION II On a scale of 1 to 7, rate the fabric by 1 = Very Dry and 7 = Very Wet.
Definition
The amount of moistness on the surface and in the interior of the fabric.
Evaluation Procedure
Gather fabric into palm with fingers closed; flex fingers and squeeze sample gently for 3 seconds. Do not squeeze fabric again or longer than 3 seconds.
1
Very Dry
2
Dry
3
Slightly Dry
4
Neither Wet nor Dry
5
Slightly Wet
6
Wet
7
Very Wet
Next

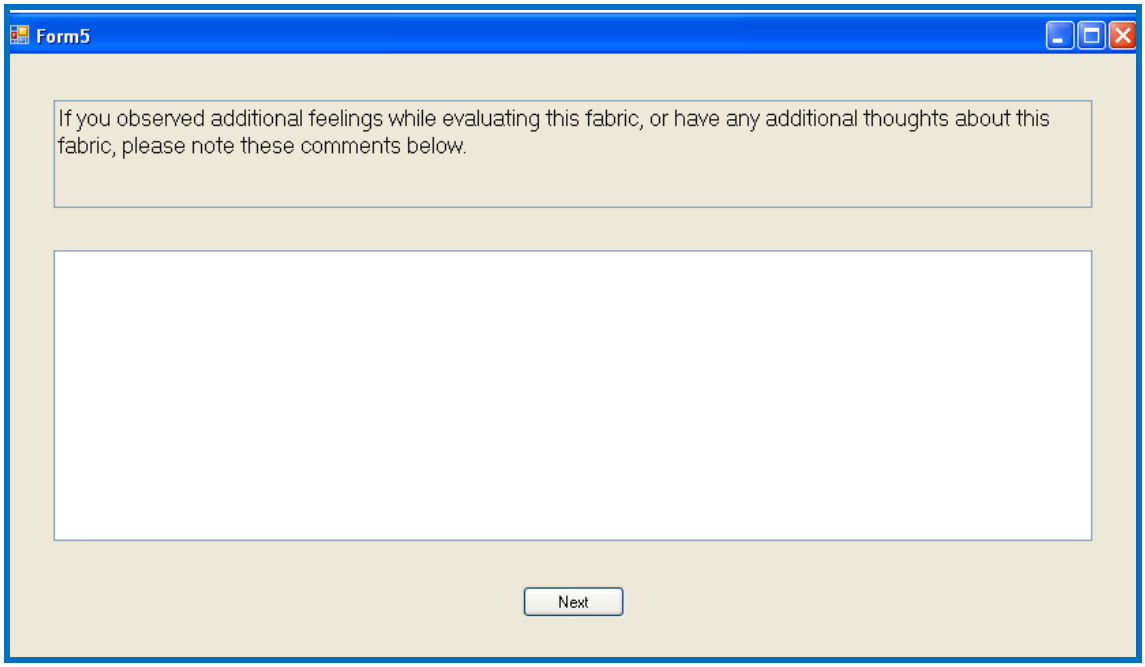

Survey
SECTION II On a scale of 1 to 7, rate the fabric by 1 = Very Smooth and 7 = Very Rough.
Definition
The overall presence of gritty, grainy, or lumpy particles in the surface.
Evaluation Procedure
Lay sample flat on the table; place wrist on the table top; move index and middle fingers across the surface lightly (left to right) using weight of hand; rotate fabric to stroke along all four directions of fabric.
1
Very Smooth
2
Smooth
3
Slightly Smooth
4
Neither Rough nor Smooth
5
Slightly Rough
6
Rough
7
Very Rough
Next

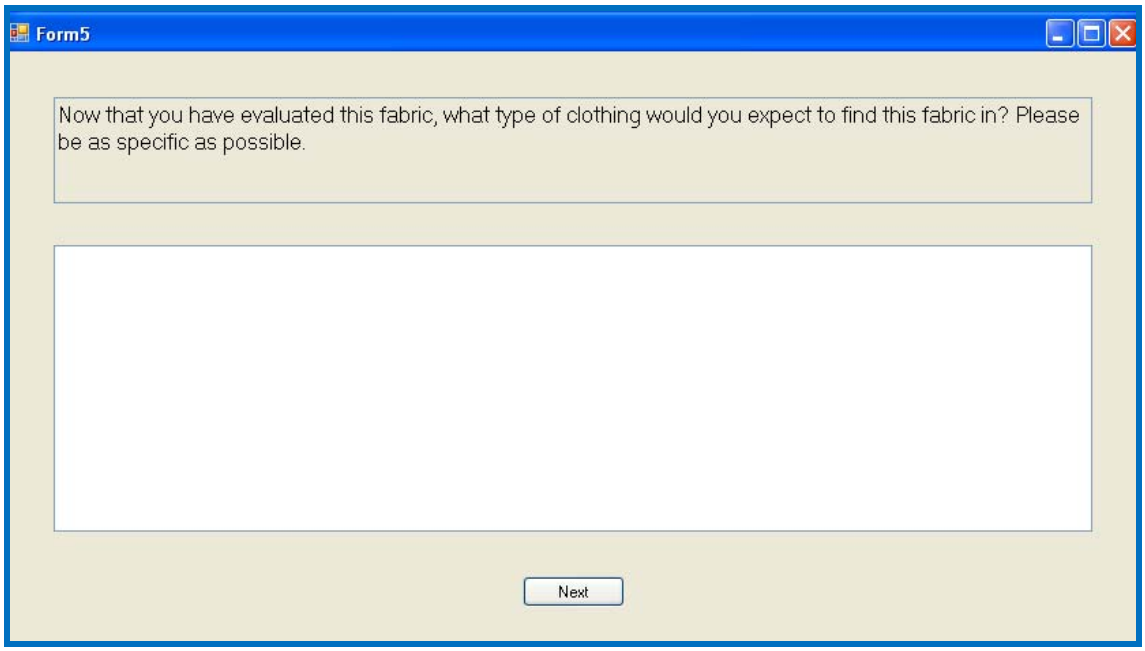

Survey
SECTION II On a scale of 1 to 7, rate the fabric by 1 = Very Bald and 7 = Very Fuzzy.
Definition
The amount of fiber on the surface.
Evaluation Procedure
Lay sample flat on the table; place wrist on the table top; rotate index finger lightly on surface in small quarter size circles.
1
2
3
4
5
6
7
Very Bald
Bald
Slightly Bald
Neither Fuzzy nor Bald
Slightly Fuzzy
Fuzzy
Very Fuzzy
Next

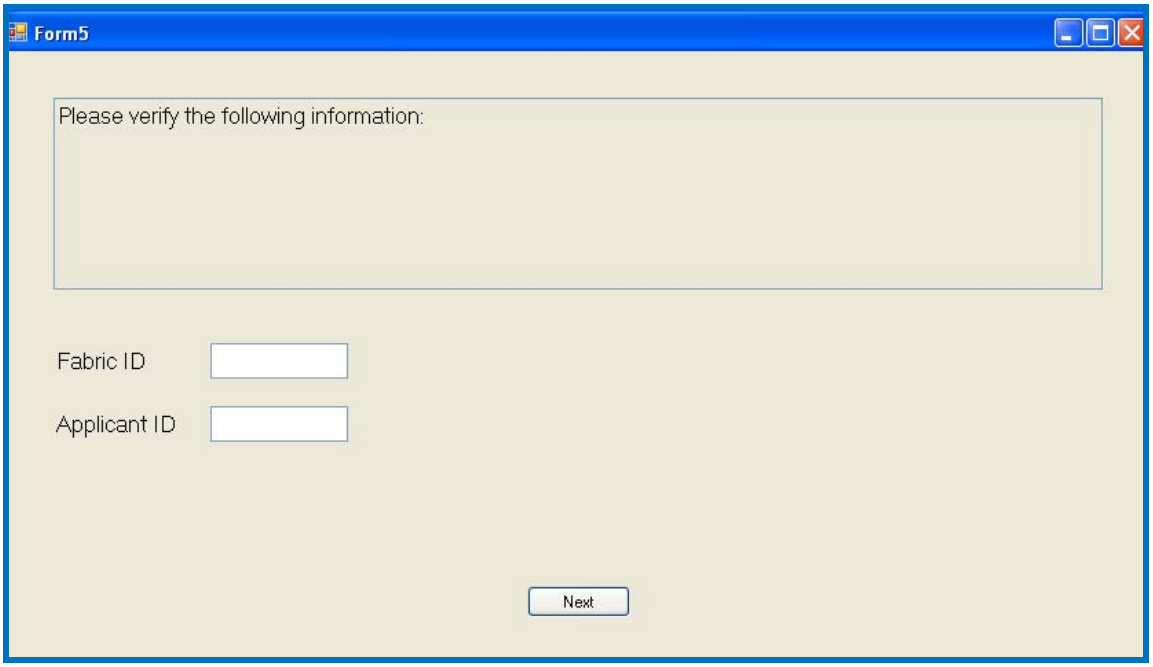

Survey
SECTION II On a scale of 1 to 7, rate the fabric by 1 = Very Thin and 7 = Very Thick.
Definition
The perceived distance between thumb and fingers.
Evaluation Procedure
Hold corner of sample with non-dominant hand thumb, index and middle fingers; grasp sample with thumb and index finger of dominant hand just next to non-dominant hand; run dominant hand fingers over sample using light pressure; do not go off the edge.
1
2
3
4
5
6
7
Very Thin
Thin
Slightly Thin
Neither Thick nor Thin
Slightly Thick
Thick
Very Thick
Next

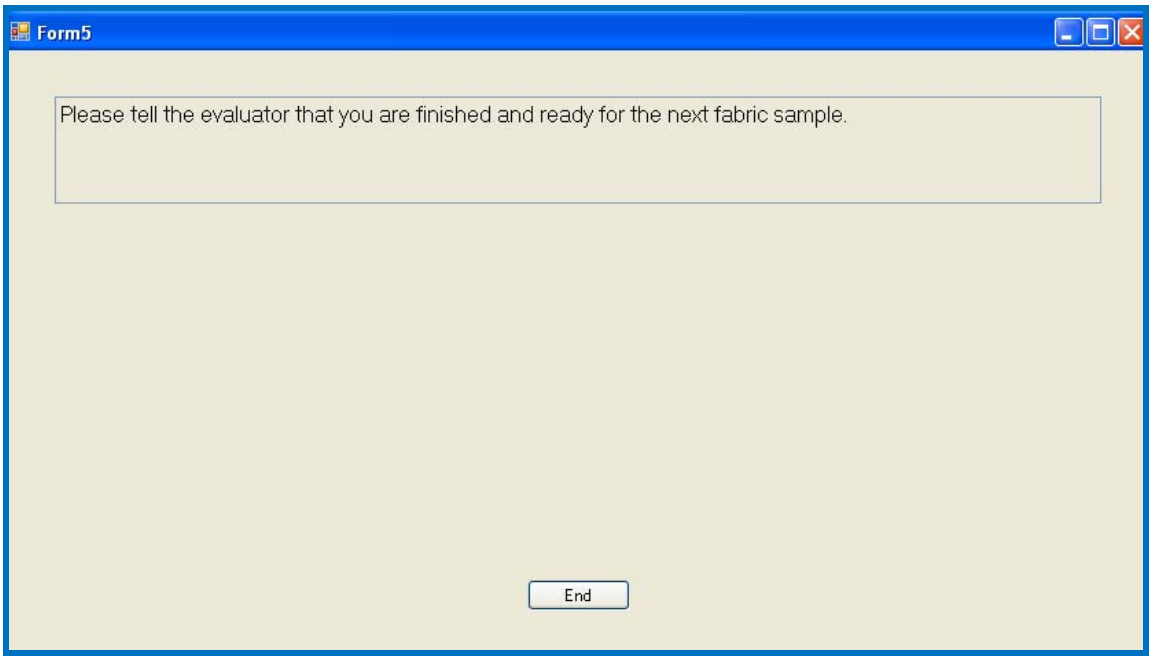

Survey
SECTION II On a scale of 1 to 7, rate the fabric by 1 = Very Flexible and 7 = Very Stiff.
Definition
The degree to which the sample feels pointed, ridged, and cracked.
Evaluation Procedure
Place dominant hand on top of sample; gather sample with fingers toward palm; close hand slightly and manipulate by rotating sample in palm.
1
2
3
4
5
6
7
Very Flexible
Flexible
Slightly Flexible
Neither Stiff nor Flexible
Slightly Stiff
Stiff
Very Stiff
Next


Survey
SECTION II On a scale of 1 to 7, rate the fabric by 1 = Very Tight and 7 = Very Stretchy.
Definition
The degree to which the sample stretches from its original shape.
Evaluation Procedure
Grasp opposite edges (near the edges) in hands; pull sample square across in direction 1 (left and right side) for 5 seconds; repeat for direction 2 (top and bottom side) for 5 seconds.
1
2
3
4
5
6
7
Very Tight
Tight
Slightly Tight
Neither Stretchy nor Tight
Slightly Stretchy
Stretchy
Very Stretchy
Next


Form5
If you observed additional feelings while evaluating this fabric, or have any additional thoughts about this fabric, please note these comments below.
Next


Form5
Now that you have evaluated this fabric, what type of clothing would you expect to find this fabric in? Please be as specific as possible.
Next


Form5
Please verify the following information:
Fabric ID
Applicant ID
Next


Form5
Please tell the evaluator that you are finished and ready for the next fabric sample.
End

Part II: Ranking - Pretest Proctor's Guide

Fabric Ranking Form

Applicant # _____

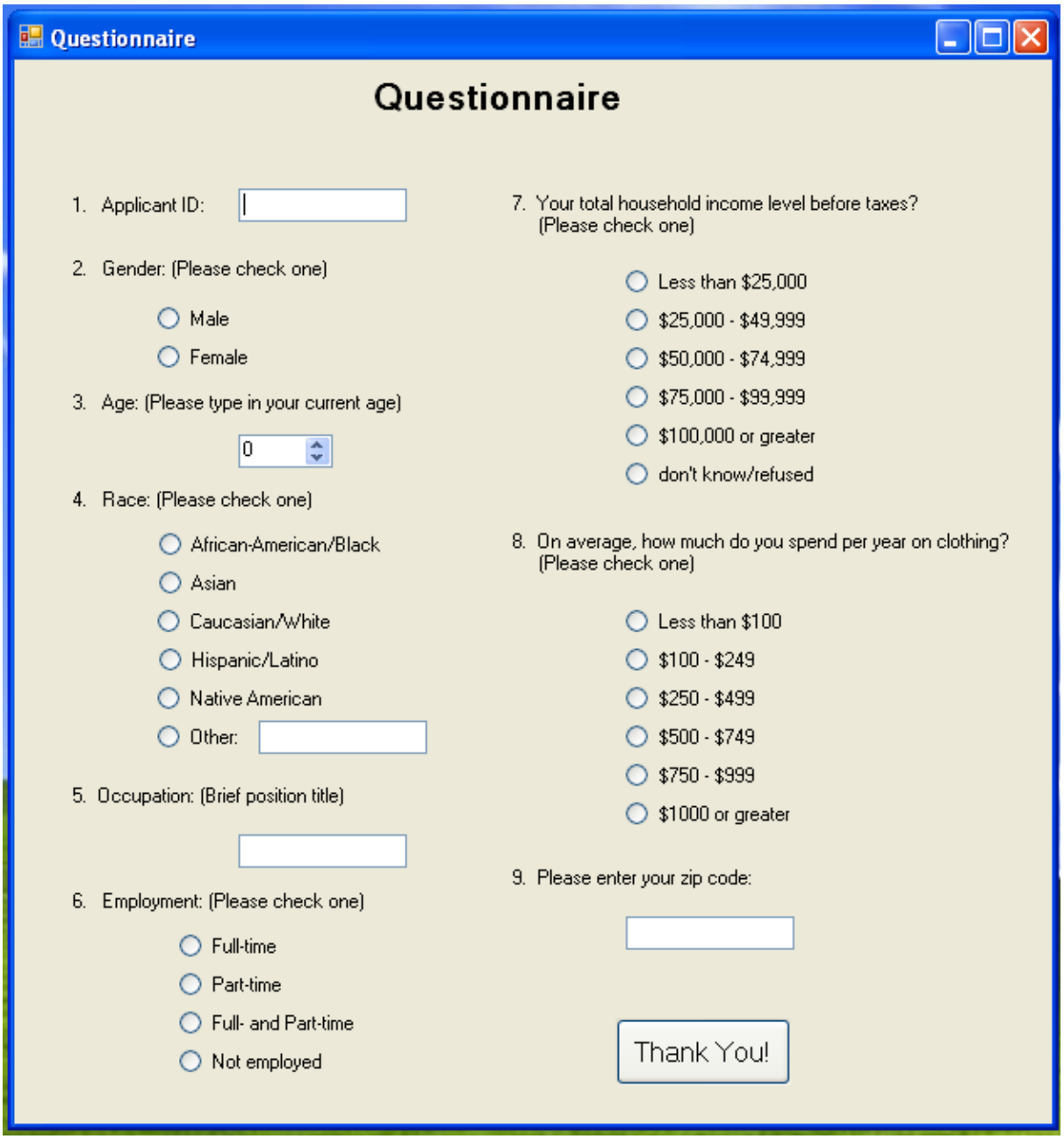
To be read by the proctor:

- The end use product for these fabrics is this image (*show image)*.
- Please put on these blindfolds so you will not be able to see the fabric samples.
- (*Once all blindfold are on*) I have placed all 6 fabric samples on the table in random order.
- Please rank these fabrics based on your perception of the image seen. Rank from the most desirable fabric for this image to the least desirable fabric for this image.
- Thank you. Now please wait one moment while I mark these down. Don't take off the blindfolds until I have hidden the fabric from your view.
- You may now take off your blindfolds. *Present the subjects with the next image and repeat process until all four (4) images have been viewed.*
- Thank you for participating. You are now finished with the test session.

Rank	**Fabric ID**			
	LS Shirt	*SS Shirt*	*Shorts*	*Bag*
Most desirable:	_____	_____	_____	_____
	_____	_____	_____	_____
	_____	_____	_____	_____
	_____	_____	_____	_____
	_____	_____	_____	_____
Least desirable:	_____	_____	_____	_____

APPENDIX D

Questionnaire



Questionnaire

Questionnaire

1. Applicant ID:

2. Gender: (Please check one)
   - Male
   - Female

3. Age: (Please type in your current age)
   0

4. Race: (Please check one)
   - African-American/Black
   - Asian
   - Caucasian/White
   - Hispanic/Latino
   - Native American
   - Other:

5. Occupation: (Brief position title)

6. Employment: (Please check one)
   - Full-time
   - Part-time
   - Full- and Part-time
   - Not employed

7. Your total household income level before taxes? (Please check one)
   - Less than $25,000
   - $25,000 - $49,999
   - $50,000 - $74,999
   - $75,000 - $99,999
   - $100,000 or greater
   - don't know/refused

8. On average, how much do you spend per year on clothing? (Please check one)
   - Less than $100
   - $100 - $249
   - $250 - $499
   - $500 - $749
   - $750 - $999
   - $1000 or greater

9. Please enter your zip code:

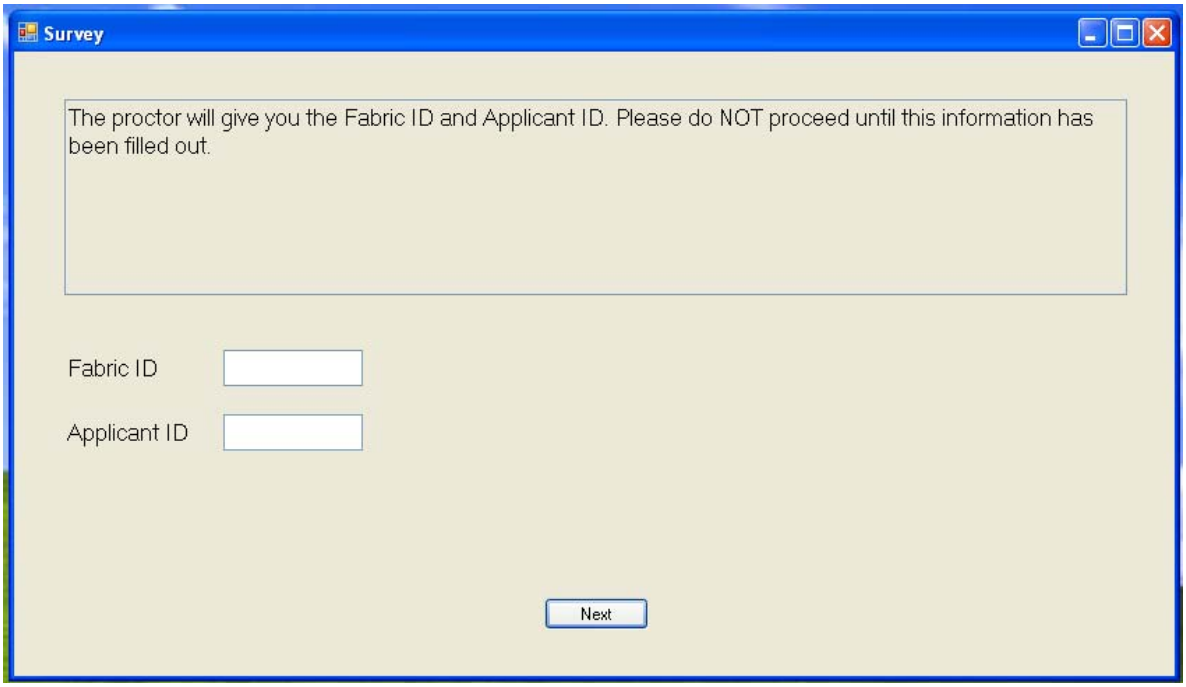
Thank You!

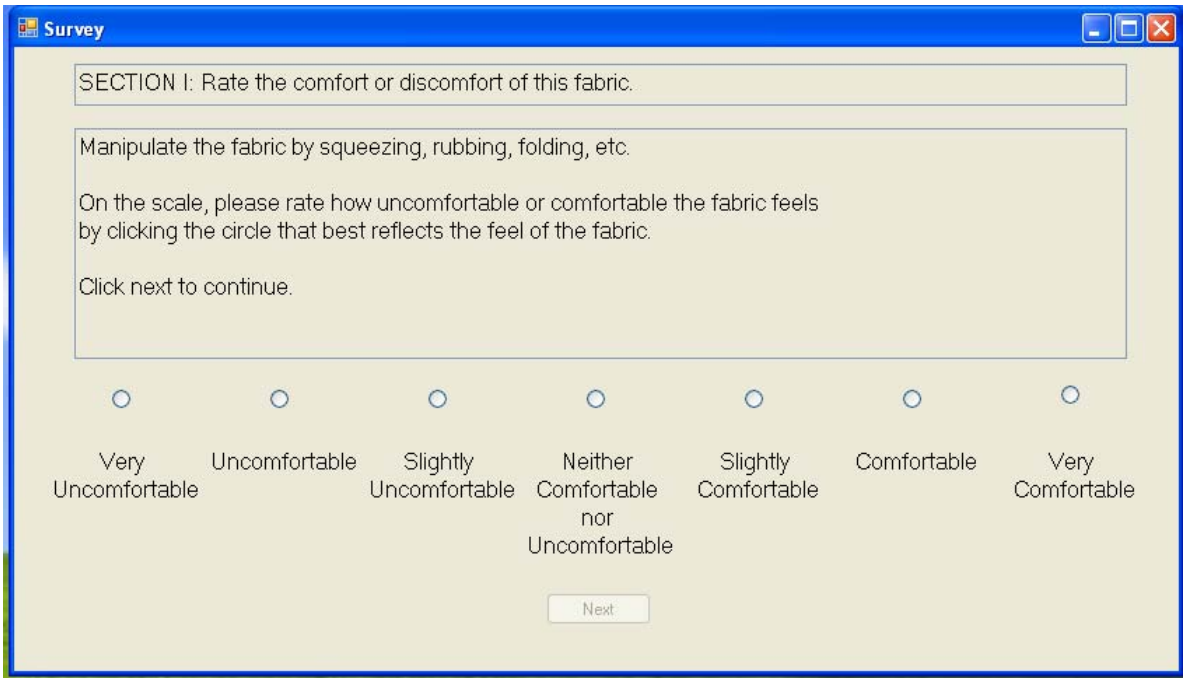
Part I: Rating - Proctor's Guide

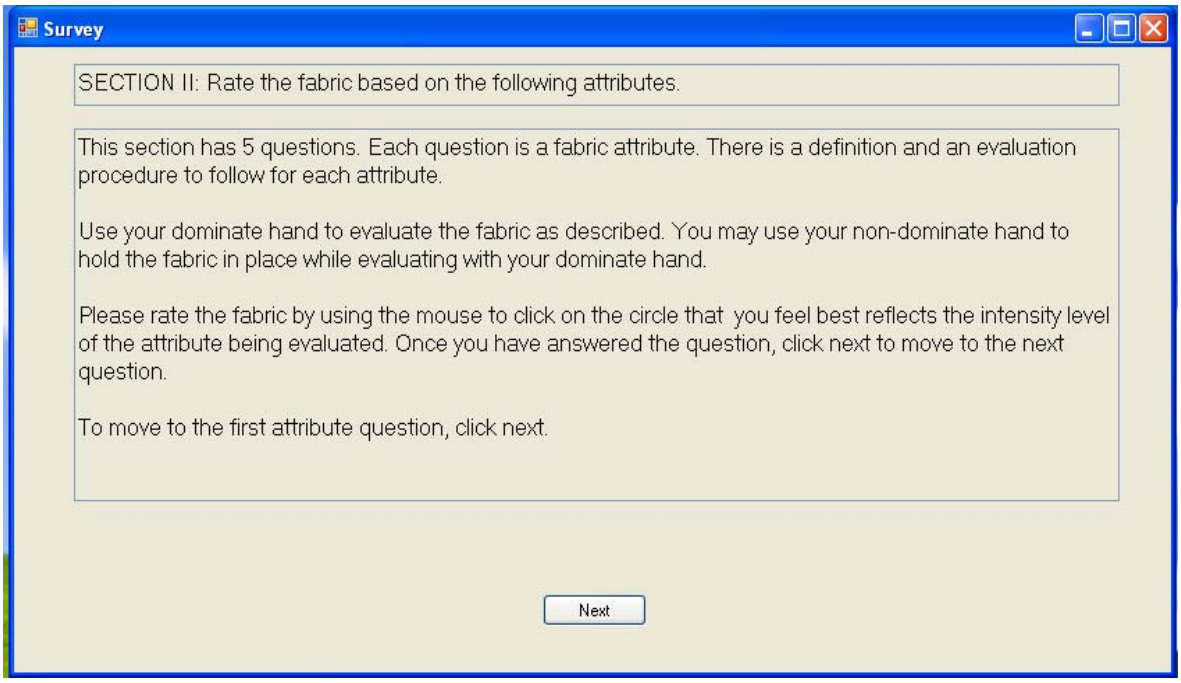
Fabric Evaluation Proctor's Guide

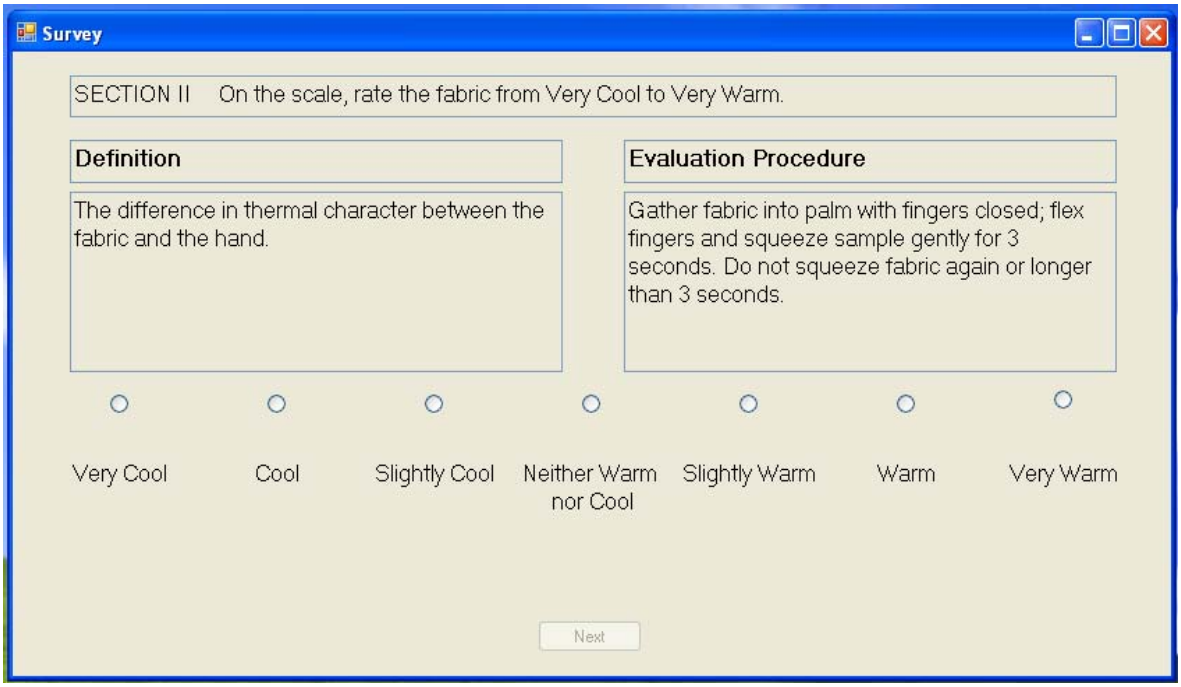
- You are here to evaluate 6 pieces of fabric. These fabrics might be used in clothing.
- You will fill out the evaluation on the computer for each fabric sample. To open the evaluation form, double click on the survey icon in the center of the computer screen.
- The fabric will be placed in the box. You will place your hands through the holes, on the sides of the box, to feel the fabric. *(Point to the holes in the box).* Please do not look in the box at the fabric, or pull the fabric out of the box, because it will affect the results.
- Also, please do not share your comments about the fabric out load. We do not want one person's thoughts to affect another person's thoughts about a fabric.
- When you are finished with each sample, push it back though the box to me. I will then give you a new sample. You will open up the survey and start again with the new sample.
- You will be evaluating the fabric for 6 different attributes. For each attribute, a definition and an evaluation procedure are given. Please follow the evaluation procedure as described. It is very important that we all feel the fabric the same way.
- If you have any questions, please feel free to ask. Are there any questions before we get started?
- Warning: The first sample seems to take 3 times as long as the other samples. As you saw in your consent form, the whole session should take between 30 – 60 minutes.
- Alright, if there are no questions at this time, let's get started.

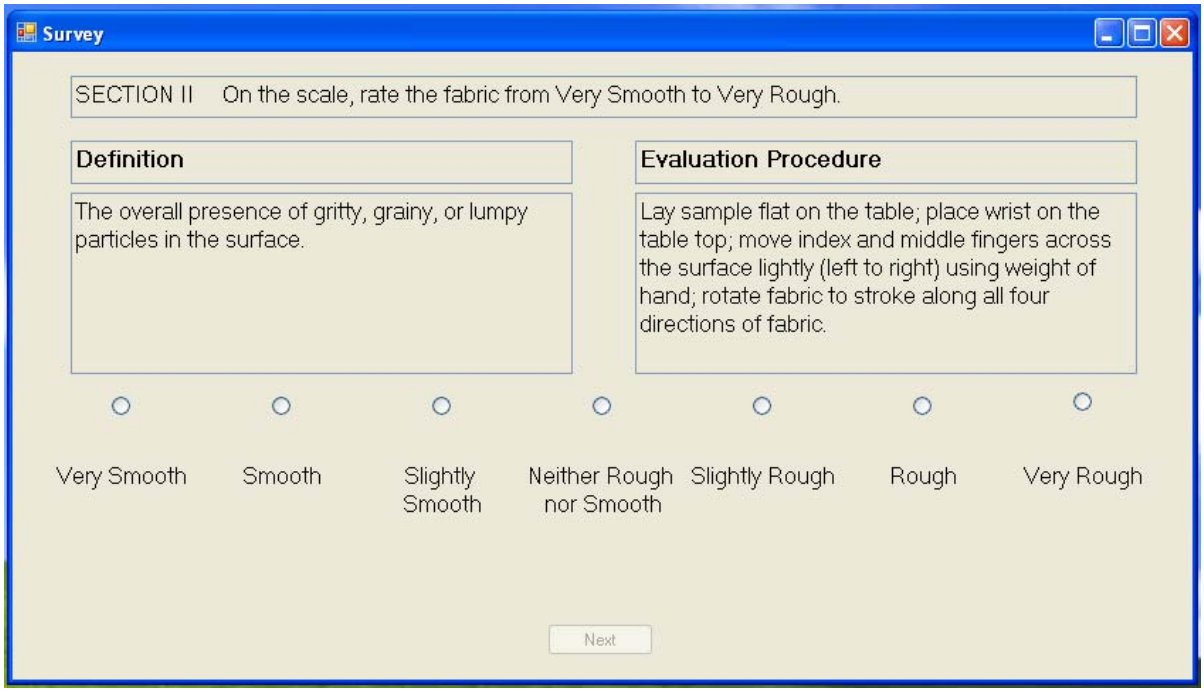
Part I: Rating – Survey

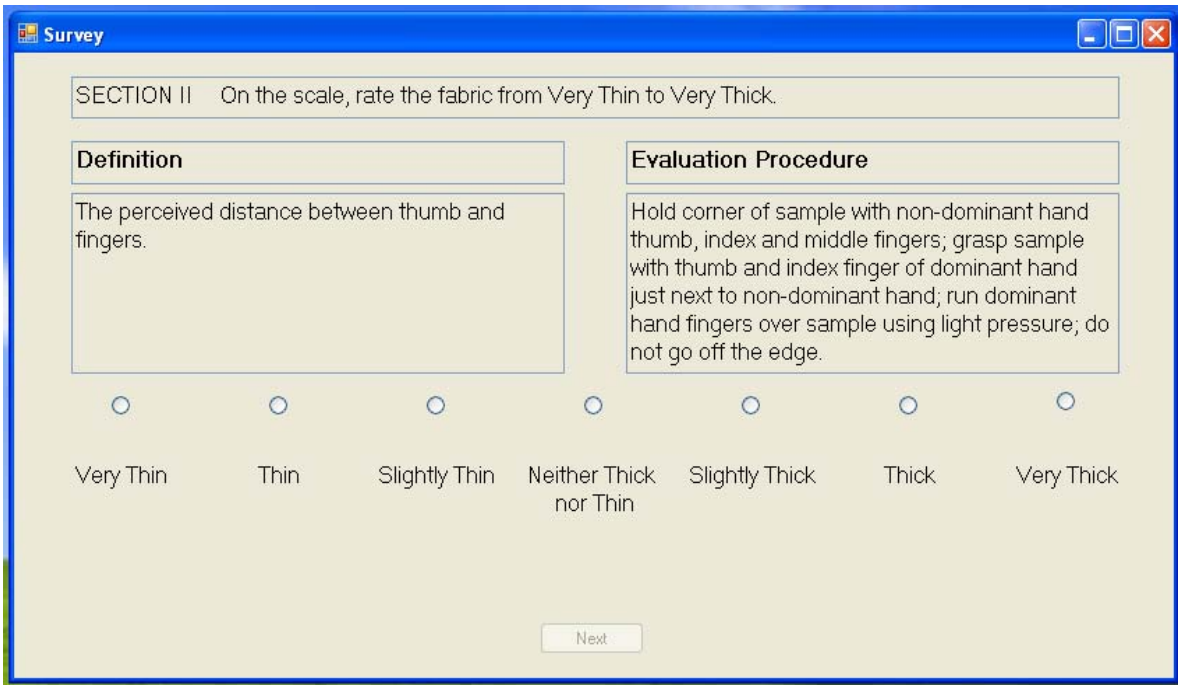


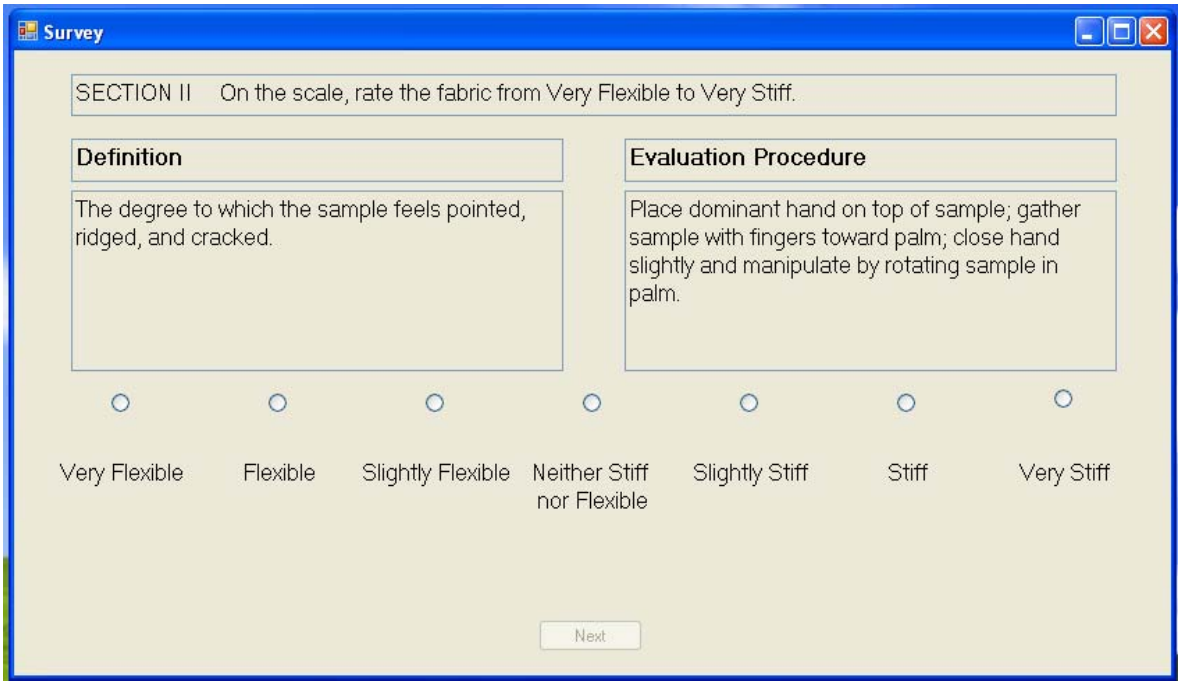


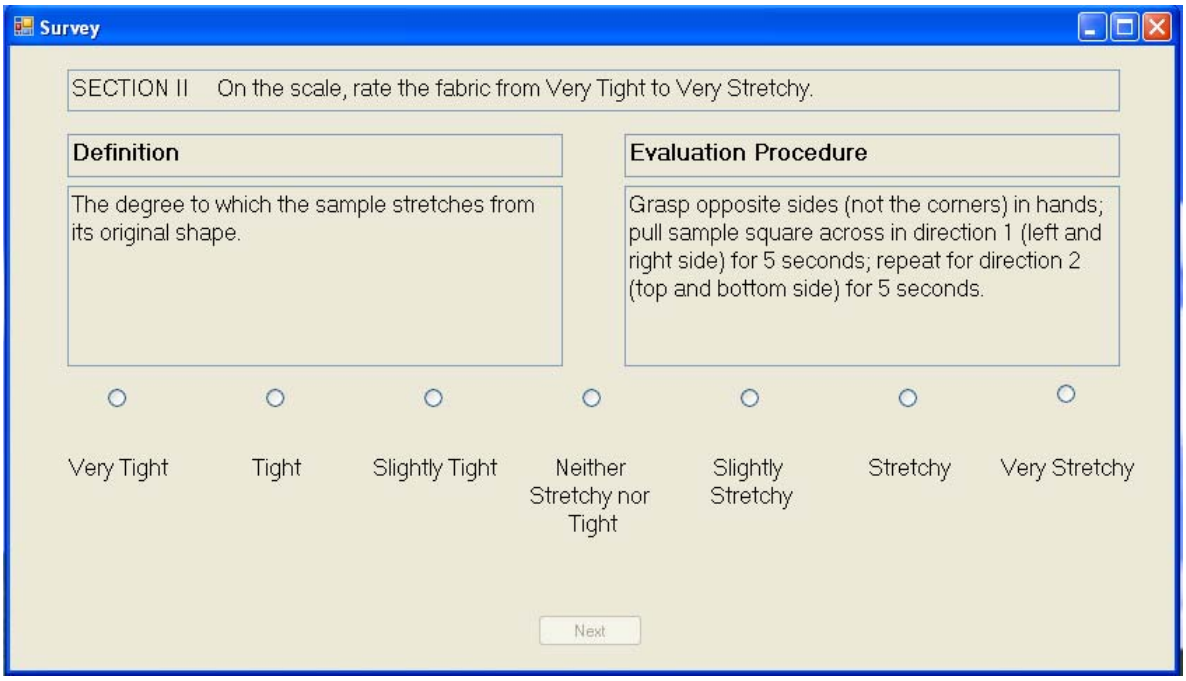

Survey
SECTION II: Rate the fabric based on the following attributes.
This section has 5 questions. Each question is a fabric attribute. There is a definition and an evaluation procedure to follow for each attribute.
Use your dominate hand to evaluate the fabric as described. You may use your non-dominate hand to hold the fabric in place while evaluating with your dominate hand.
Please rate the fabric by using the mouse to click on the circle that you feel best reflects the intensity level of the attribute being evaluated. Once you have answered the question, click next to move to the next question.
To move to the first attribute question, click next.
Next

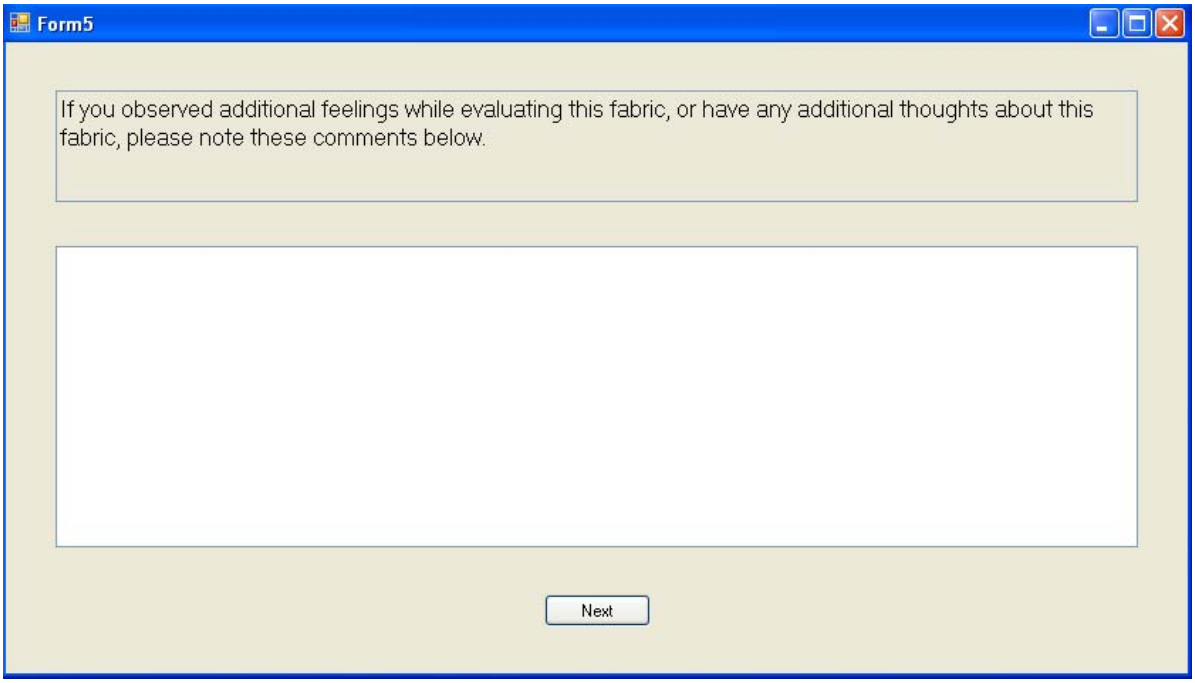

Survey
SECTION II On the scale, rate the fabric from Very Cool to Very Warm.
Definition
The difference in thermal character between the fabric and the hand.
Evaluation Procedure
Gather fabric into palm with fingers closed; flex fingers and squeeze sample gently for 3 seconds. Do not squeeze fabric again or longer than 3 seconds.
Very Cool
Cool
Slightly Cool
Neither Warm nor Cool
Slightly Warm
Warm
Very Warm
Next

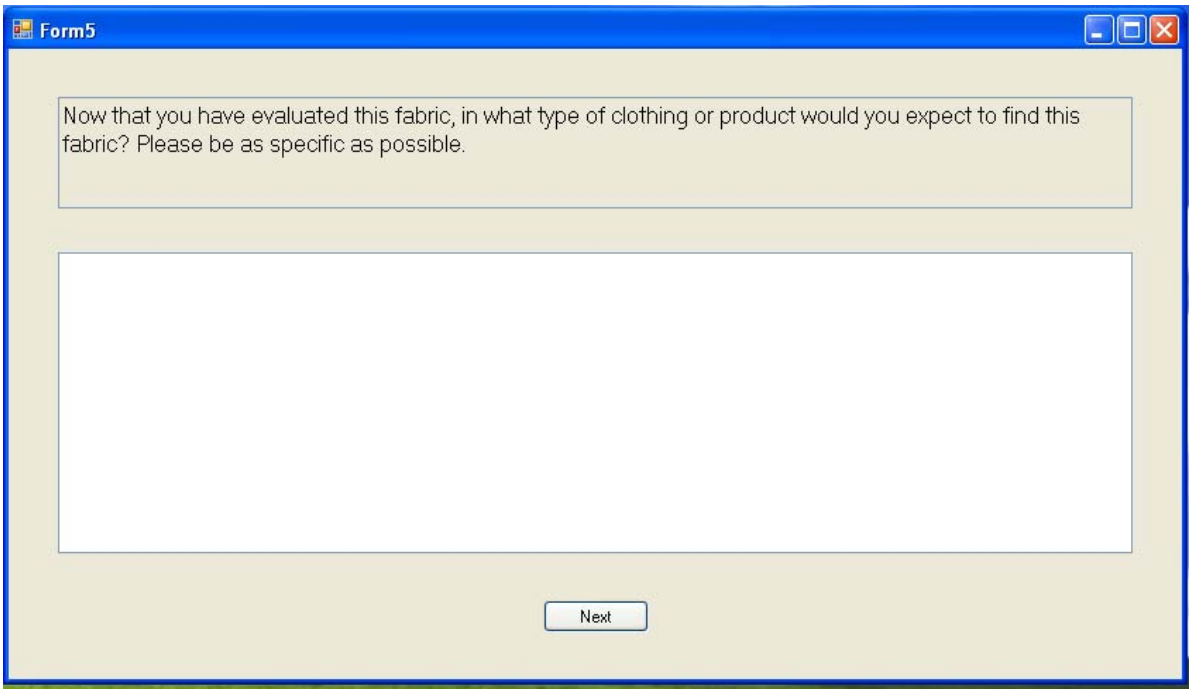

Survey
SECTION II On the scale, rate the fabric from Very Smooth to Very Rough.
Definition
The overall presence of gritty, grainy, or lumpy particles in the surface.
Evaluation Procedure
Lay sample flat on the table; place wrist on the table top; move index and middle fingers across the surface lightly (left to right) using weight of hand; rotate fabric to stroke along all four directions of fabric.
Very Smooth
Smooth
Slightly Smooth
Neither Rough nor Smooth
Slightly Rough
Rough
Very Rough
Next

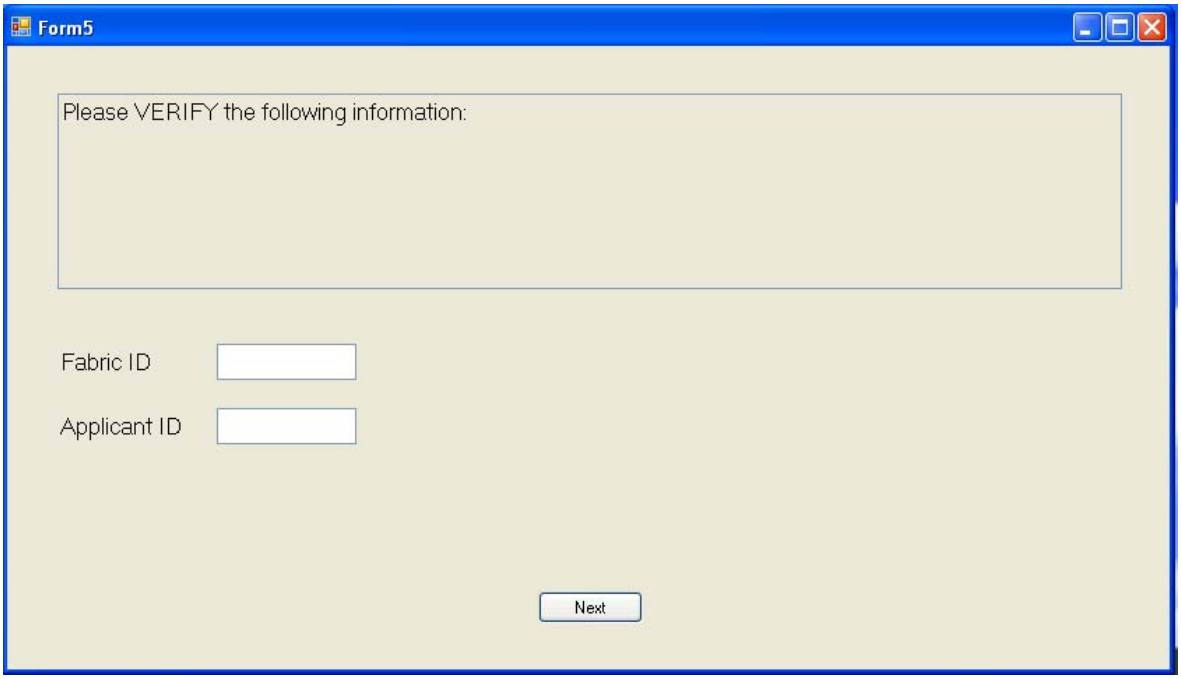

Survey
SECTION II On the scale, rate the fabric from Very Thin to Very Thick.
Definition
The perceived distance between thumb and fingers.
Evaluation Procedure
Hold corner of sample with non-dominant hand thumb, index and middle fingers; grasp sample with thumb and index finger of dominant hand just next to non-dominant hand; run dominant hand fingers over sample using light pressure; do not go off the edge.
Very Thin
Thin
Slightly Thin
Neither Thick nor Thin
Slightly Thick
Thick
Very Thick
Next

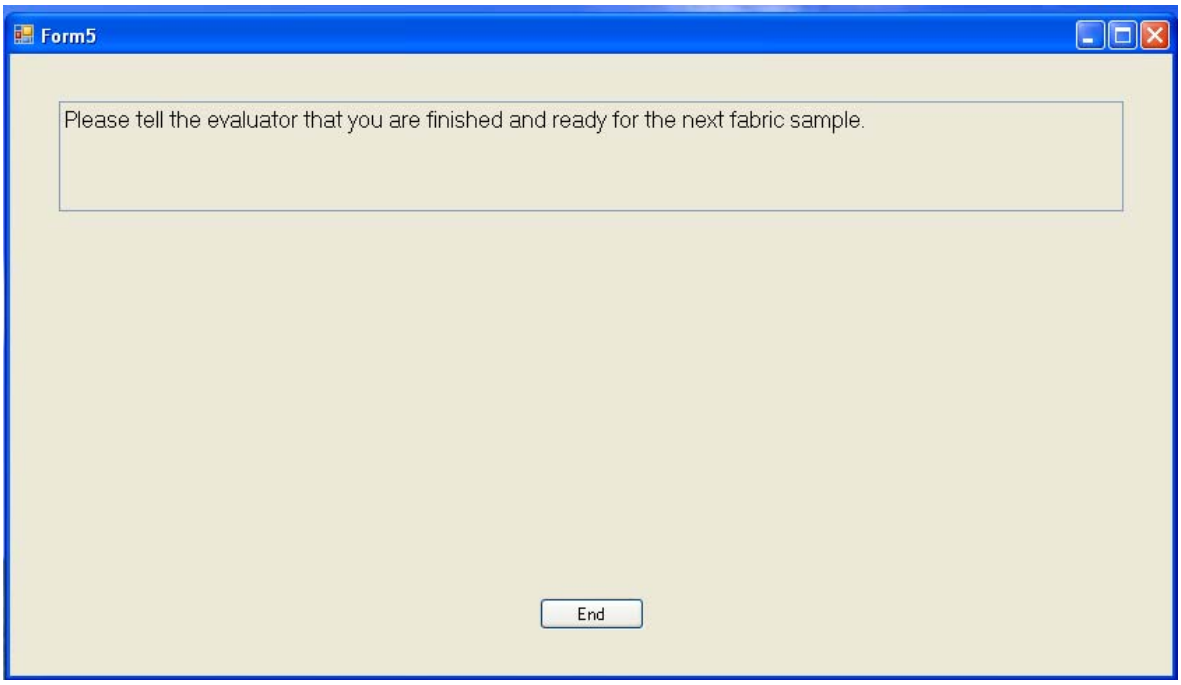

Survey
SECTION II On the scale, rate the fabric from Very Flexible to Very Stiff.
Definition
The degree to which the sample feels pointed, ridged, and cracked.
Evaluation Procedure
Place dominant hand on top of sample; gather sample with fingers toward palm; close hand slightly and manipulate by rotating sample in palm.
Very Flexible
Flexible
Slightly Flexible
Neither Stiff nor Flexible
Slightly Stiff
Stiff
Very Stiff
Next


Survey
SECTION II On the scale, rate the fabric from Very Tight to Very Stretchy.
Definition
The degree to which the sample stretches from its original shape.
Evaluation Procedure
Grasp opposite sides (not the corners) in hands; pull sample square across in direction 1 (left and right side) for 5 seconds; repeat for direction 2 (top and bottom side) for 5 seconds.
Very Tight
Tight
Slightly Tight
Neither Stretchy nor Tight
Slightly Stretchy
Stretchy
Very Stretchy
Next


Form5
If you observed additional feelings while evaluating this fabric, or have any additional thoughts about this fabric, please note these comments below.
Next


Form5
Now that you have evaluated this fabric, in what type of clothing or product would you expect to find this fabric? Please be as specific as possible.
Next


Form5
Please VERIFY the following information:
Fabric ID
Applicant ID
Next


Form5
Please tell the evaluator that you are finished and ready for the next fabric sample.
End

Part II: Ranking – Proctor's Guide & Ranking Form

Fabric Ranking Form & Proctor's Guide

Applicant # _____

To be read by the proctor:

- I will be showing you 4 images, one at a time. Images shown are that of general clothing and accessories. You will rank all 6 fabrics from most desirable to least desirable based on your perception of the image shown.
- The end use product for these fabrics is this image (*show image).*
- Please put on these blindfolds so you will not be able to see the fabric samples.
- (*Once all blindfold are on*) I have placed all 6 fabric samples on the table in random order.
- Please rank these fabrics based on your perception of the image seen. Rank from the most desirable fabric for this image to the least desirable fabric for this image.
- Thank you. Now please wait one moment while I mark these down. Don't take off the blindfolds until I have hidden the fabric from your view.
- You may now take off your blindfolds. Here is the next image. *Present the subjects with the next image and repeat process until all four (4) images have been viewed.*
- So what do you think about these fabrics? I've noticed you have ranked this one least desirable for all images/ranked this one most desirable for all images/etc. *Purpose is to gain open ended feedback from the subject regarding the 6 fabrics they have just ranked.*
- Thank you for participating. You are now finished with the test session.

Rank	**Fabric ID**			
	LS Shirt	*SS Shirt*	*Shorts*	*Bag*
Most desirable:	_____	_____	_____	_____
	_____	_____	_____	_____
	_____	_____	_____	_____
	_____	_____	_____	_____
	_____	_____	_____	_____
Least desirable:	_____	_____	_____	_____

APPENDIX E

Testing Date, Time, & Location

Date (m/d/y)	Time (EST)	Applicant		Location	City, State
		ID	Total		
2/5/2009	7:00 PM – 8:00 PM	1-2	2	Private Residence	Raleigh, NC
2/6/2009	9:00 AM – 6:00 PM	3-10	8	Generation Hair Designs	Raleigh, NC
2/7/2009	6:00 PM – 10:00 PM	11-17	7	Creative Memories Crop Event	Raleigh, NC
2/8/2009	6:30 PM – 9:30 PM	18-23	6	Private Residence	Raleigh, NC
2/10/2009	7:30 PM – 8:00 PM	24-25	2	Private Residence	Raleigh, NC
2/11/2009	1:00 PM – 7:00 PM	26-32	7	Generation Hair Design	Raleigh, NC
2/12/2009	10:30 AM – 5:30 PM	33-46	14	Capital Ford	Raleigh, NC
	6:30 PM – 7:00 PM	47	1	College of Textiles	Raleigh, NC
2/13/2009	11:00 AM – 12:30 PM	48-50	3	Jarco Supply	Fuquay Varina, NC
	2:30 PM – 3:30 PM	51-54	4	The Little Gym	Raleigh, NC
2/15/2009	12:00 PM – 3:00 PM	55-63	9	Private Residence	Raleigh, NC
	7:00 PM – 10:00 PM	64-73	10	Private Residence	Raleigh, NC
2/17/2009	12:00 PM – 3:00 PM	74-78	5	Duke Division of Clinical Informatics	Durham, NC
	5:30 PM – 6:00 PM	79	1	Private Residence	Durham, NC
2/18/2009	12:00 PM – 6:30 PM	80-84	5	Salon 116 North	Raleigh, NC
2/19/2009	9:00 AM – 3:00 PM	85-90	6	Capital Ford Service	Raleigh, NC
	4:00 PM – 5:30 PM	91-93	3	Salon 116 North	Raleigh, NC
	7:00 PM – 10:00 PM	94-100	7	Bagwell Residence Hall, NCSU	Raleigh, NC
2/20/2009	12:00 PM – 10:00 PM	101-121	21	Capital Ford	Raleigh, NC
2/21/2009	6:00 PM – 11:00 PM	122-129	8	Private Residence	Raleigh, NC
2/22/2009	11:00 AM – 12:00 PM	130-133	4	Private Residence	Holly Springs, NC
	4:00 PM – 4:30 PM	134-135	2	Private Residence	Raleigh, NC
2/23/2009	9:00 AM – 9:30 AM	136	1	Roi Industries Group	Raleigh, NC
	1:00 PM – 3:30 PM	137-140	4	Daniels Hall, NCSU	Raleigh, NC
	8:00 PM – 8:30 PM	141-142	2	Private Residence	Raleigh, NC
2/24/2009	1:30 PM – 4:30 PM	143-151	9	Durant Middle School	Raleigh, NC
	7:00 PM – 10:30 PM	152-160	9	Univ. Towers Residence Hall, NCSU	Raleigh, NC
2/26/2009	11:00 AM – 2:30 PM	161-164	4	Broughton Hall, NCSU	Raleigh, NC
	4:00 PM – 5:00 PM	165-166	2	Southeast Raleigh High School	Raleigh, NC
	7:30 PM – 9:30 PM	167-174	8	DH Hill Library, NCSU	Raleigh, NC
2/28/2009	5:45 PM – 6:15 PM	175-176	2	Private Residence	Raleigh, NC
	8:00 PM – 12:00 AM	177-186	10	Private Residence	Raleigh, NC
3/3/2009	10:30 AM – 7:30 PM	187-198	12	Capital Ford	Raleigh, NC

APPENDIX F

Weather During Testing Dates

Weather Key

Sunny Clear	Mostly Cloudy Partly Sunny	Partly Cloudy Mostly Sunny	Cloudy	Rain	Snow	Date Condition Temp: max/mean/min Humidity: max/mean/min Percip: event/inches Ap ID Testing Hour
Hail Flurries	Thunderstorms	Hazy Fog	Sleet	'?' denotes 'chance of'	Unknown	

February 2009

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1 62/47/32 64/45/25 -/0 No testing	**2** 64/51/37 82/58/34 Rain/0.11 No testing	**3** 46/39/32 96/62/28 Rain-Snow/0.15 No testing	**4** 38/32/25 85/56/27 -/0 No testing	**5** 34/27/19 54/39/24 -/0 1-2 7p-8p	**6** 55/38/20 62/42/22 -/0 3-10 9a-6p	**7** 71/51/31 69/47/25 -/0 11-17 6p-10p
8 75/60/44 74/54/33 -/0 18-23 6:30p-9:30p	**9** 66/53/40 82/57/31 -/0 No testing	**10** 73/61/48 93/67/41 Fog/0 24-25 7:30p-8p	**11** 75/65/54 90/67/44 Rain/0.04 26-30 1p-7p	**12** 69/60/51 84/50/15 -/0 33-46 10:30p-5:30p 47 6:30p-7p	**13** 68/55/41 55/39/22 -/0 48-50 11a-12:30p 51-54 2:30p-3:30p	**14** 63/54/45 86/62/38 -/0 No testing
15 54/44/34 75/55/35 -/0 55-63 12p-3p 64-73 7p-10p	**16** 46/39/31 82/58/34 Rain-Snow/T No testing	**17** 50/37/23 68/46/24 -/0 74-78 12p-3p 79 5:30p-6p	**18** 57/49/40 96/66/36 Rain/0.59 80-84 12p-6:30p	**19** 58/46/34 96/60/24 Fog/0 85-90 9a-3p 91-93 4p-5:30p 94-100 7p-10p	**20** 43/35/27 47/34/20 -/0 101-121 12p-10p	**21** 54/38/22 77/49/21 -/0 122-129 6p-11p
22 50/41/31 65/43/21 Rain/0.01 130-133 11a-12p 134-135 4p-4:30p	**23** 44/36/28 46/34/22 -/0 136 9a-9:30a 137-140 1p-3:30p 141-142 8p-8:30p	**24** 46/35/23 55/37/19 -/0 143-151 1:30p-4:30p 152-160 7p-10:30p	**25** 56/41/25 58/39/19 -/0 No testing	**26** 65/51/37 70/55/40 -/0 161-164 11a-2:30p 165-166 4p-5p 167-174 7:30p-9:30p	**27** 72/63/53 86/64/41 Rain/0.03 No testing	**28** 58/48/38 93/87/80 Rain/0.72 175-176 5:45p-6:15p 177-186 8p-12a

March 2009

Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
1 38/37/35 92/87/82 Rain-Snow/1.38	**2** 35/29/23 89/71/53 Fog-Snow/0.3	**3** 36/27/18 80/58/35 -/0 187-198 10:30a-7:30p	Source: www.weatherunderground.com Retrieved: March 11, 2009			

APPENDIX G

Quantiles: Rating

All Subjects

Fabric ID	Minimum	25%	Median	75%	Maximum
Comfort					
A	1	3	5	6	7
B	1	3	3	5	7
C	1	3	4	5	7
D	1	3	5	6	7
E	1	3	4	6	7
T	1	2	3	5	7
Cool/Warm					
A	1	3	3	4	6
B	1	3	4	4	7
C	1	3	4	5	7
D	2	3	4	5	7
E	1	4	5	5.5	7
T	1	3	4	5	7
Smooth/Rough					
A	1	2	4	5	6
B	1	3	5	5	7
C	1	2	3	5	6
D	1	2	3	3	7
E	1	2	3	5	7
T	1	5	5	6	7
Thin/Thick					
A	1	2	2	3	6
B	1	2	3	4	6
C	1	3	4	5	7
D	1	3	4	5	6
E	1	3	4	5	7
T	1	2	4	5	7
Flexible/Stiff					
A	1	2	3	4	7
B	1	2	3	5	7
C	1	2	3	5	7
D	1	2	3	5	7
E	1	3	4	5	7
T	1	2	3	5	7
Tight/Stretchy					
A	1	2	3	5	6
B	1	2	2	3	6
C	1	5	5	6	7
D	1	3	5	5	7
E	1	2	2	3	6
T	1	3	5	5	7

By Gender

Comfort

Gender	Minimum	25%	Median	75%	Maximum
Fabric A					
female	1	3	5	6	7
male	1	3	5	6	7
Fabric B					
female	1	3	3	5	7
male	2	3	4	5	7
Fabric C					
female	1	3	4	6	7
male	1	3	4	5	6
Fabric D					
female	1	3	5	6	7
male	1	3	5	6	7
Fabric E					
female	1	2	4	5	7
male	1	3	4	6	7
Fabric T					
female	1	2	3	5	7
male	1	3	4	5	7

Cool/Warm

Gender	Minimum	25%	Median	75%	Maximum
Fabric A					
female	1	3	3	4	6
male	1	3	3	4	6
Fabric B					
female	2	3	4	5	7
male	1	3	4	4	6
Fabric C					
female	1	3	4	5	7
male	2	2	3	5	6
Fabric D					
female	2	4	5	5	7
male	2	3	4	5	6
Fabric E					
female	1	4	5	6	7
male	1	3	4	5	7
Fabric T					
female	1	4	4	5	7
male	2	3	4	5	7

Smooth/Rough

Gender	Minimum	25%	Median	75%	Maximum
Fabric A					
female	1	2	4	5	6
male	1	2	4	5	6
Fabric B					
female	1	3	5	5	7
male	1	3	5	5	6
Fabric C					
female	1	2	3	5	6
male	1	2	3	5	6
Fabric D					
female	1	2	2	3	7
male	1	2	3	3	6
Fabric E					
female	1	2	3	5	7
male	1	2	3	5	6
Fabric T					
female	1	4	5	5	7
male	2	5	5	6	7

Thin/Thick

Gender	Minimum	25%	Median	75%	Maximum
Fabric A					
female	1	2	2	3	6
male	1	2	2	3	5
Fabric B					
female	1	2	3	4	6
male	1	2	3	4	6
Fabric C					
female	1	3	4	5	7
male	1	3	4	5	6
Fabric D					
female	1	3	4	5	6
male	1	3	4	5	6
Fabric E					
female	1	3	4	5	7
male	1	3	4	5	7
Fabric T					
female	1	2	3	5	7
male	1	3	4	5	6

Flexible/Stiff

Gender	Minimum	25%	Median	75%	Maximum
Fabric A					
female	1	2	3	4	7
male	1	2	2	4	6
Fabric B					
female	1	3	4	5	7
male	1	2	3	5	6
Fabric C					
female	1	2	3	5	7
male	1	2	3	5	7
Fabric D					
female	1	2	3	5	7
male	1	2	3	4.25	6
Fabric E					
female	1	3	4	5	7
male	2	3	4	5	7
Fabric T					
female	1	3	4	5	7
male	1	2	3	5	6

Tight/Stretchy

Gender	Minimum	25%	Median	75%	Maximum
Fabric A					
Female	1	2	3	5	6
Male	1	2	3	5	6
Fabric B					
female	1	2	2	4	6
male	1	2	2	3	6
Fabric C					
female	1	5	5	6	7
male	1	4.75	5	6	7
Fabric D					
female	1	3	5	5	7
male	1	3	5	5	7
Fabric E					
female	1	2	2	3	6
male	1	2	2	3	5
Fabric T					
female	1	3	5	5	7
male	1	3	5	5.25	7

Quantiles: Ranking

All Subjects

Fabric ID	Minimum	25%	Median	75%	Maximum
Long Sleeve Shirt					
A	1	1	2	4	6
B	1	2	3	4	6
C	1	2	3	4	6
D	1	2	4	5	6
E	1	2	4	5	6
T	1	3	5	6	6
Short Sleeve Shirt					
A	1	1	1	3	6
B	1	2	2	4	6
C	1	3	3	4	6
D	1	3	4	5	6
E	1	3	4	5	6
T	1	3	5	6	6
Shorts					
A	1	2	3	5	6
B	1	2	3	4	6
C	1	1	2	4	6
D	1	2	3	5	6
E	1	3	4	5	6
T	1	3	5	6	6
Bag					
A	1	4	6	6	6
B	1	3	4	5	6
C	1	1	2	4	6
D	1	2	3	4	6
E	1	2	3	5	6
T	1	1	3	4	6

By Gender

Long Sleeve Shirt

Gender	Minimum	25%	Median	75%	Maximum
Fabric A					
female	1	1	2	4	6
male	1	1	2	5	6
Fabric B					
female	1	2	3	5	6
male	1	2	3	4	6
Fabric C					
female	1	2	3	5	6
male	1	2	3	4	6
Fabric D					
female	1	2	4	5	6
male	1	2	4	5	6
Fabric E					
female	1	2	4	5	6
male	1	3	4	5	6
Fabric T					
female	1	4	5	6	6
male	1	3	5	6	6

Short Sleeve Shirt

Gender	Minimum	25%	Median	75%	Maximum
Fabric A					
female	1	1	1	2	6
male	1	1	1.5	4	6
Fabric B					
female	1	2	2	4	6
male	1	2	3	4	6
Fabric C					
female	1	3	3	5	6
male	1	2	3	4	6
Fabric D					
female	1	3	4	5	6
male	1	3	4	5	6
Fabric E					
female	1	4	4	5	6
male	1	3	4	5	6
Fabric T					
female	1	3	5	6	6
male	1	3	5	6	6

Shorts

Gender	Minimum	25%	Median	75%	Maximum
Fabric A					
female	1	2	4	5	6
male	1	2	3	5	6
Fabric B					
female	1	2	2	4	6
male	1	2	3	4	6
Fabric C					
female	1	1	2	4	6
male	1	1	3	4	6
Fabric D					
female	1	3	4	5	6
male	1	2	3	5	6
Fabric E					
female	1	3	4	5	6
male	1	3	5	5	6
Fabric T					
female	1	3	4	6	6
male	1	2	5	6	6

Bag

Gender	Minimum	25%	Median	75%	Maximum
Fabric A					
female	1	5	6	6	6
male	1	4	5	6	6
Fabric B					
female	1	3	4	5	6
male	1	2	4	5	6
Fabric C					
female	1	1	2	4	6
male	1	1	2	3.25	6
Fabric D					
female	1	2	3	4	6
male	1	2	3	4.25	6
Fabric E					
female	1	2	3	4	6
male	1	2	4	5	6
Fabric T					
female	1	1	3	4	6
male	1	1	3	4	6

Fabric Rankings between Products

Long Sleeve Shirt v. Short Sleeve Shirt

Product	Minimum	10%	Median	75%	Maximum
Fabric A					
LS	1	1	2	4	6
SS	1	1	1	3	6
Fabric B					
LS	1	2	3	4	6
SS	1	2	2	4	6
Fabric C					
LS	1	2	3	4	6
SS	1	3	3	4	6
Fabric D					
LS	1	2	4	5	6
SS	1	3	4	5	6
Fabric E					
LS	1	2	4	5	6
SS	1	3	4	5	6
Fabric T					
LS	1	3	5	6	6
SS	1	3	5	6	6

Long Sleeve Shirt v. Shorts

Product	Minimum	25%	Median	75%	Maximum
Fabric A					
LS	1	1	2	4	6
Shorts	1	2	3	5	6
Fabric B					
LS	1	2	3	4	6
Shorts	1	2	3	4	6
Fabric C					
LS	1	2	3	4	6
Shorts	1	1	2	4	6
Fabric D					
LS	1	2	4	5	6
Shorts	1	2	3	5	6
Fabric E					
LS	1	2	4	5	6
Shorts	1	3	4	5	6
Fabric T					
LS	1	3	5	6	6
Shorts	1	3	5	6	6

Long Sleeve Shirt v. Bag

Product	Minimum	25%	Median	75%	Maximum
Fabric A					
Bag	1	4	6	6	6
LS	1	1	2	4	6
Fabric B					
Bag	1	3	4	5	6
LS	1	2	3	4	6
Fabric C					
Bag	1	1	2	4	6
LS	1	2	3	4	6
Fabric D					
Bag	1	2	3	4	6
LS	1	2	4	5	6
Fabric E					
Bag	1	2	3	5	6
LS	1	2	4	5	6
Fabric T					
Bag	1	1	3	4	6
LS	1	3	5	6	6

Short Sleeve Shirt v. Shorts

Product	Minimum	25%	Median	75%	Maximum
Fabric A					
Shorts	1	2	3	5	6
SS	1	1	1	3	6
Fabric B					
Shorts	1	2	3	4	6
SS	1	2	2	4	6
Fabric C					
Shorts	1	1	2	4	6
SS	1	3	3	4	6
Fabric D					
Shorts	1	2	3	5	6
SS	1	3	4	5	6
Fabric E					
Shorts	1	3	4	5	6
SS	1	3	4	5	6
Fabric T					
Shorts	1	3	5	6	6
SS	1	3	5	6	6

Short Sleeve Shirt v. Bag

Product	Minimum	25%	Median	75%	Maximum
Fabric A					
Bag	1	4	6	6	6
SS	1	1	1	3	6
Fabric B					
Bag	1	3	4	5	6
SS	1	2	2	4	6
Fabric C					
Bag	1	1	2	4	6
SS	1	3	3	4	6
Fabric D					
Bag	1	2	3	4	6
SS	1	3	4	5	6
Fabric E					
Bag	1	2	3	5	6
SS	1	3	4	5	6
Fabric T					
Bag	1	1	3	4	6
SS	1	3	5	6	6

Shorts v. Bag

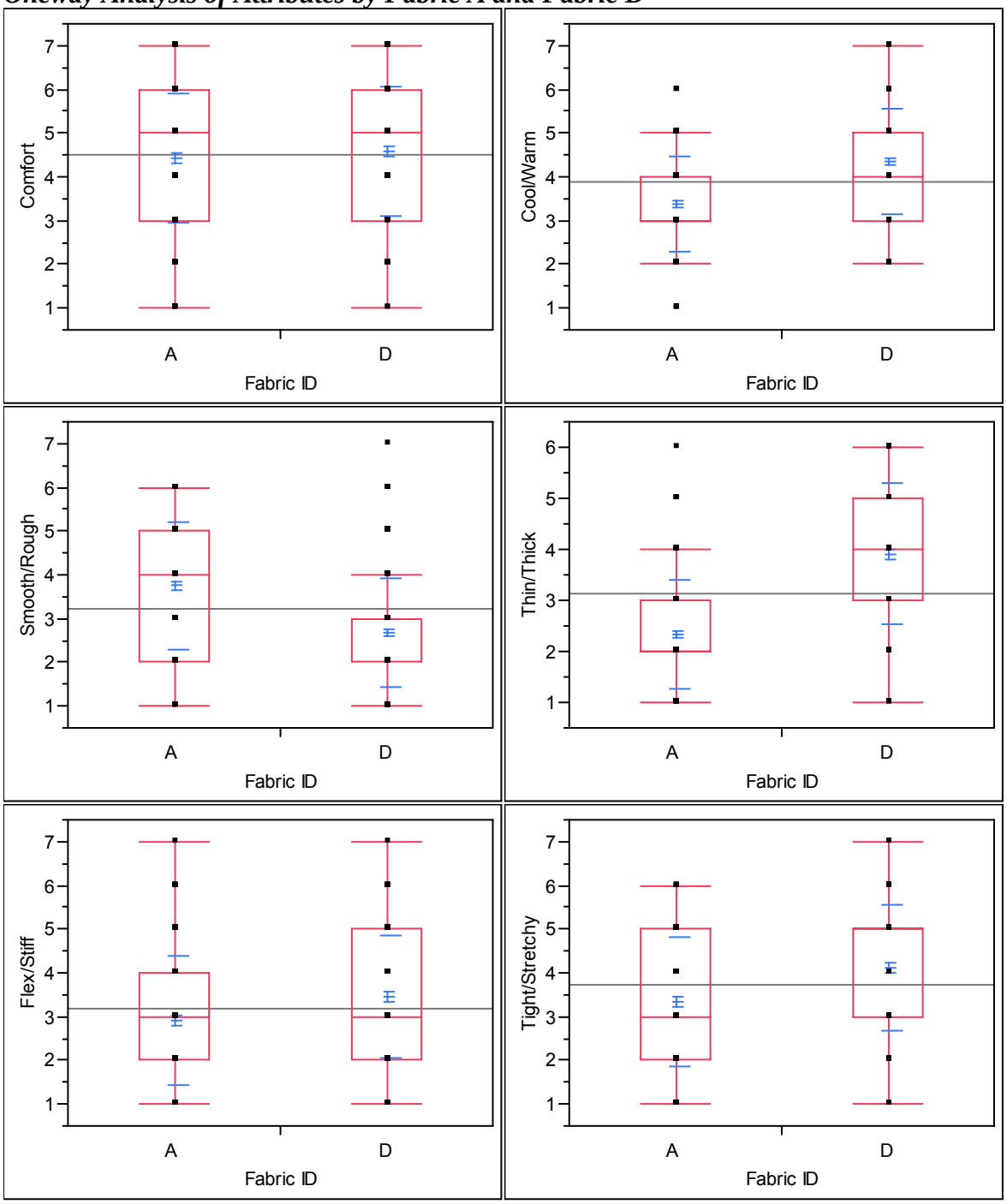
Level	Minimum	25%	Median	75%	Maximum
Fabric A					
Bag	1	4	6	6	6
Shorts	1	2	3	5	6
Fabric B					
Bag	1	3	4	5	6
Shorts	1	2	3	4	6
Fabric C					
Bag	1	1	2	4	6
Shorts	1	1	2	4	6
Fabric D					
Bag	1	2	3	4	6
Shorts	1	2	3	5	6
Fabric E					
Bag	1	2	3	5	6
Shorts	1	3	4	5	6
Fabric T					
Bag	1	1	3	4	6
Shorts	1	3	5	6	6

APPENDIX H

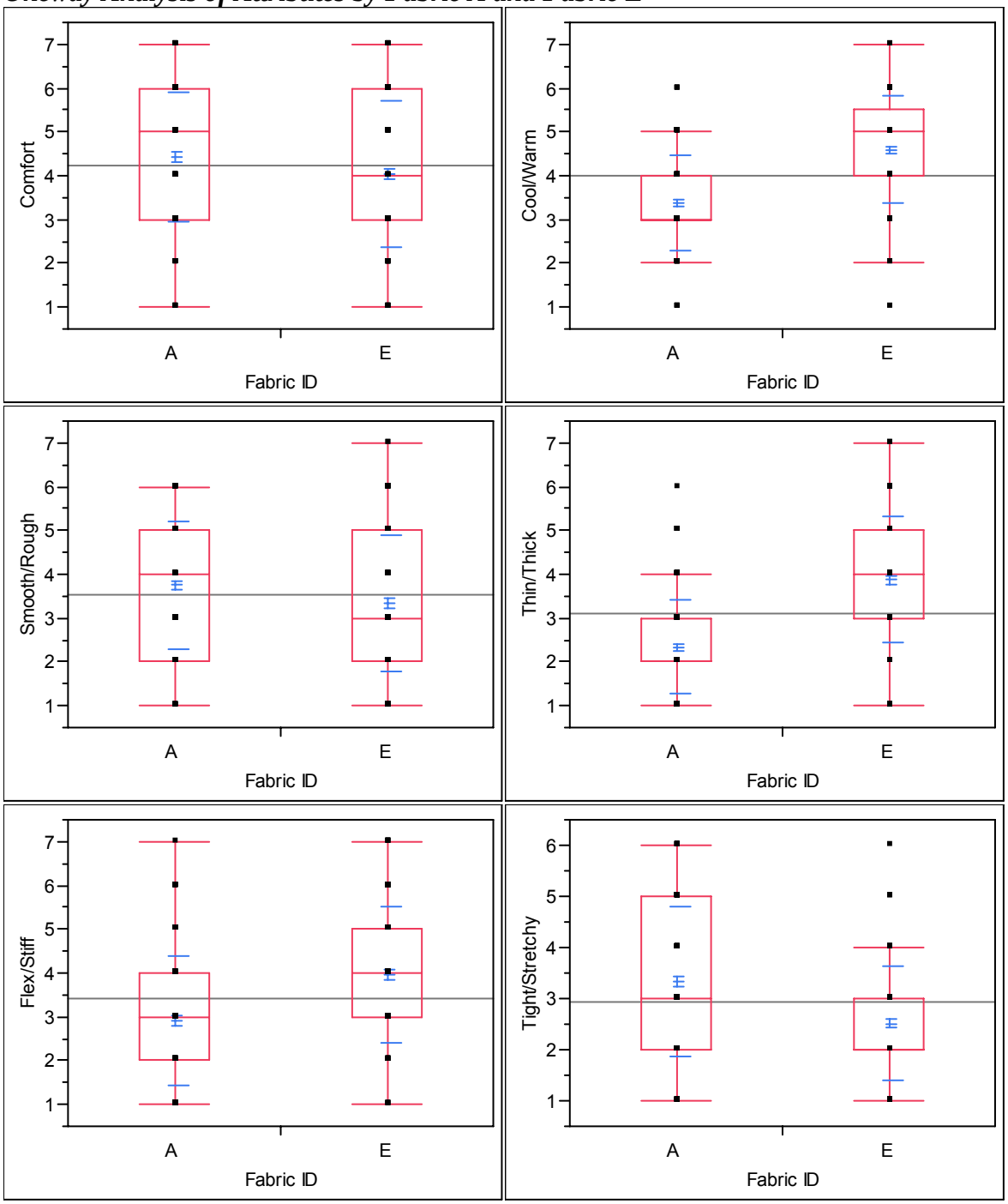
Box Plots: Rating

Woven v. Nonwoven

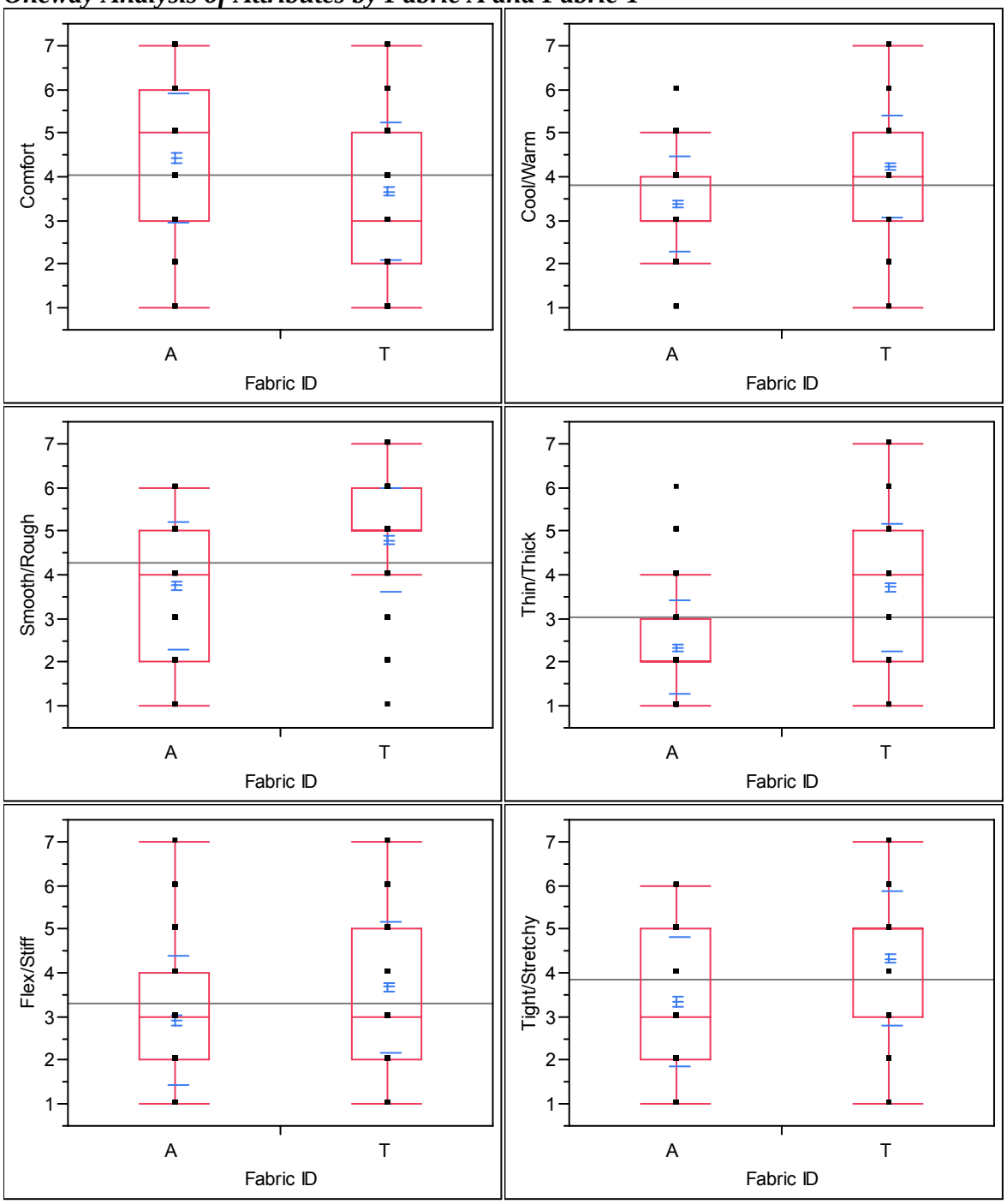
Oneway Analysis of Attributes by Fabric A and Fabric D



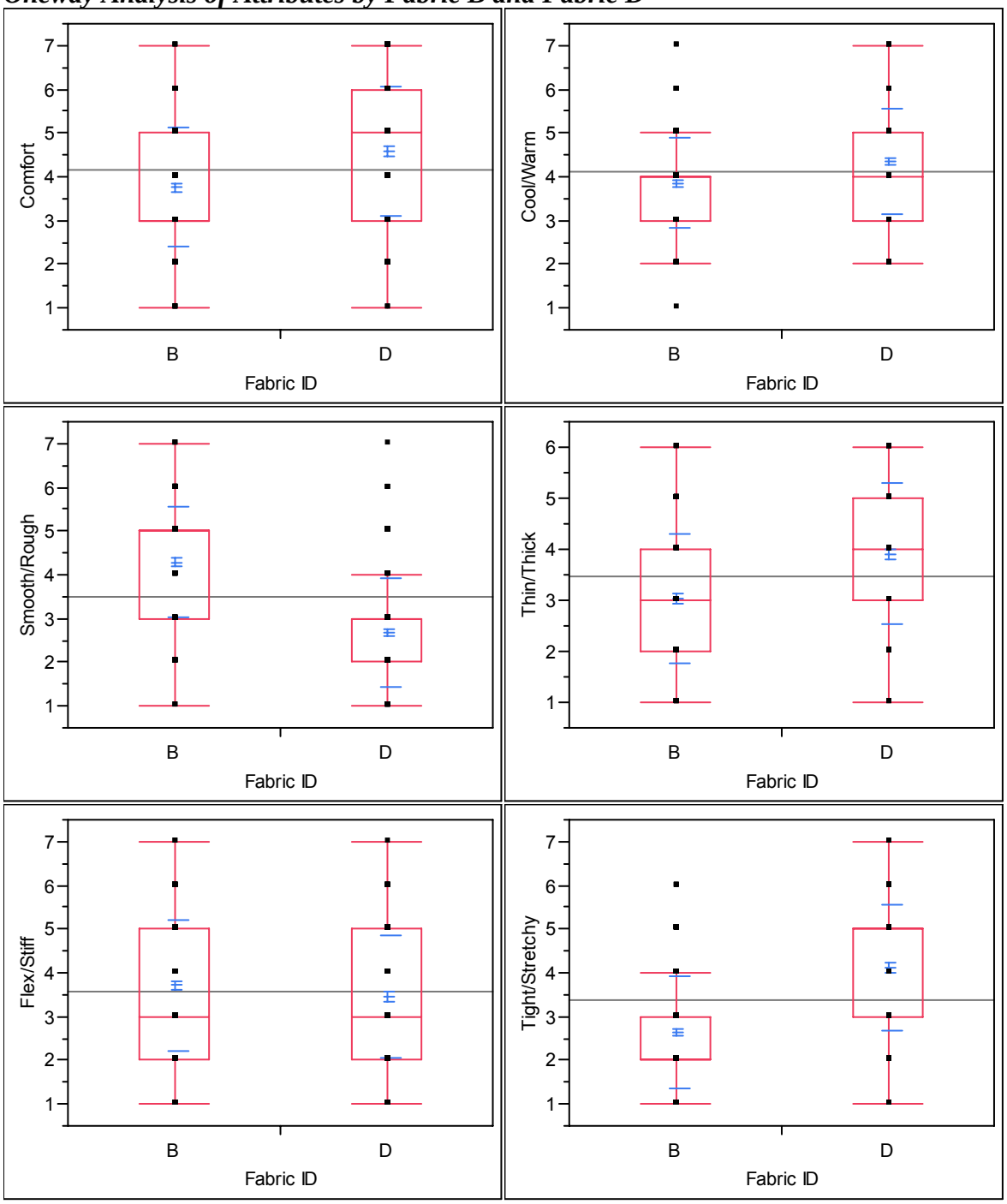
Oneway Analysis of Attributes by Fabric A and Fabric E



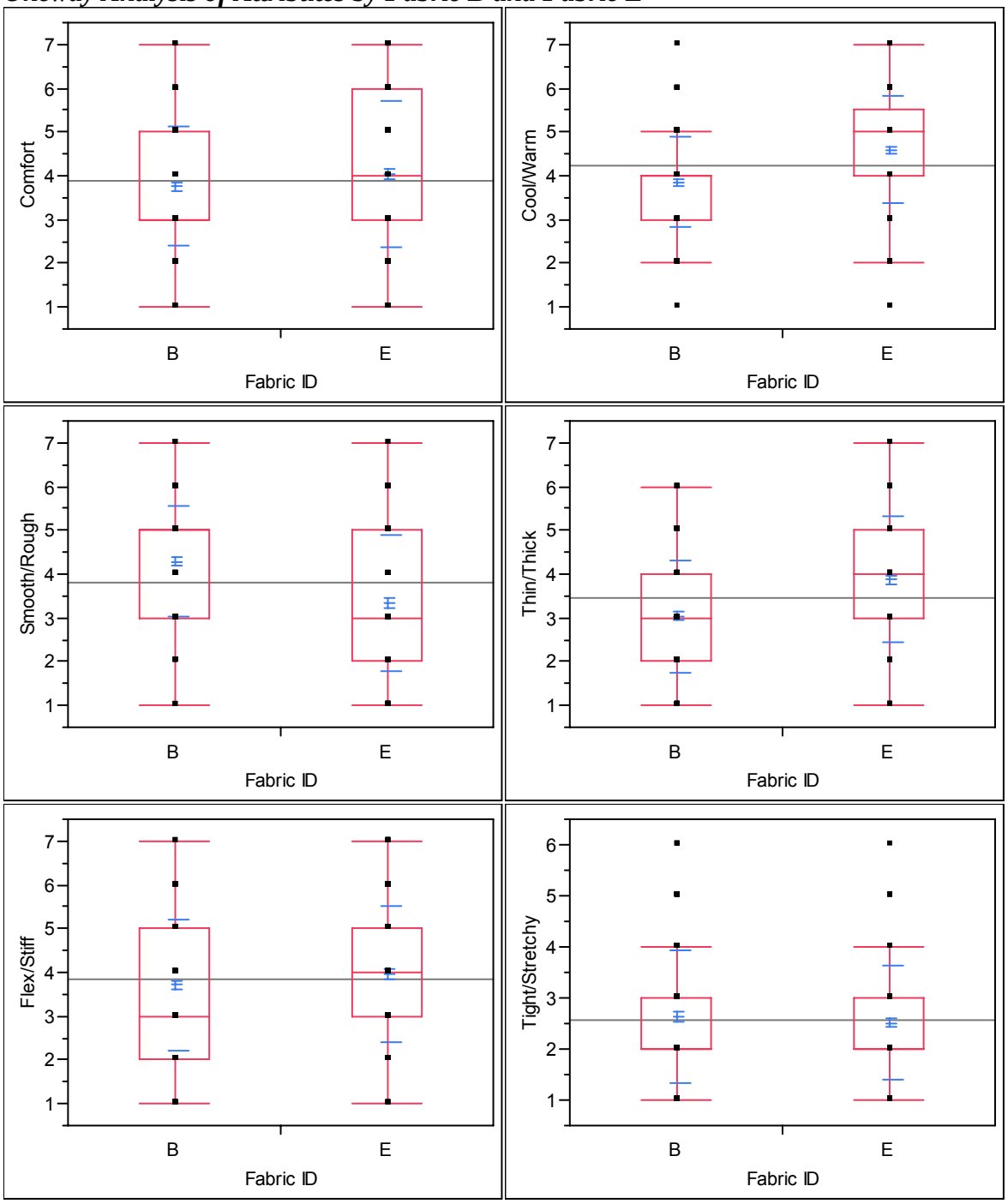
Oneway Analysis of Attributes by Fabric A and Fabric T



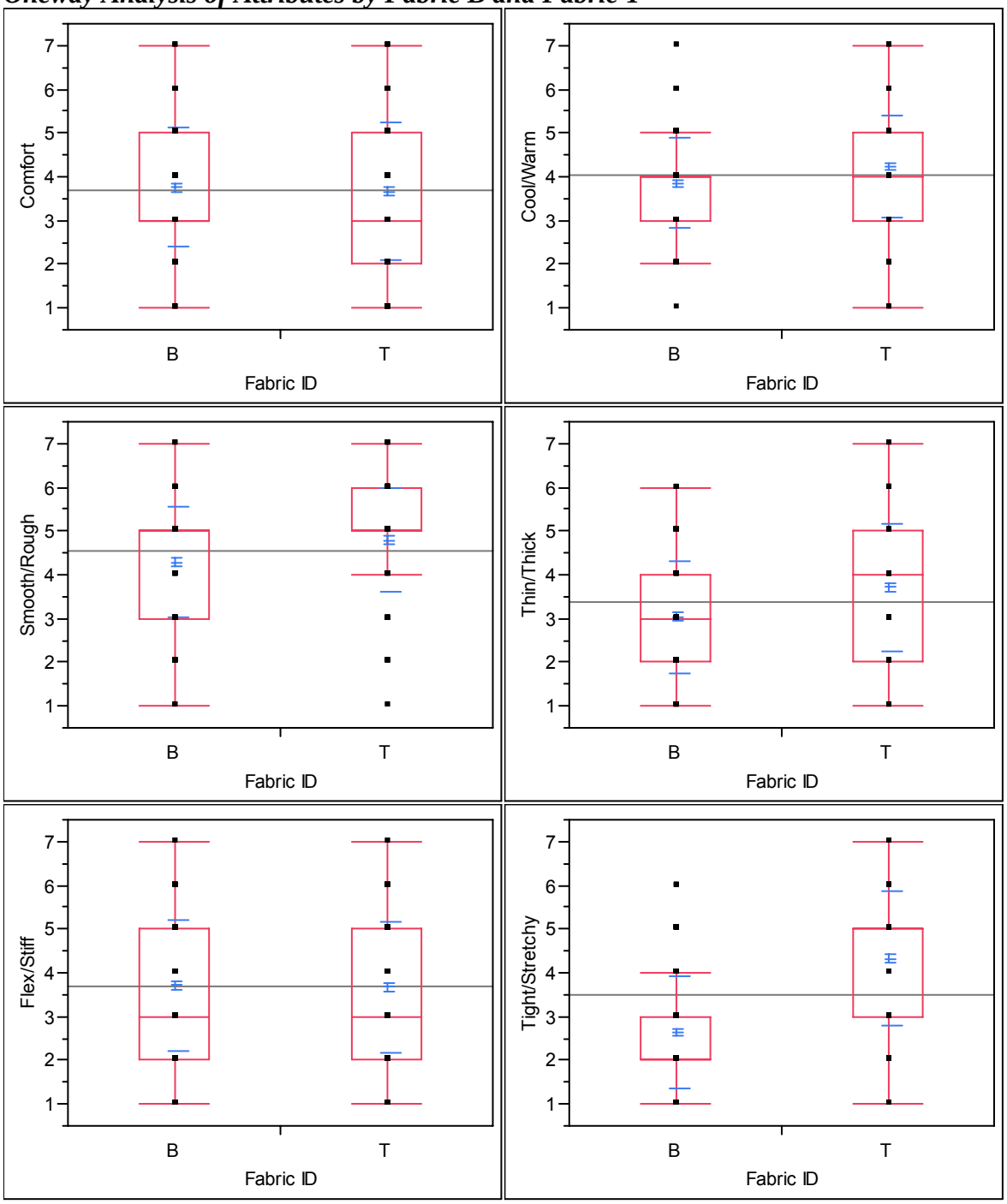
Oneway Analysis of Attributes by Fabric B and Fabric D



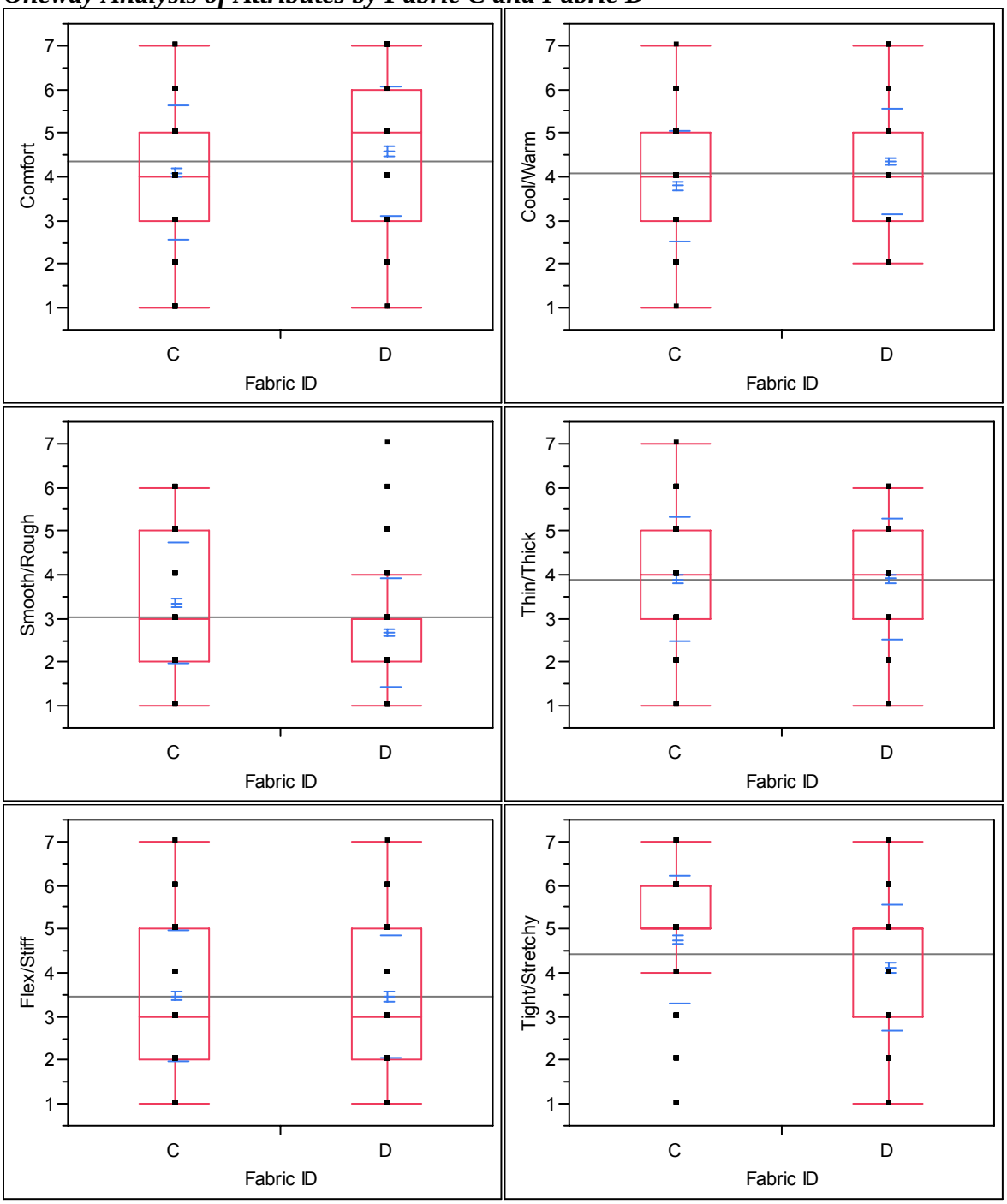
Oneway Analysis of Attributes by Fabric B and Fabric E



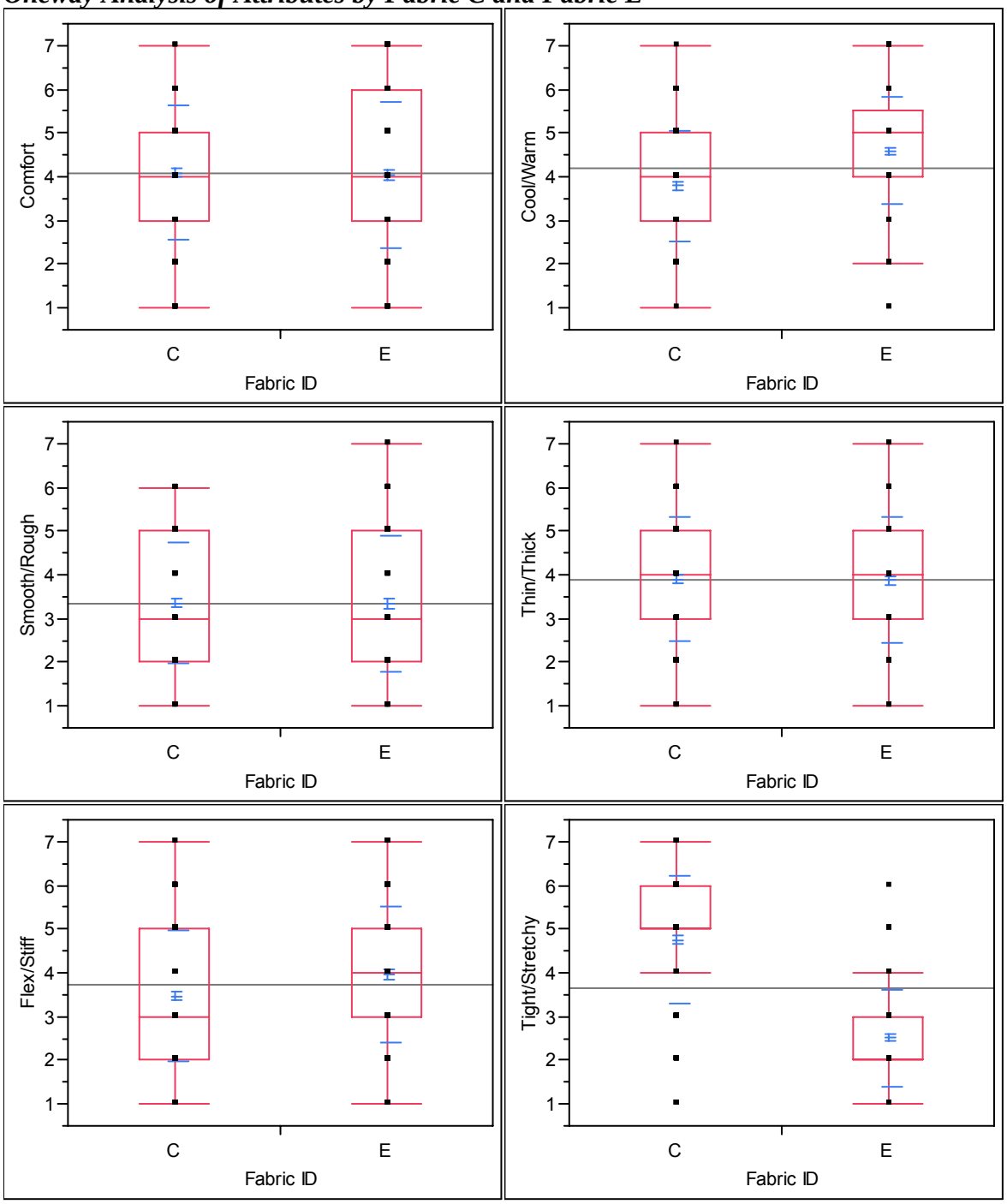
Oneway Analysis of Attributes by Fabric B and Fabric T



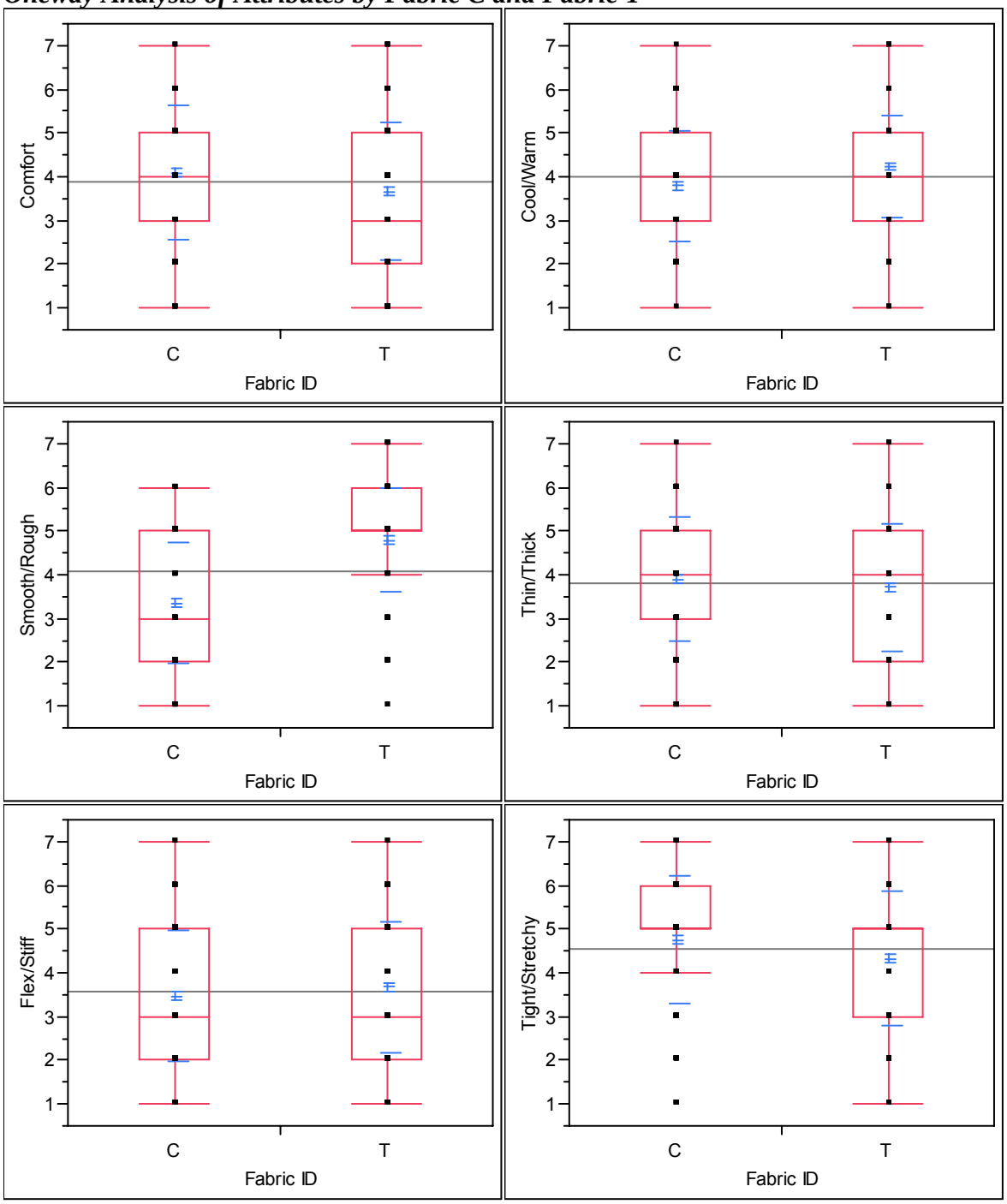
Oneway Analysis of Attributes by Fabric C and Fabric D



Oneway Analysis of Attributes by Fabric C and Fabric E

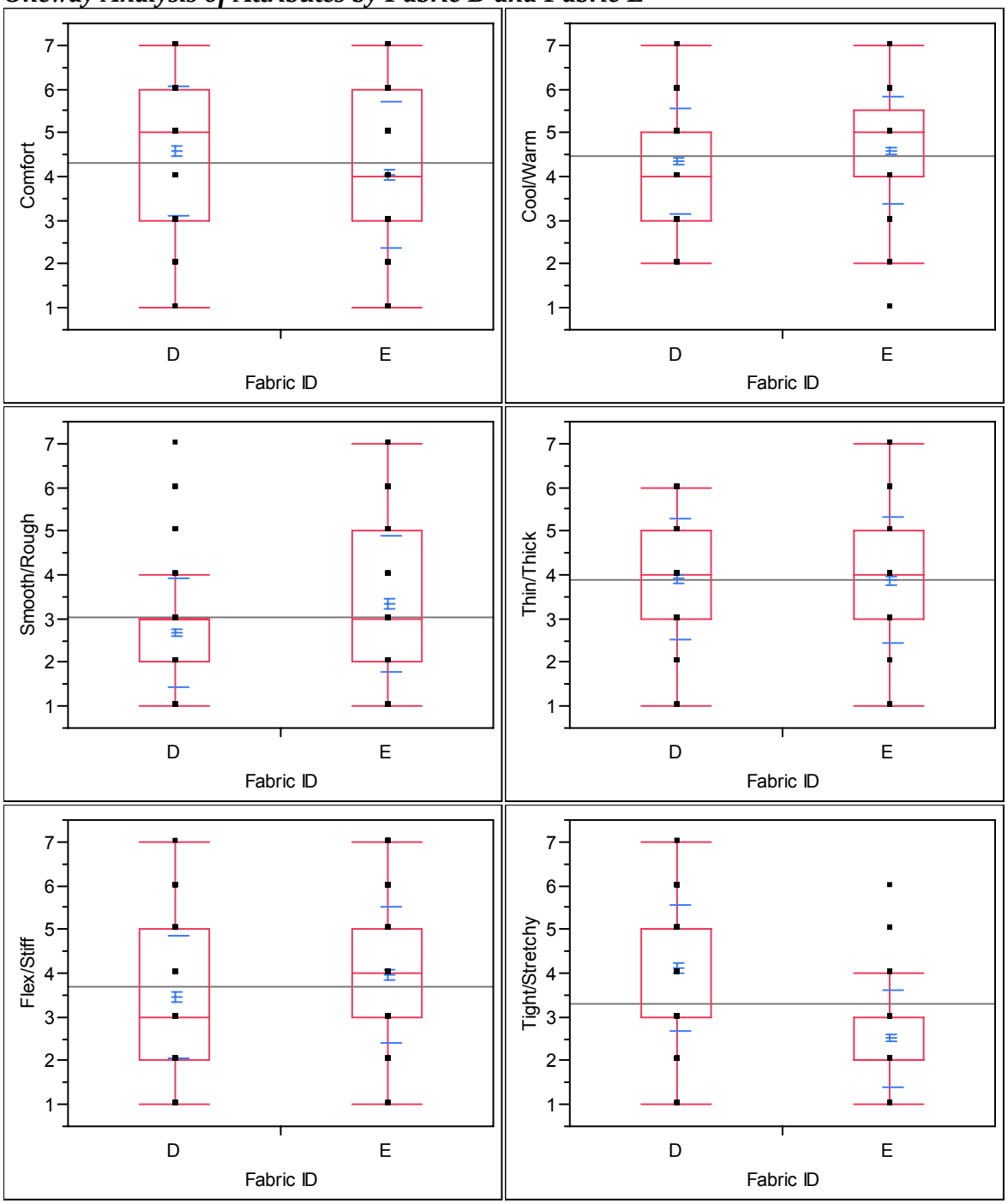


Oneway Analysis of Attributes by Fabric C and Fabric T

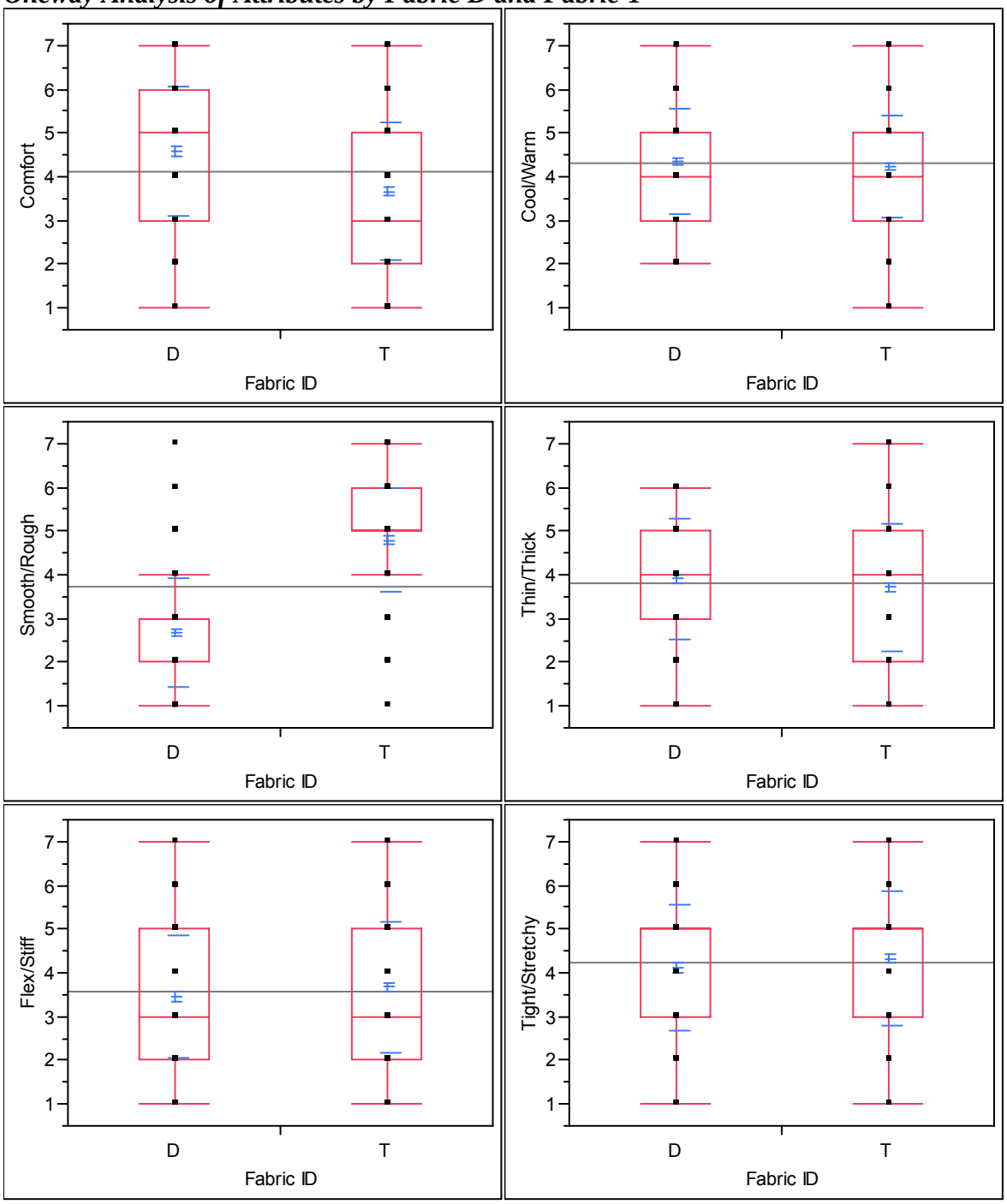


Nonwoven v. Nonwoven

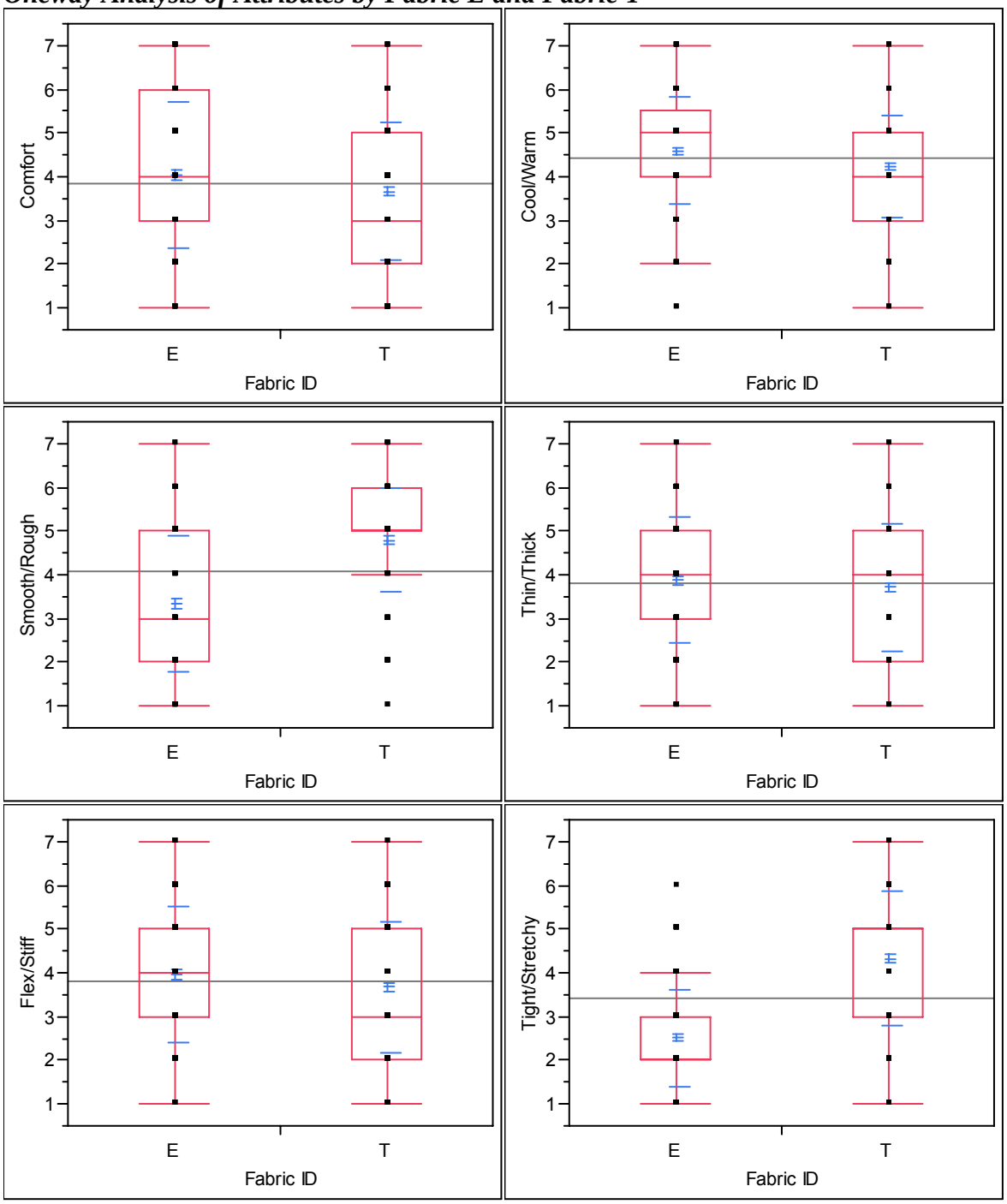
Oneway Analysis of Attributes by Fabric D and Fabric E



Oneway Analysis of Attributes by Fabric D and Fabric T

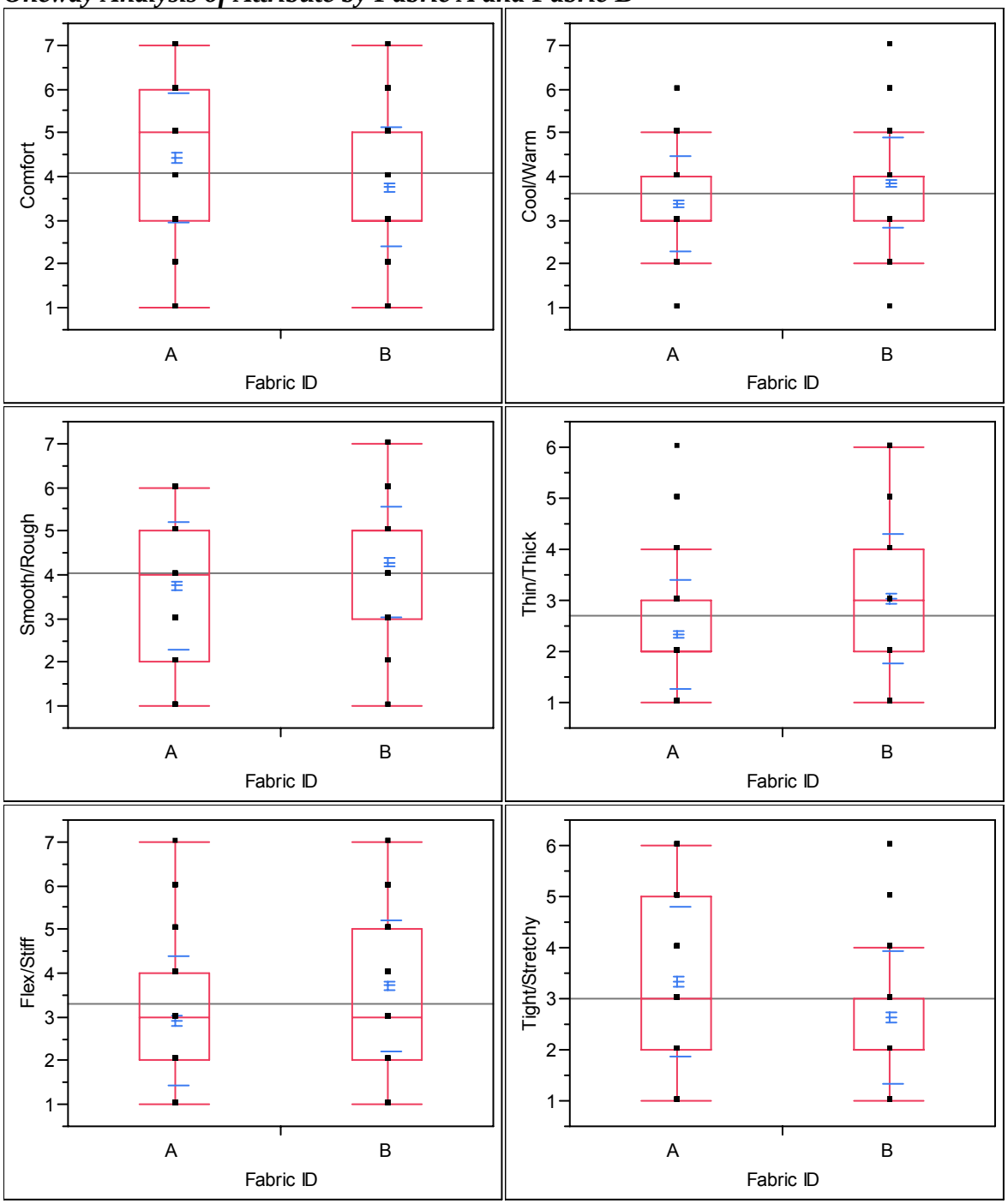


Oneway Analysis of Attributes by Fabric E and Fabric T

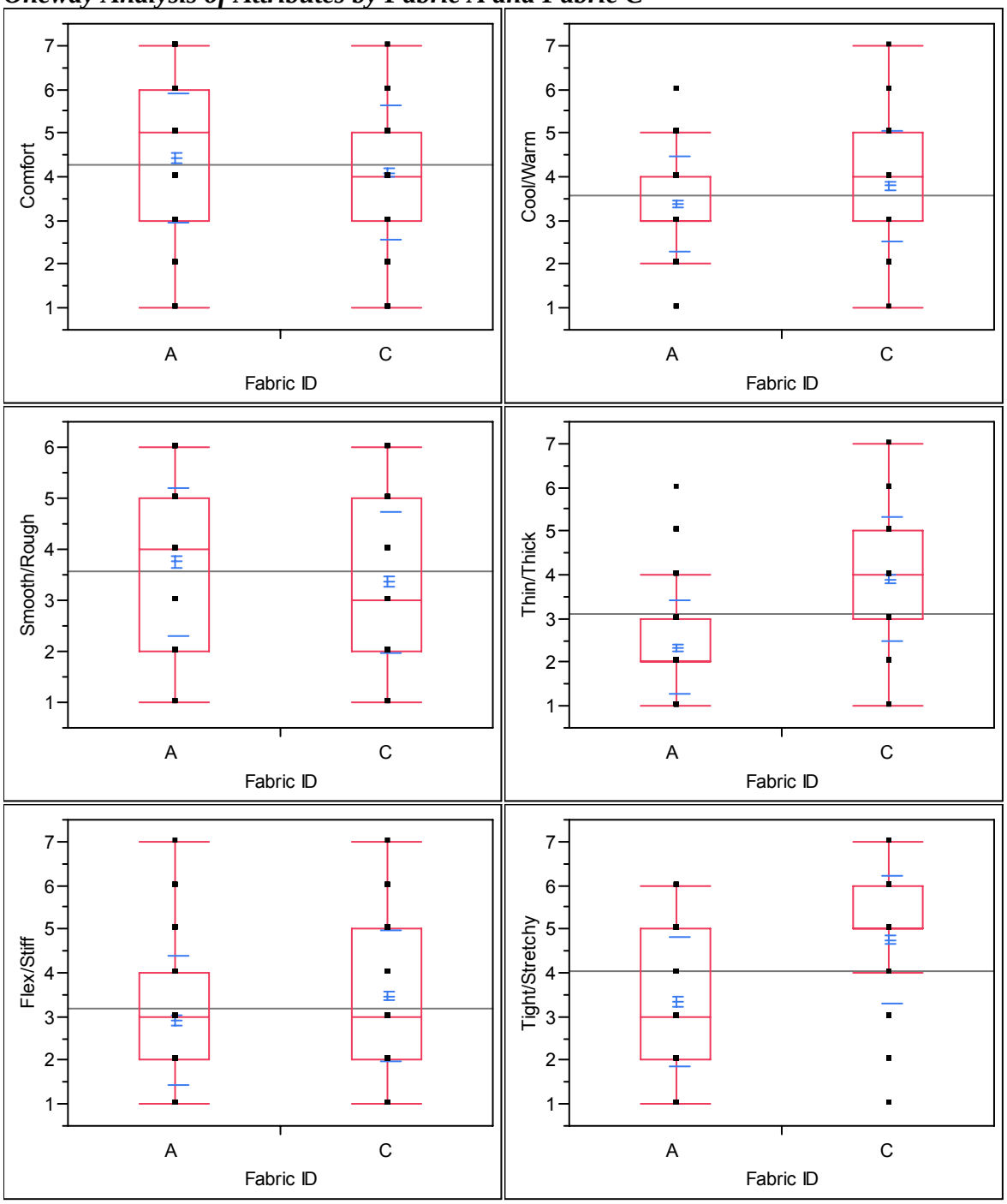


Woven v. Woven

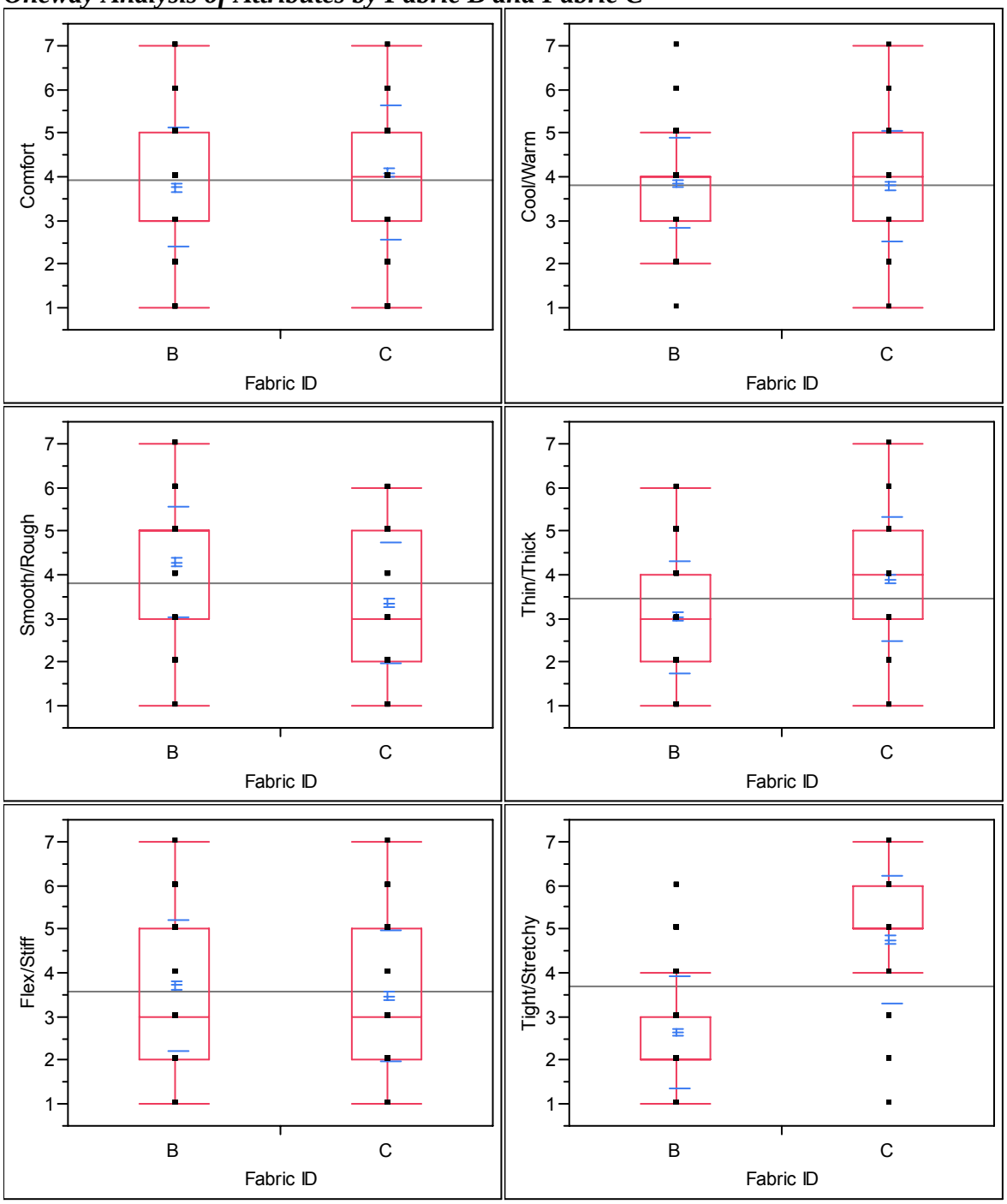
Oneway Analysis of Attribute by Fabric A and Fabric B



Oneway Analysis of Attributes by Fabric A and Fabric C

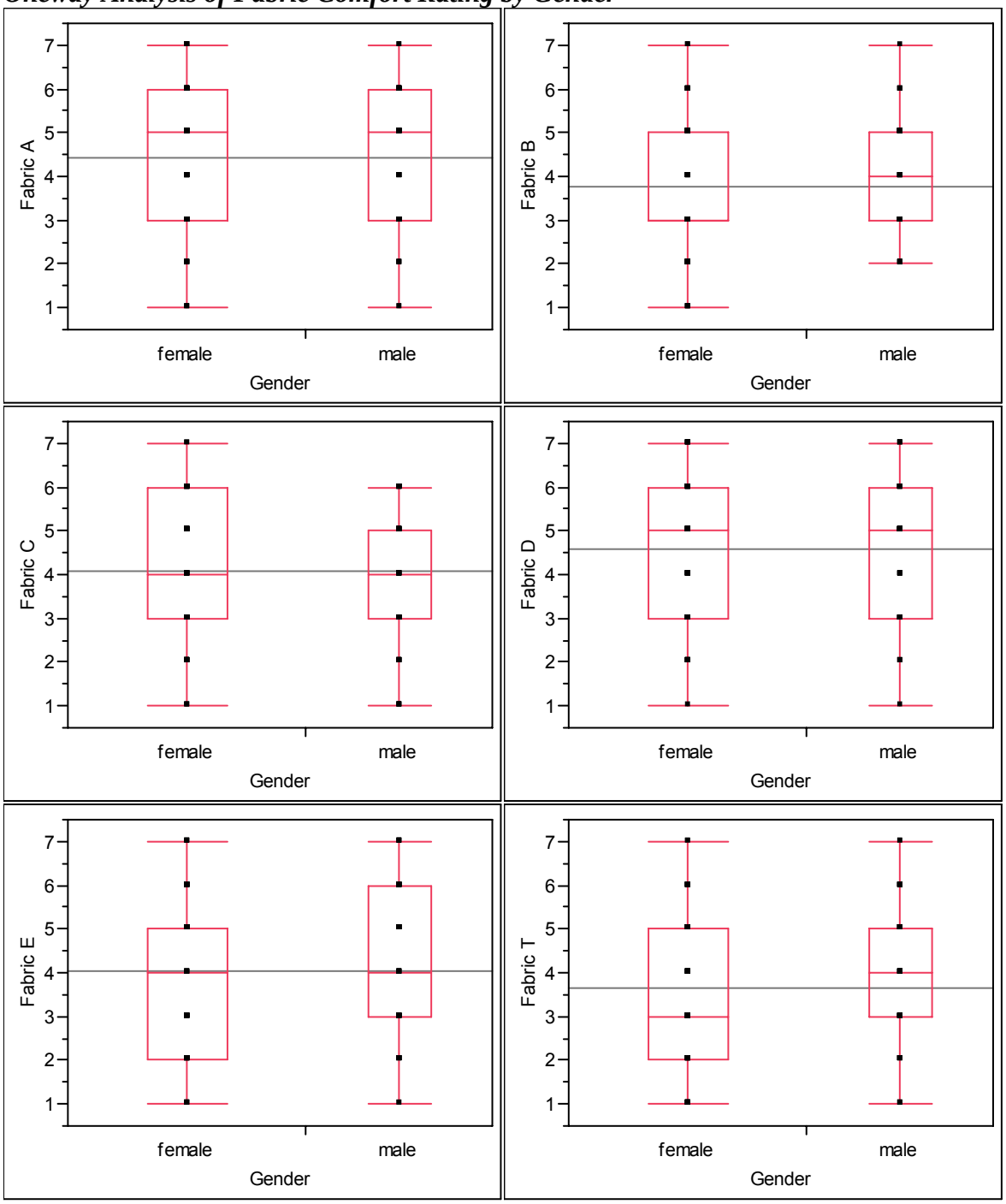


Oneway Analysis of Attributes by Fabric B and Fabric C

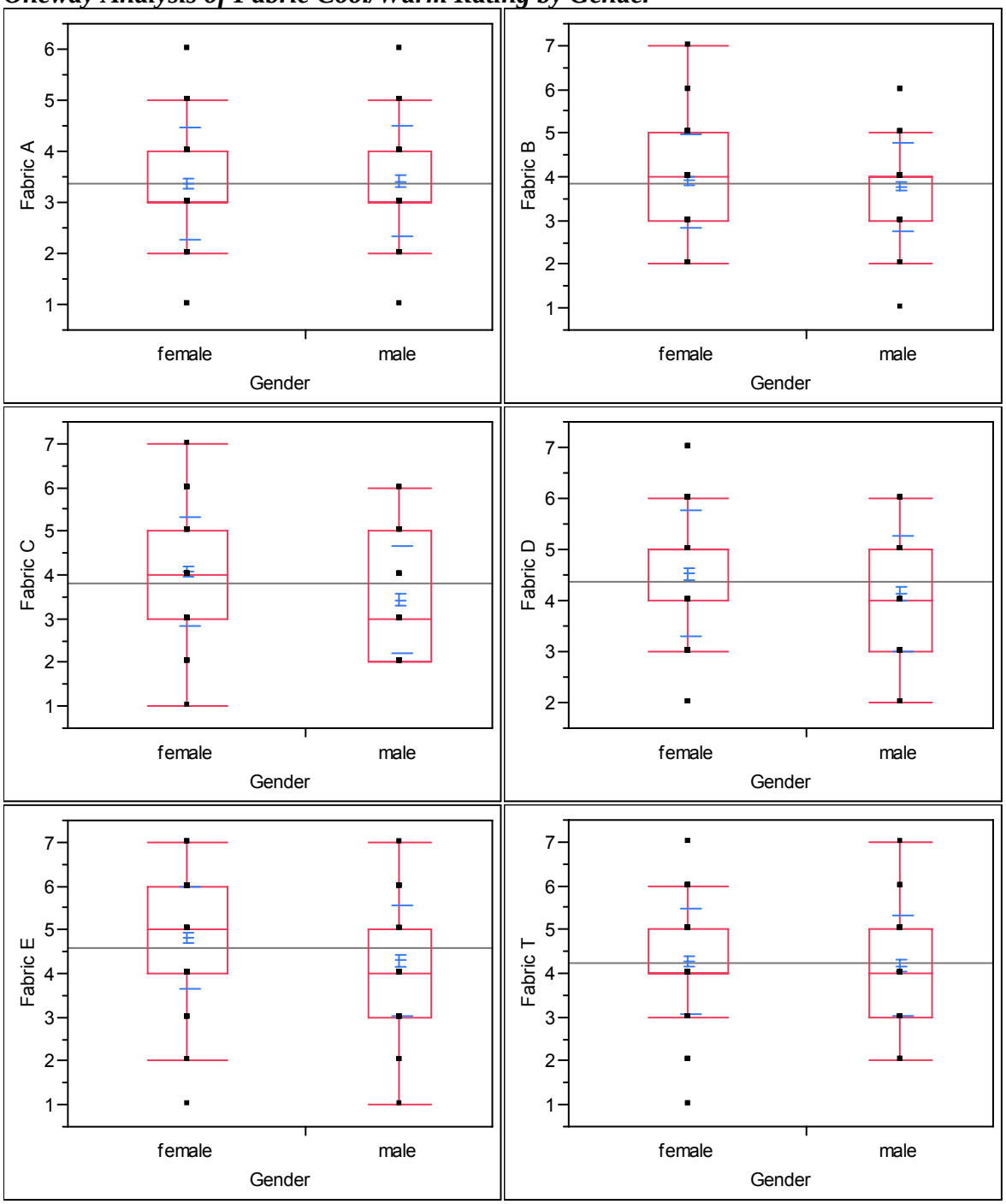


Influence of Gender on Attribute Ratings

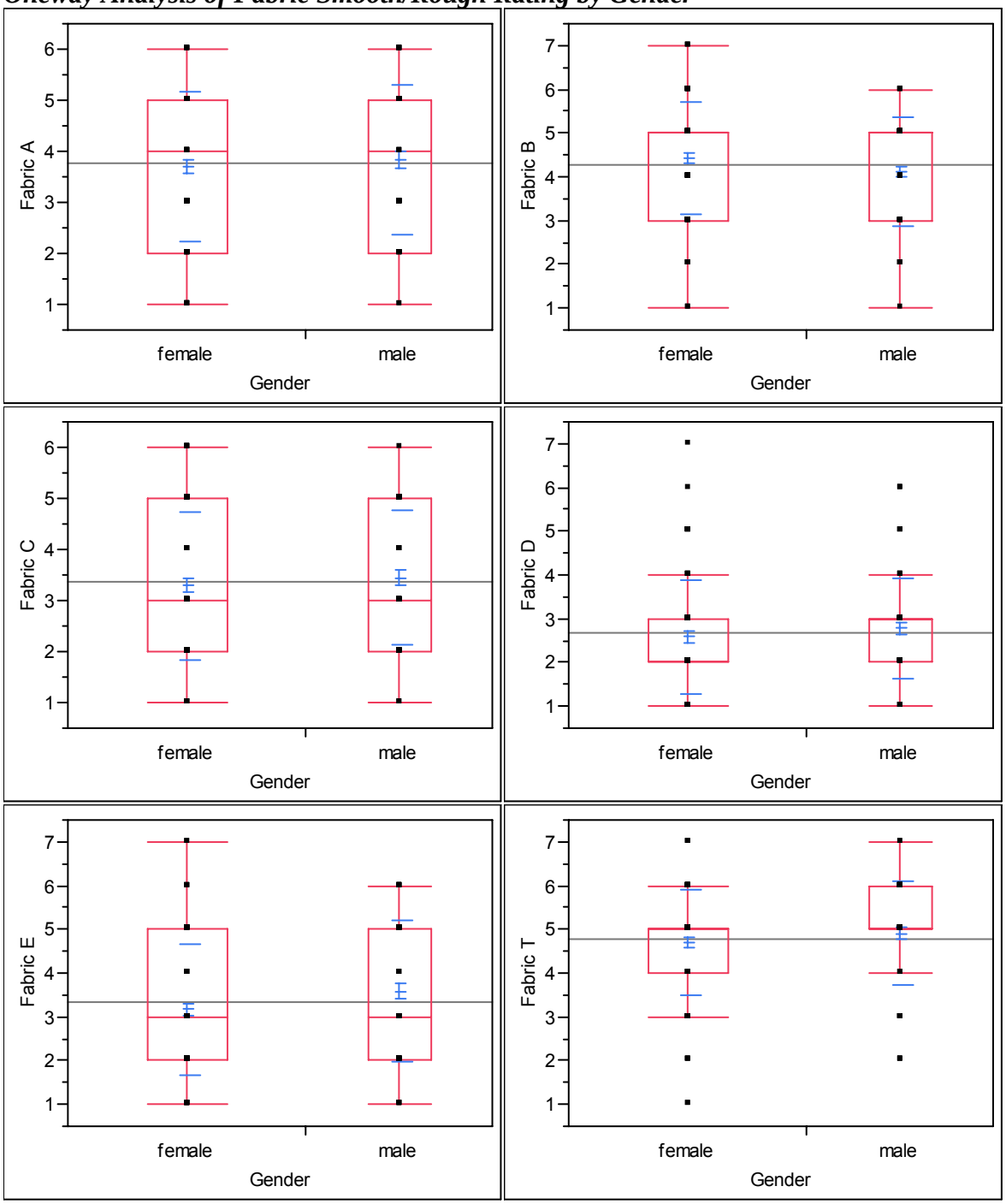
Oneway Analysis of Fabric Comfort Rating by Gender



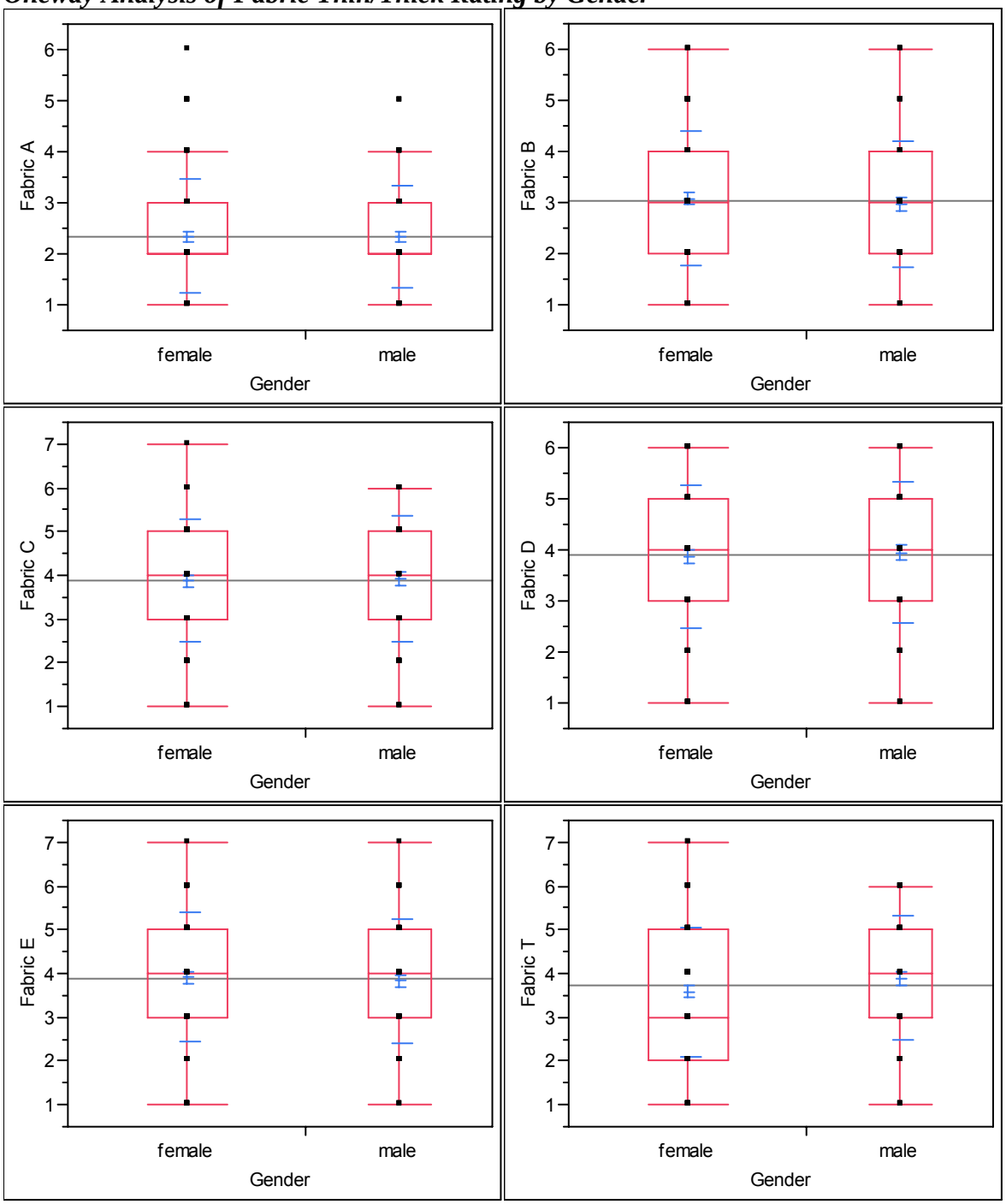
Oneway Analysis of Fabric Cool/Warm Rating by Gender



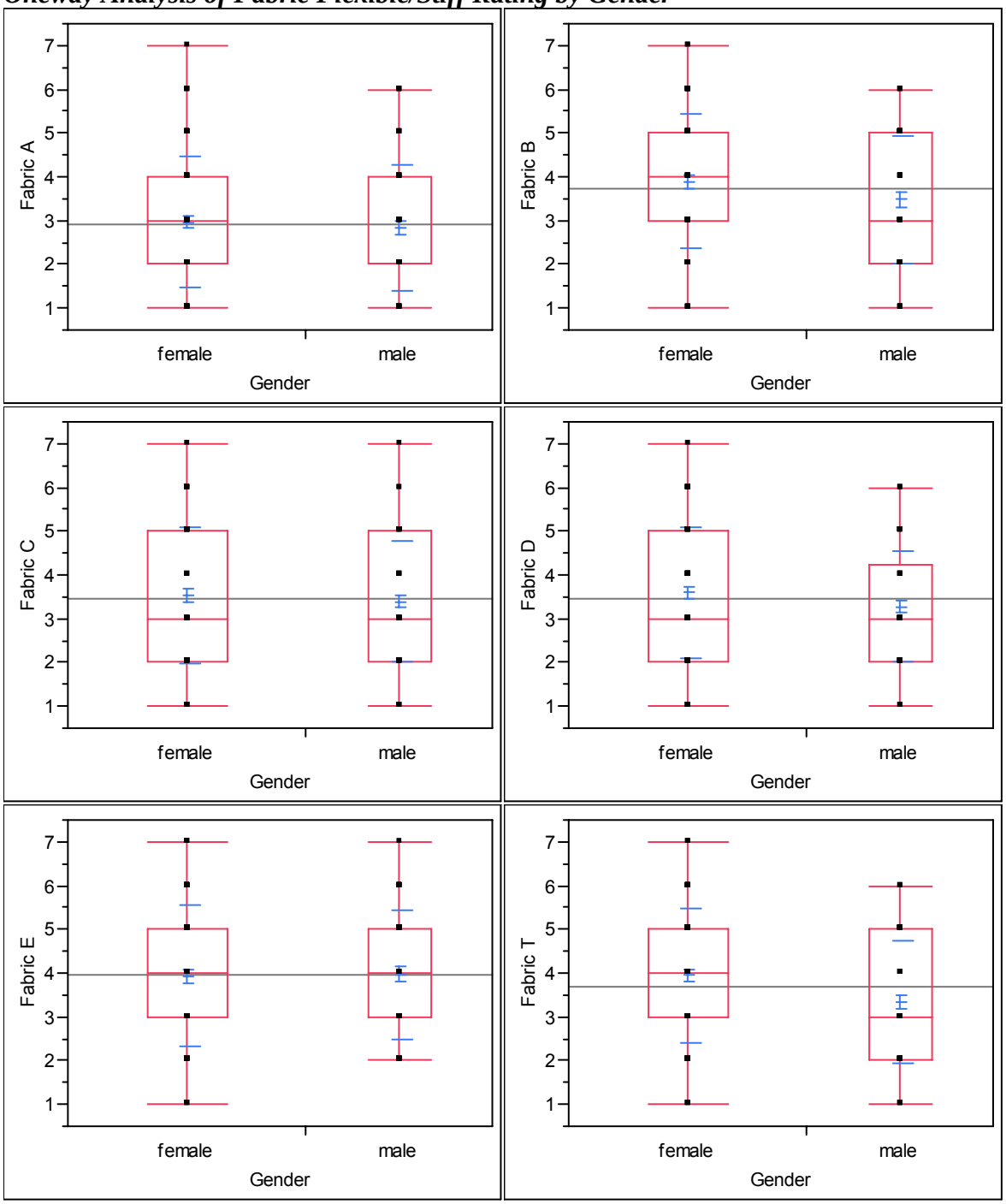
Oneway Analysis of Fabric Smooth/Rough Rating by Gender



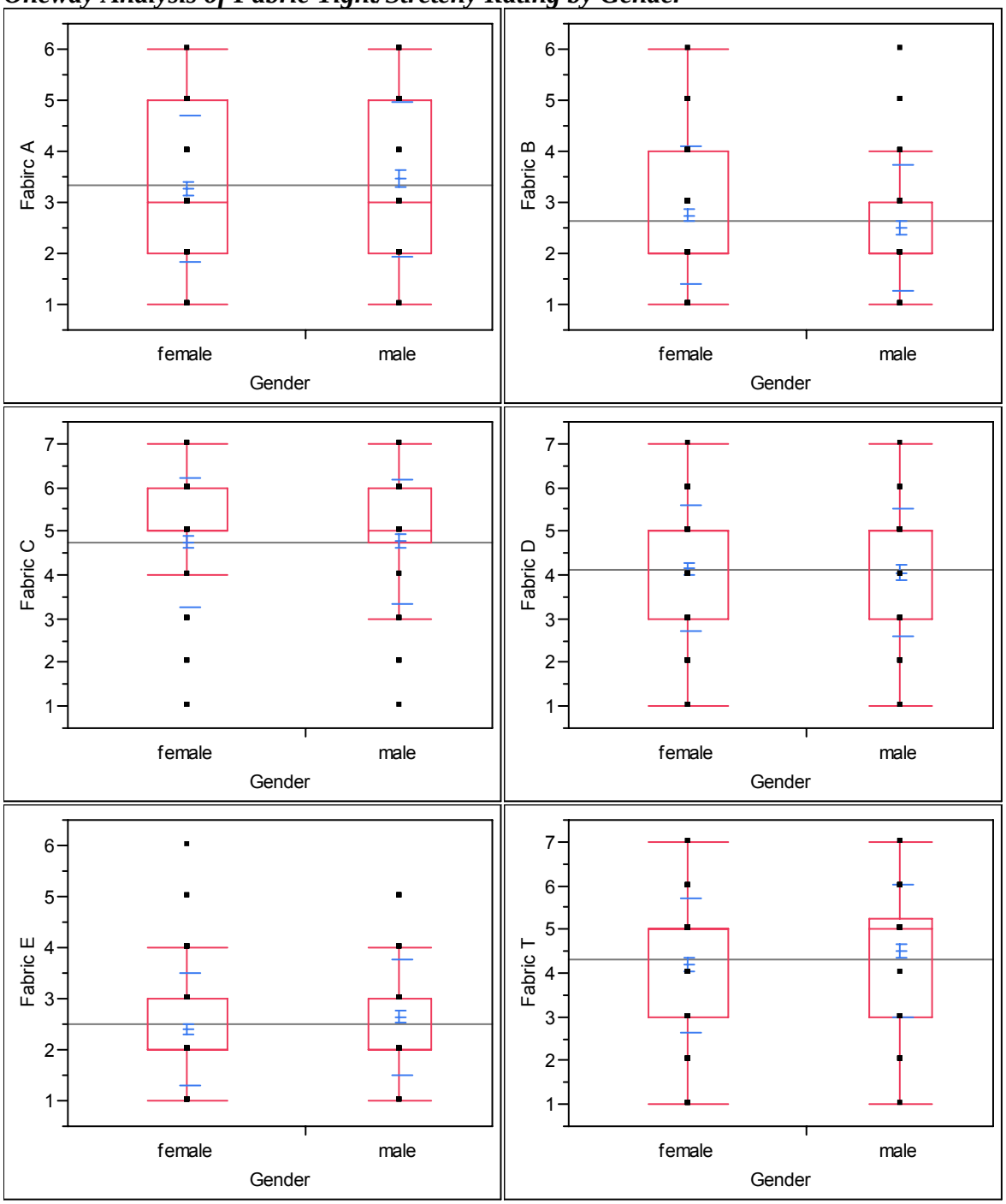
Oneway Analysis of Fabric Thin/Thick Rating by Gender



Oneway Analysis of Fabric Flexible/Stiff Rating by Gender



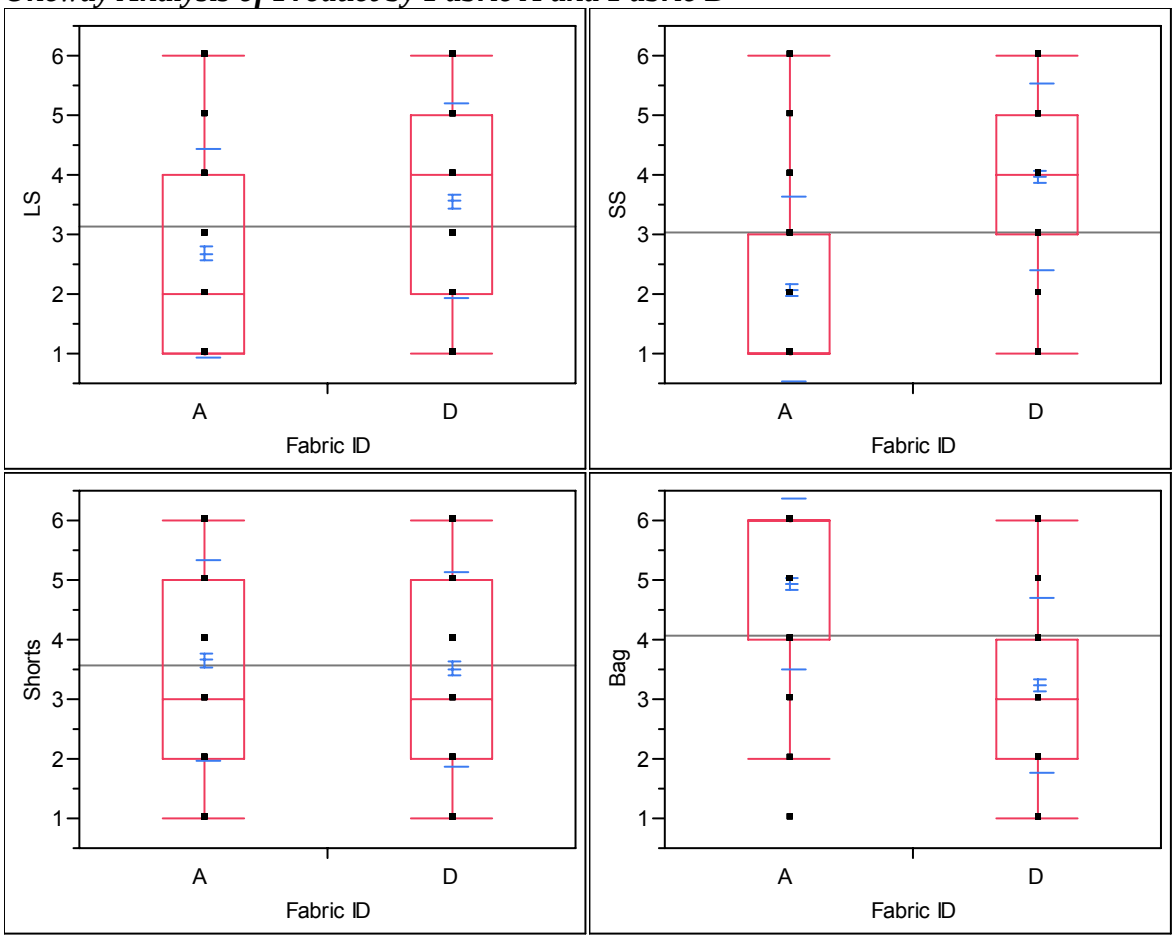
Oneway Analysis of Fabric Tight/Stretchy Rating by Gender



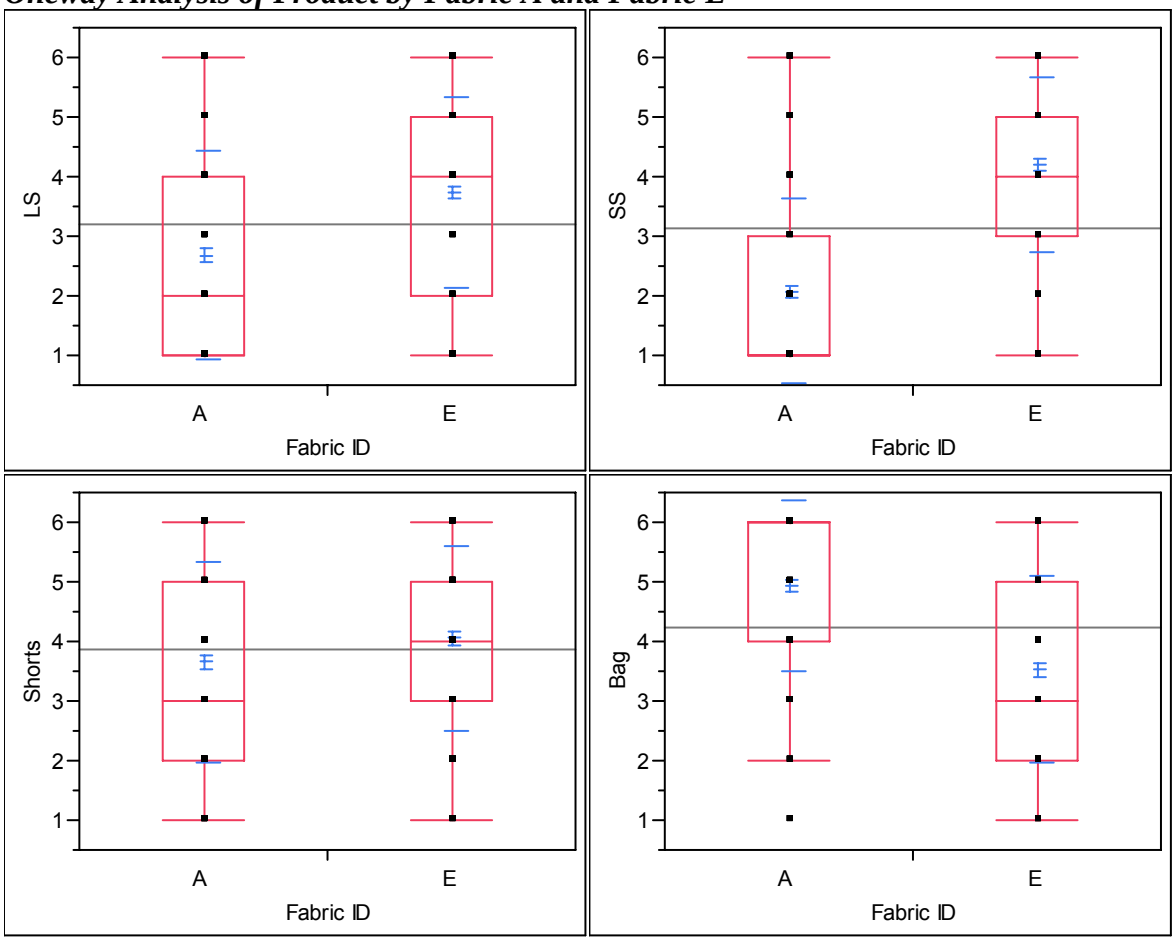
Box Plots: Ranking

Woven v. Nonwoven

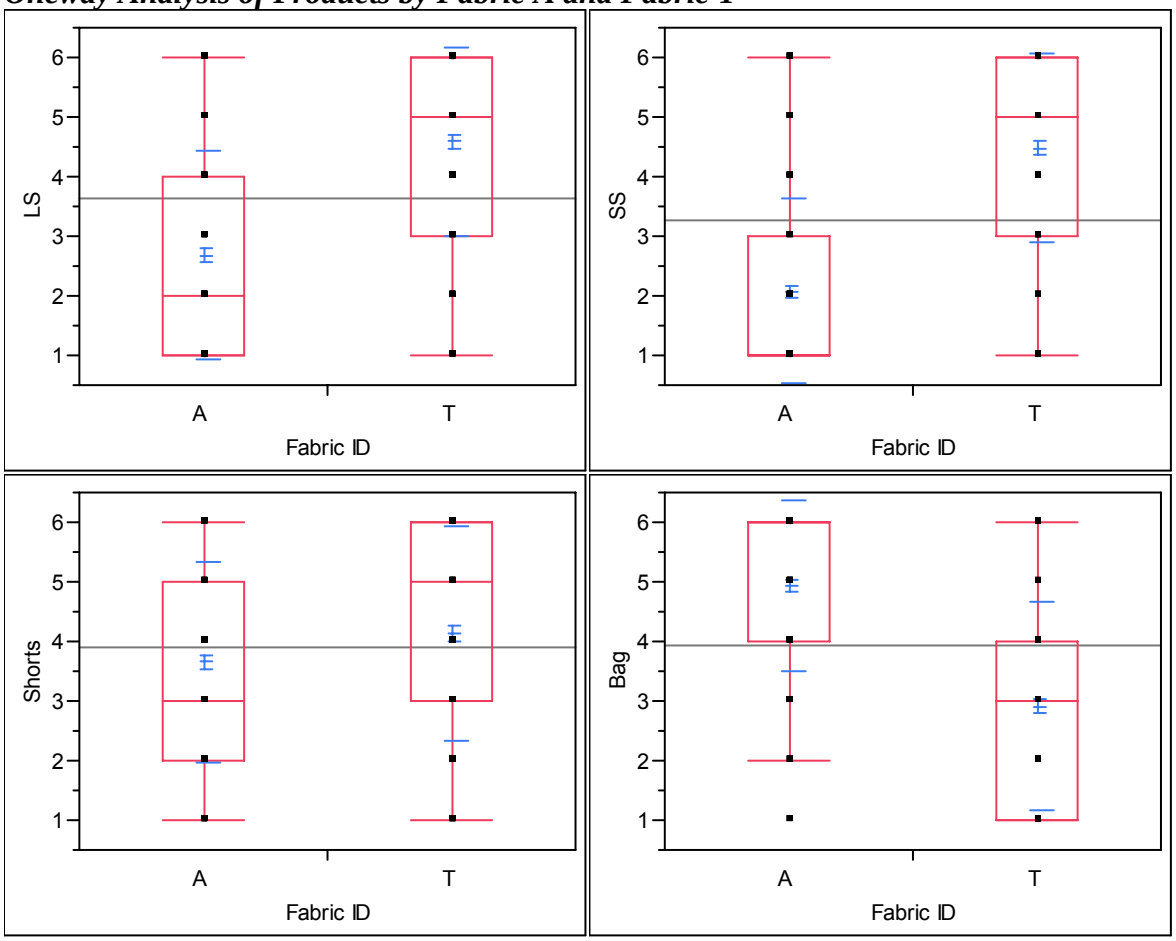
Oneway Analysis of Product by Fabric A and Fabric D



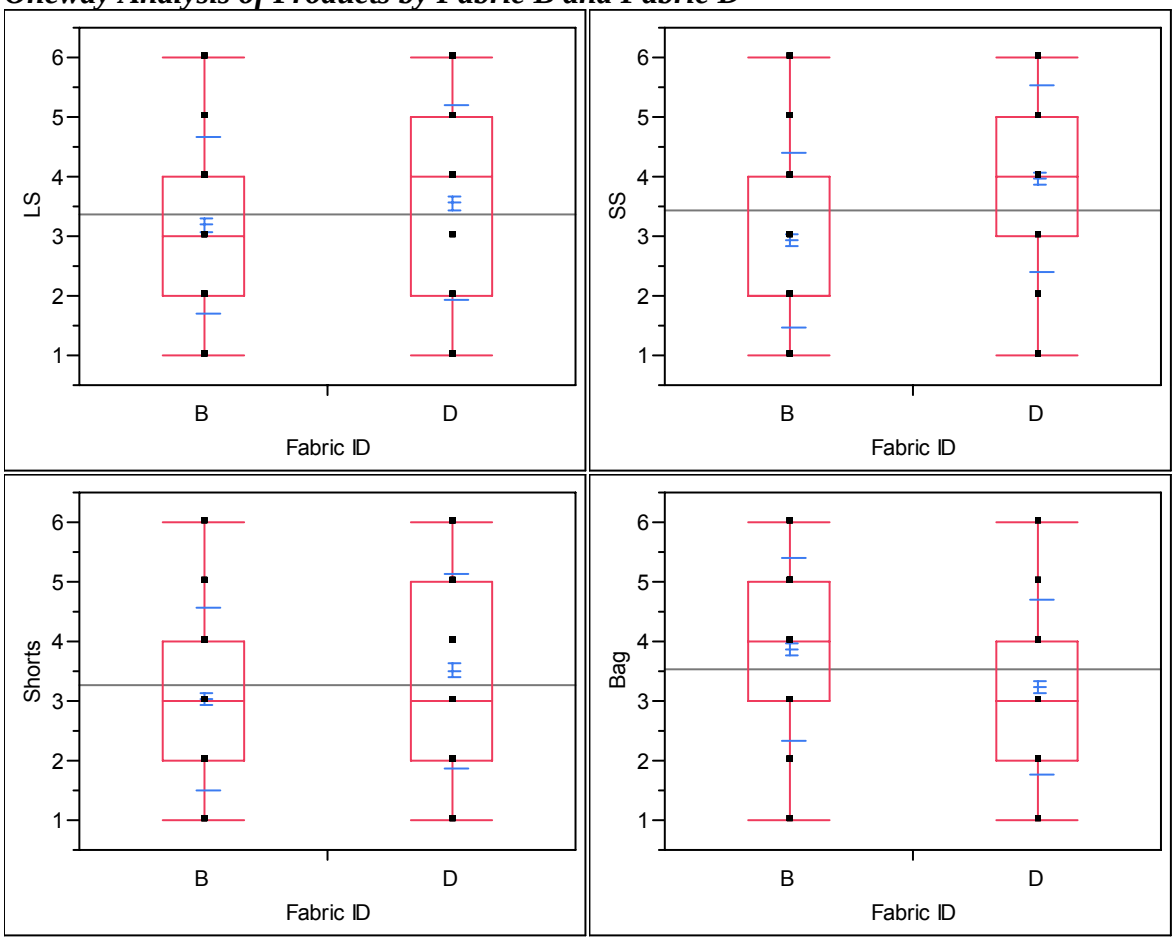
Oneway Analysis of Product by Fabric A and Fabric E



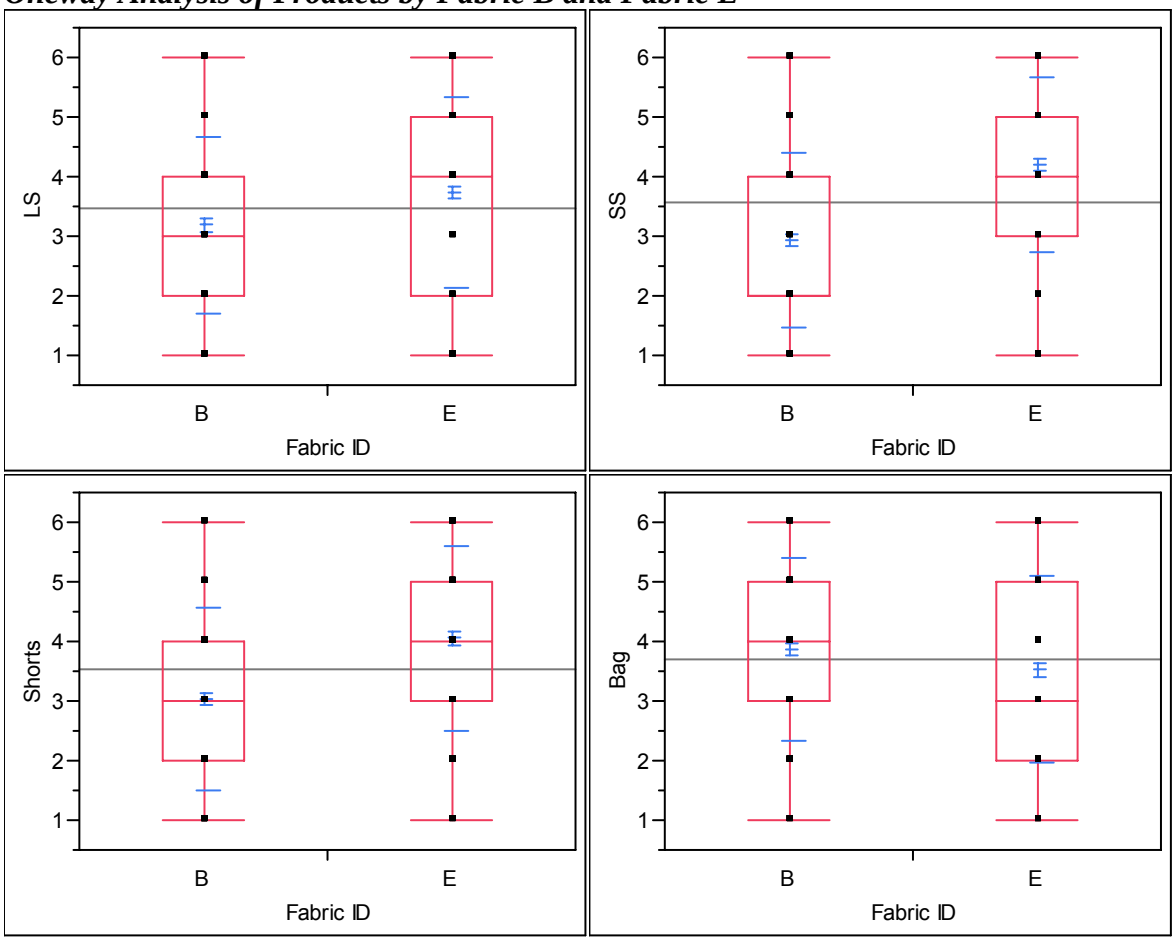
Oneway Analysis of Products by Fabric A and Fabric T



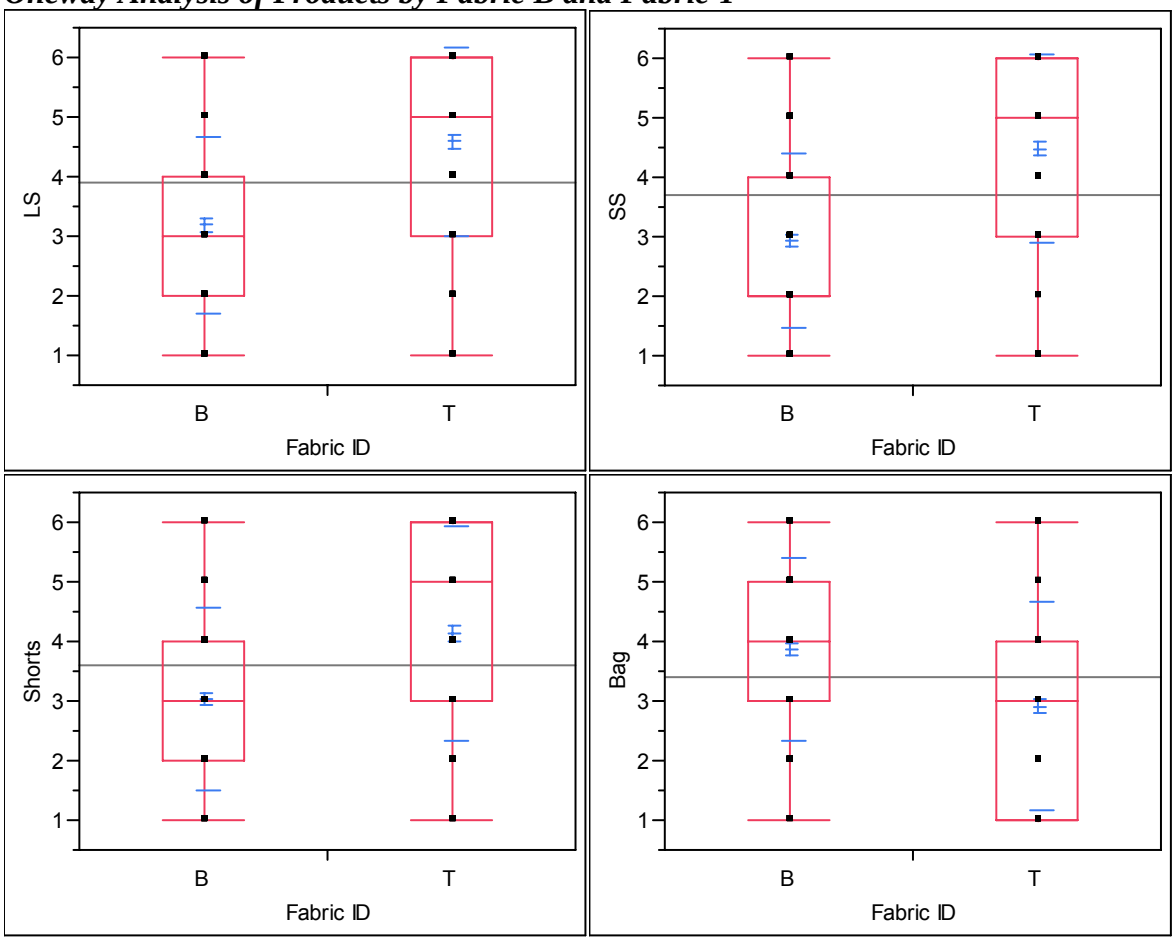
Oneway Analysis of Products by Fabric B and Fabric D



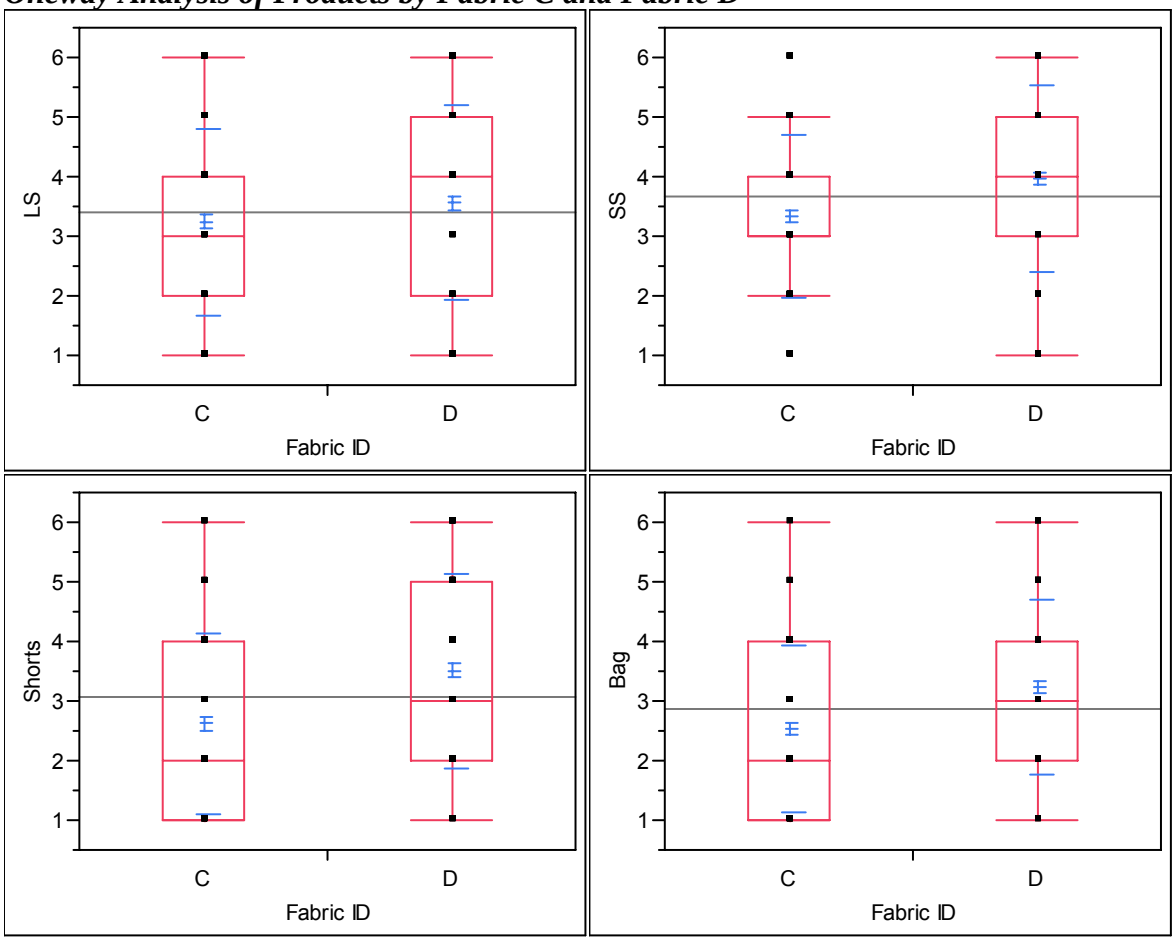
Oneway Analysis of Products by Fabric B and Fabric E



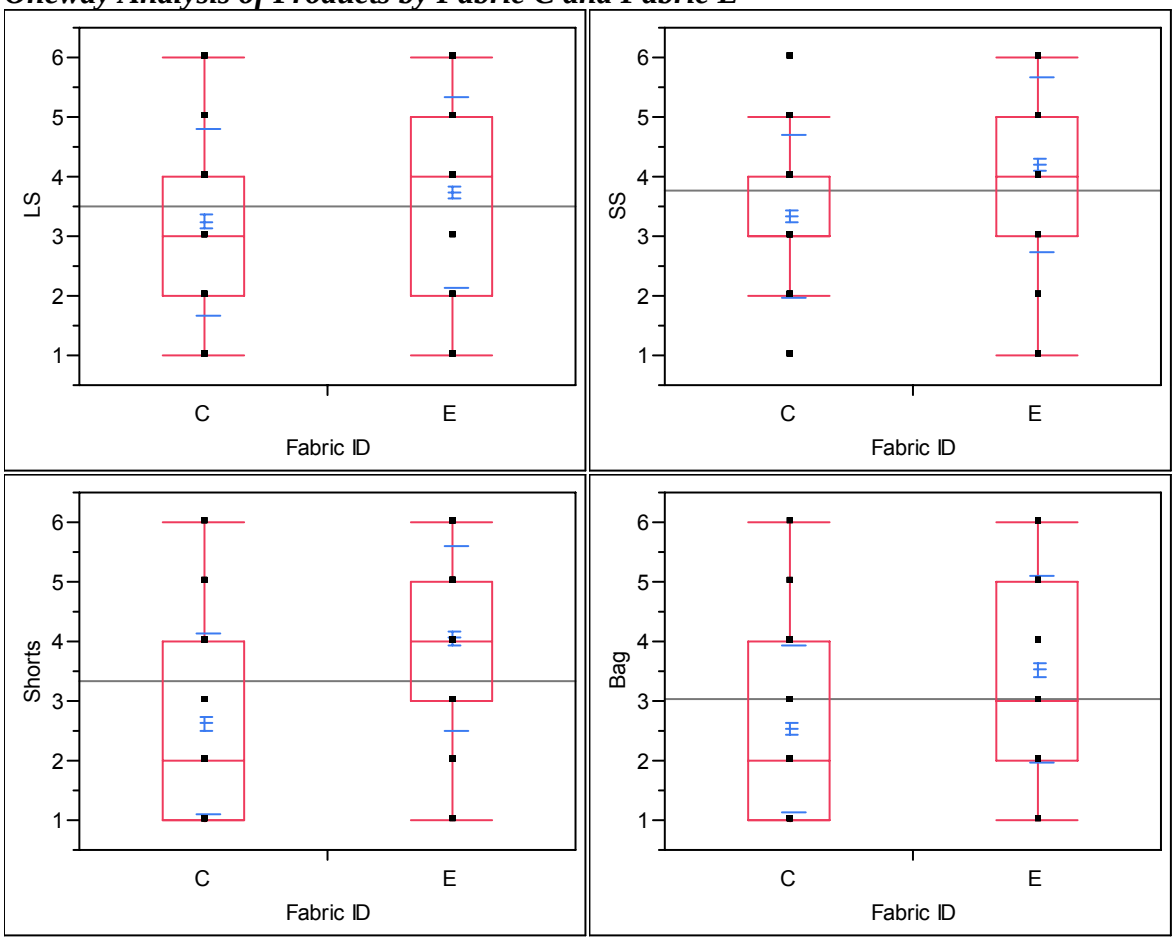
Oneway Analysis of Products by Fabric B and Fabric T



Oneway Analysis of Products by Fabric C and Fabric D



Oneway Analysis of Products by Fabric C and Fabric E



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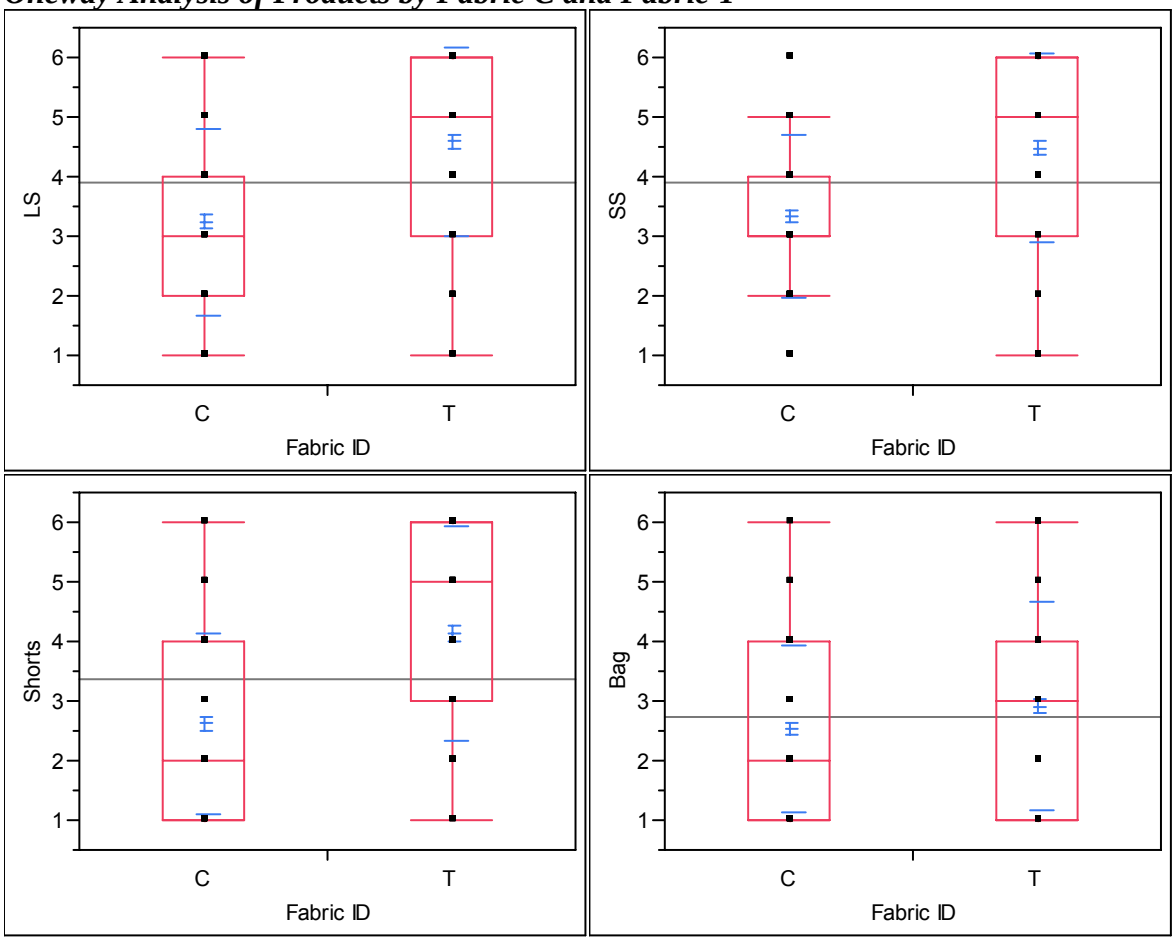
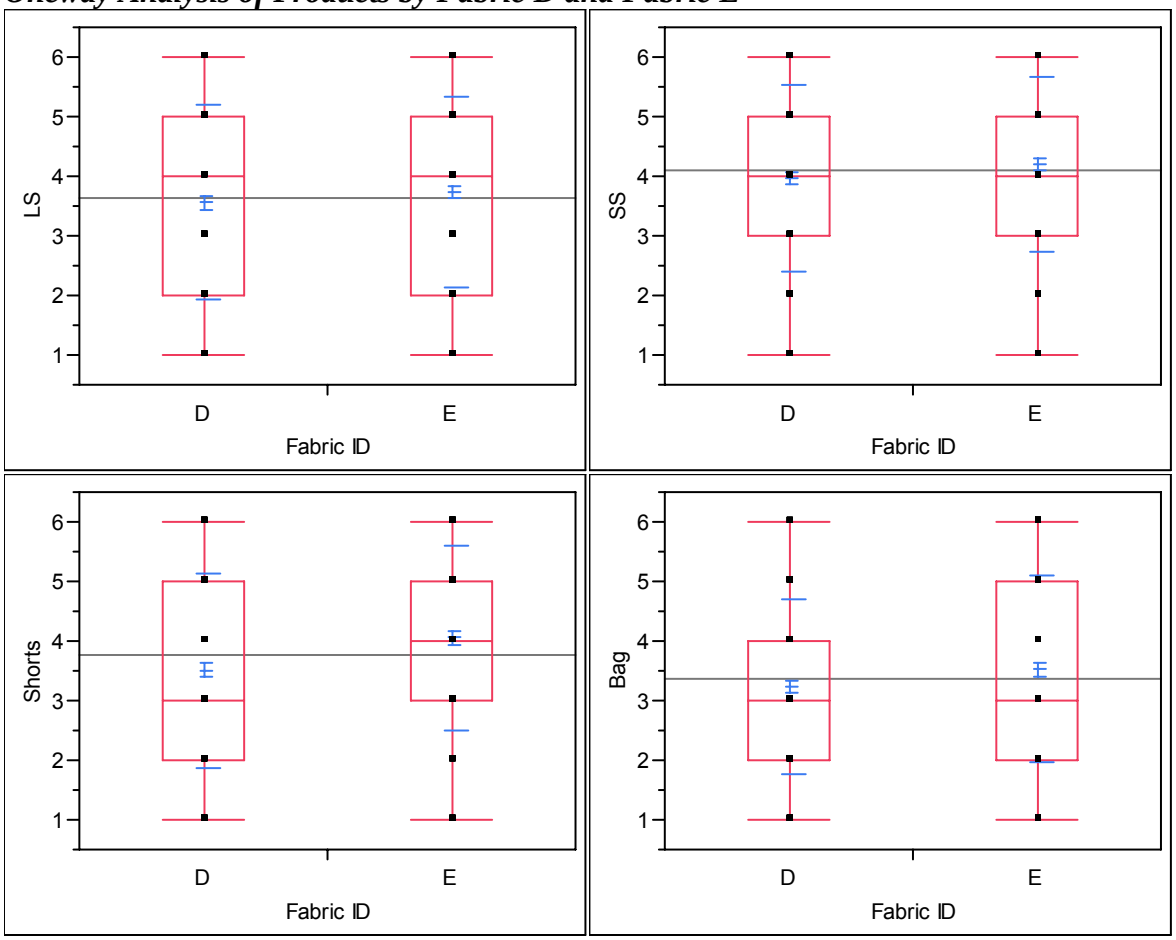
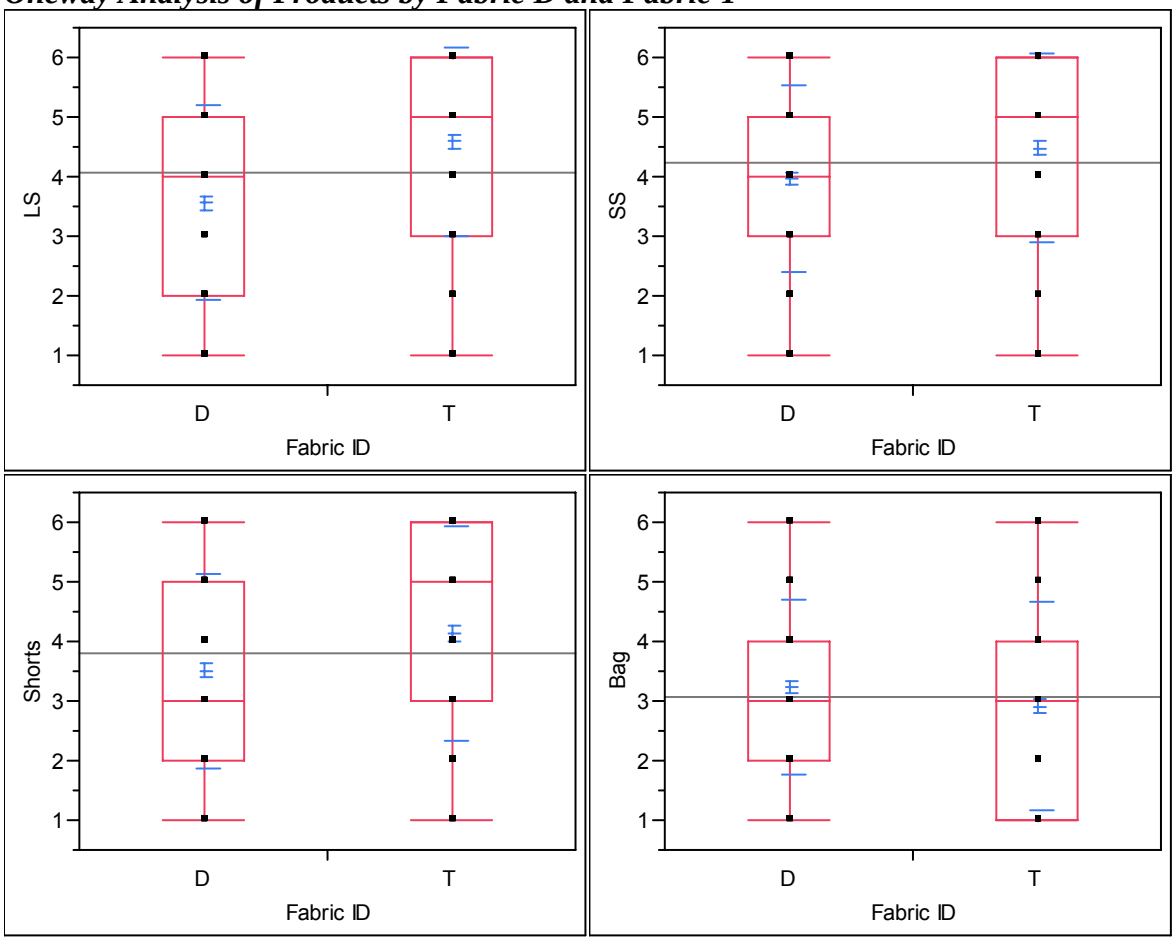


Nonwoven v. Nonwoven

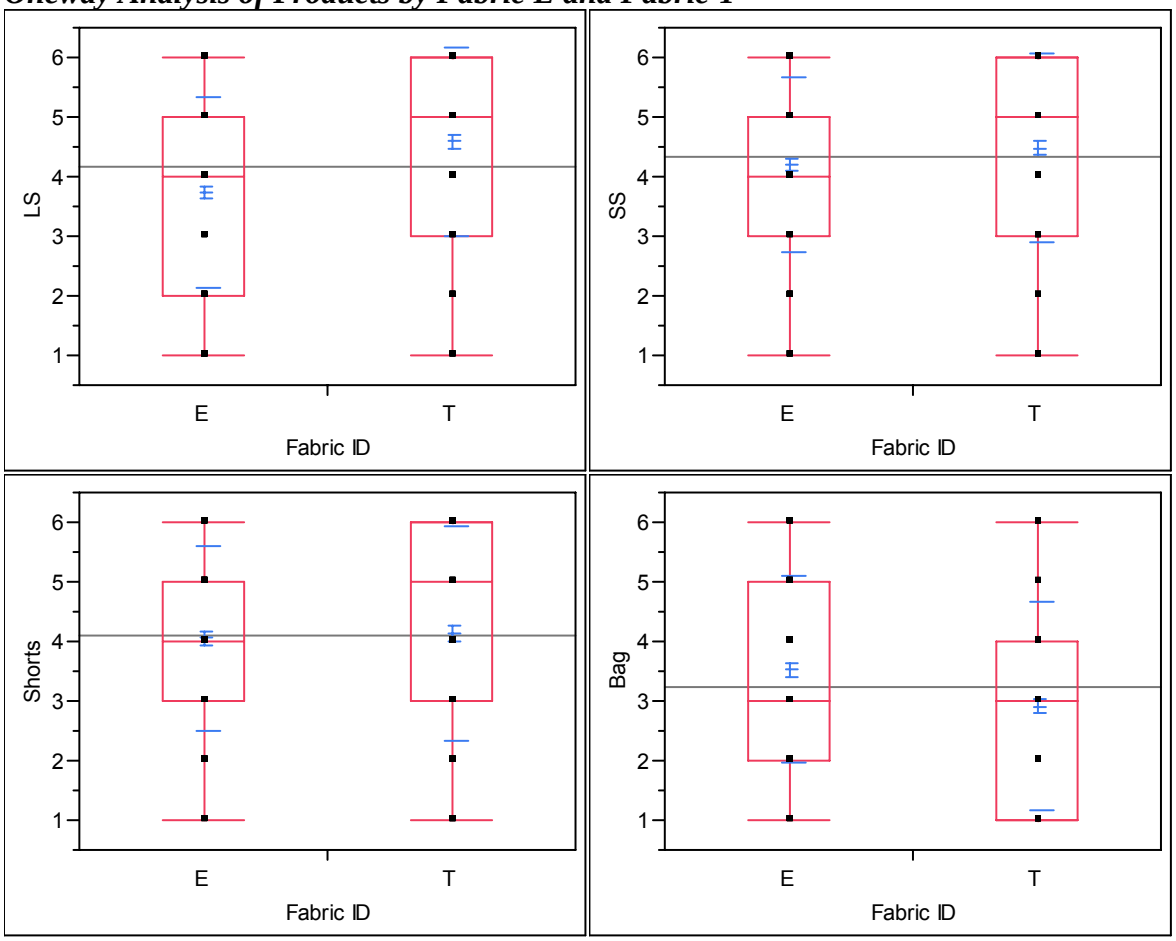
Oneway Analysis of Products by Fabric D and Fabric E



Oneway Analysis of Products by Fabric D and Fabric T

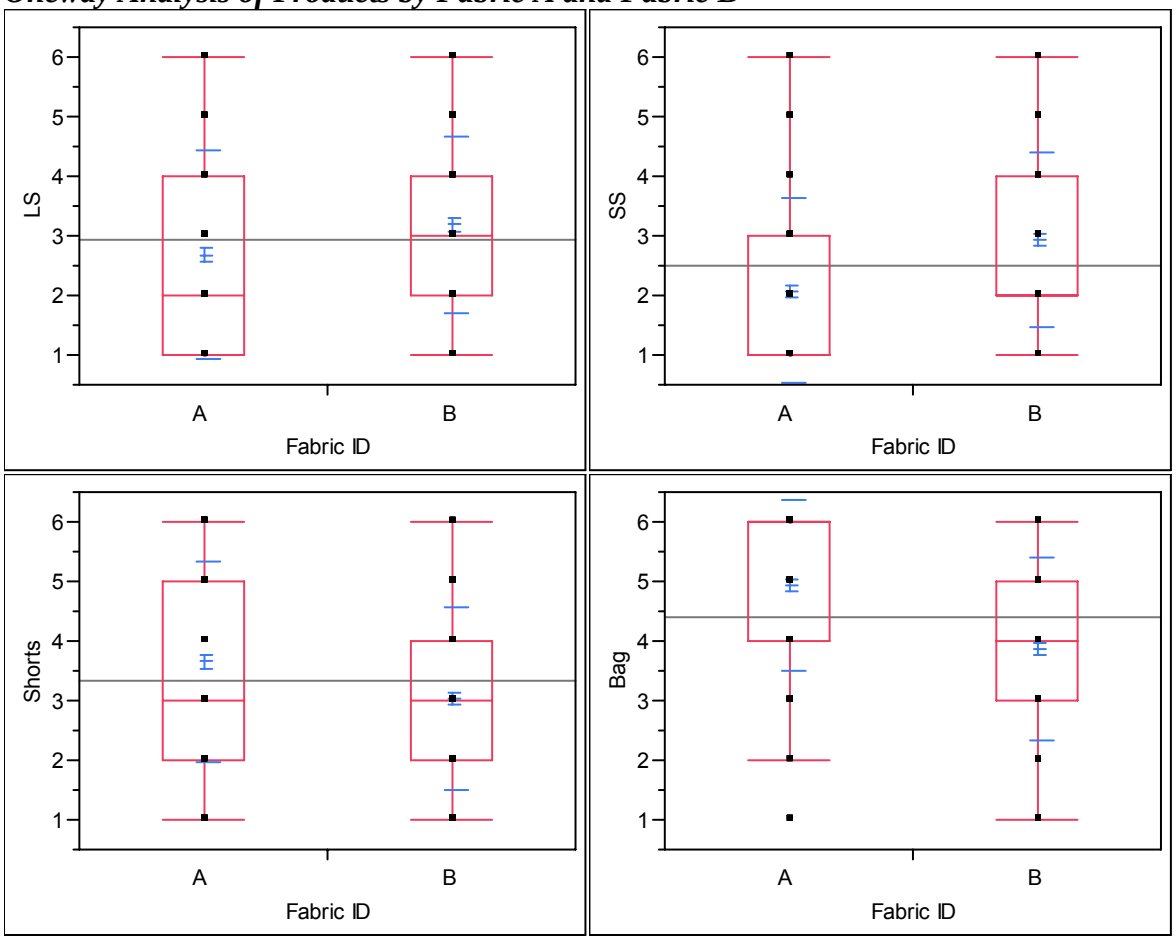


Oneway Analysis of Products by Fabric E and Fabric T

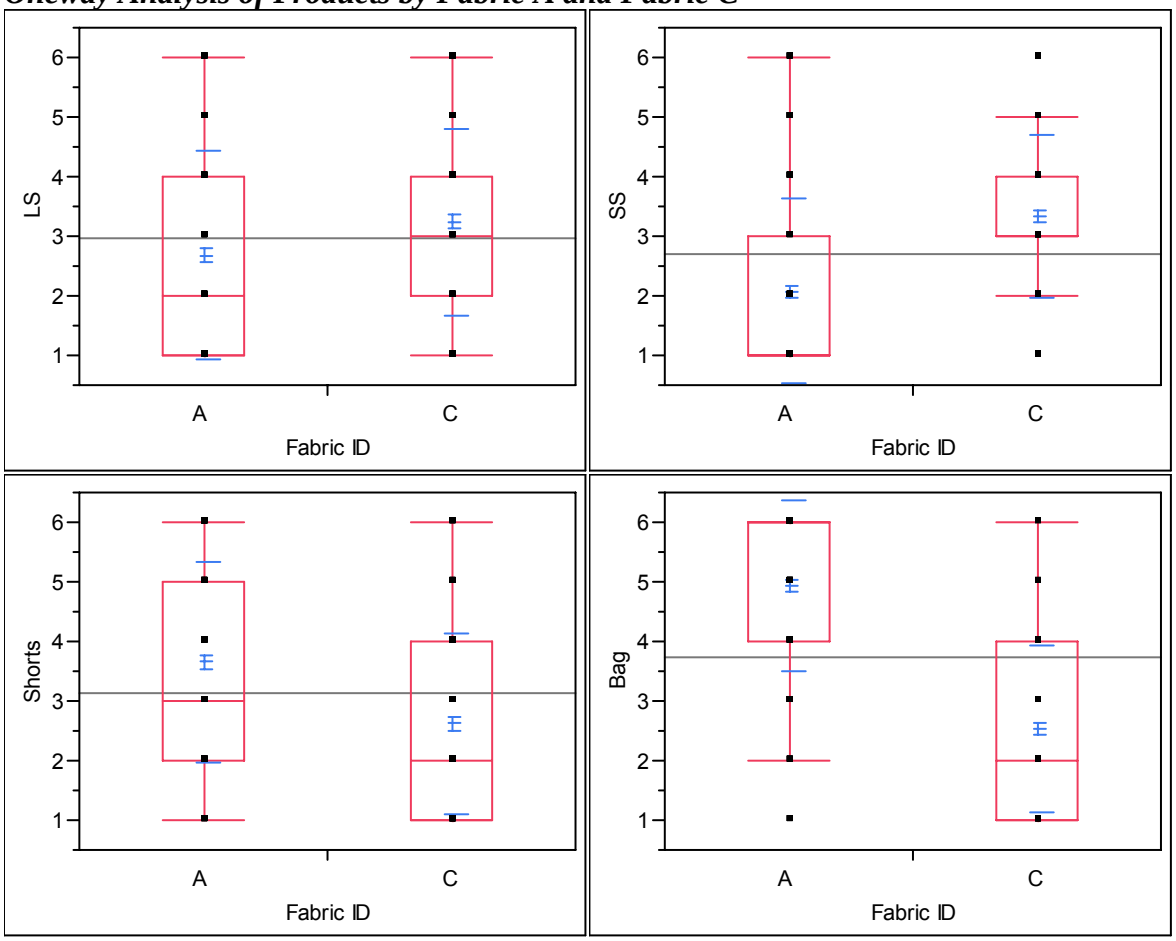


Woven v. Woven

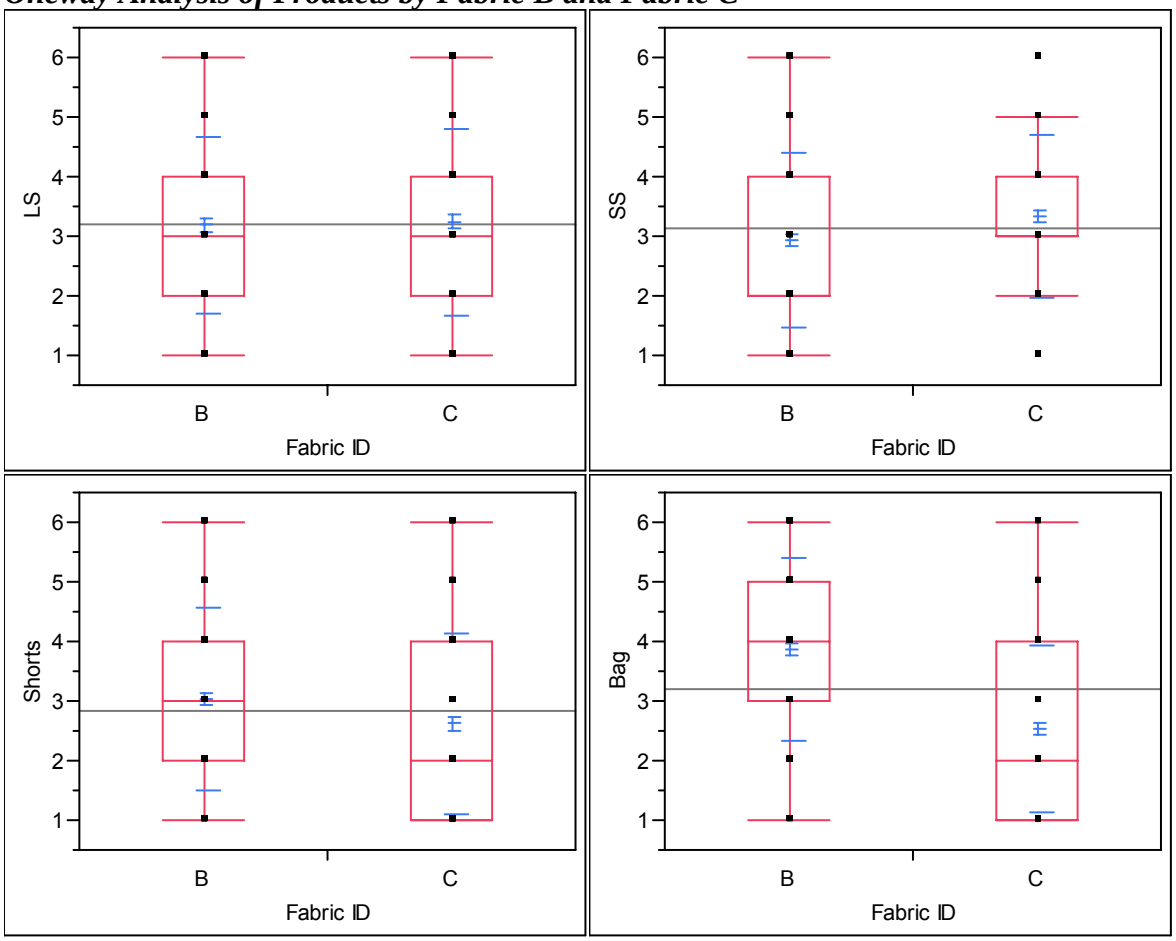
Oneway Analysis of Products by Fabric A and Fabric B



Oneway Analysis of Products by Fabric A and Fabric C

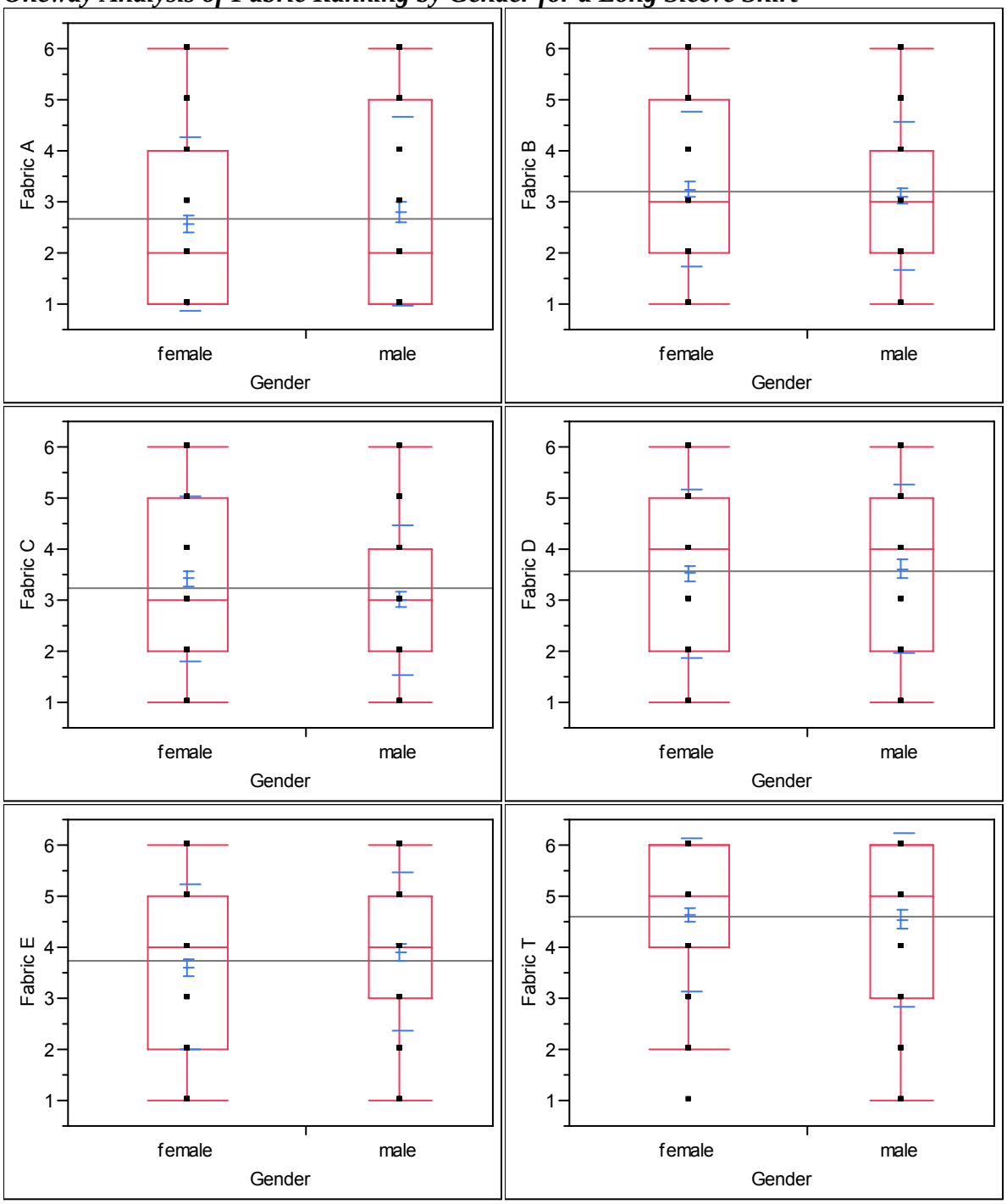


Oneway Analysis of Products by Fabric B and Fabric C

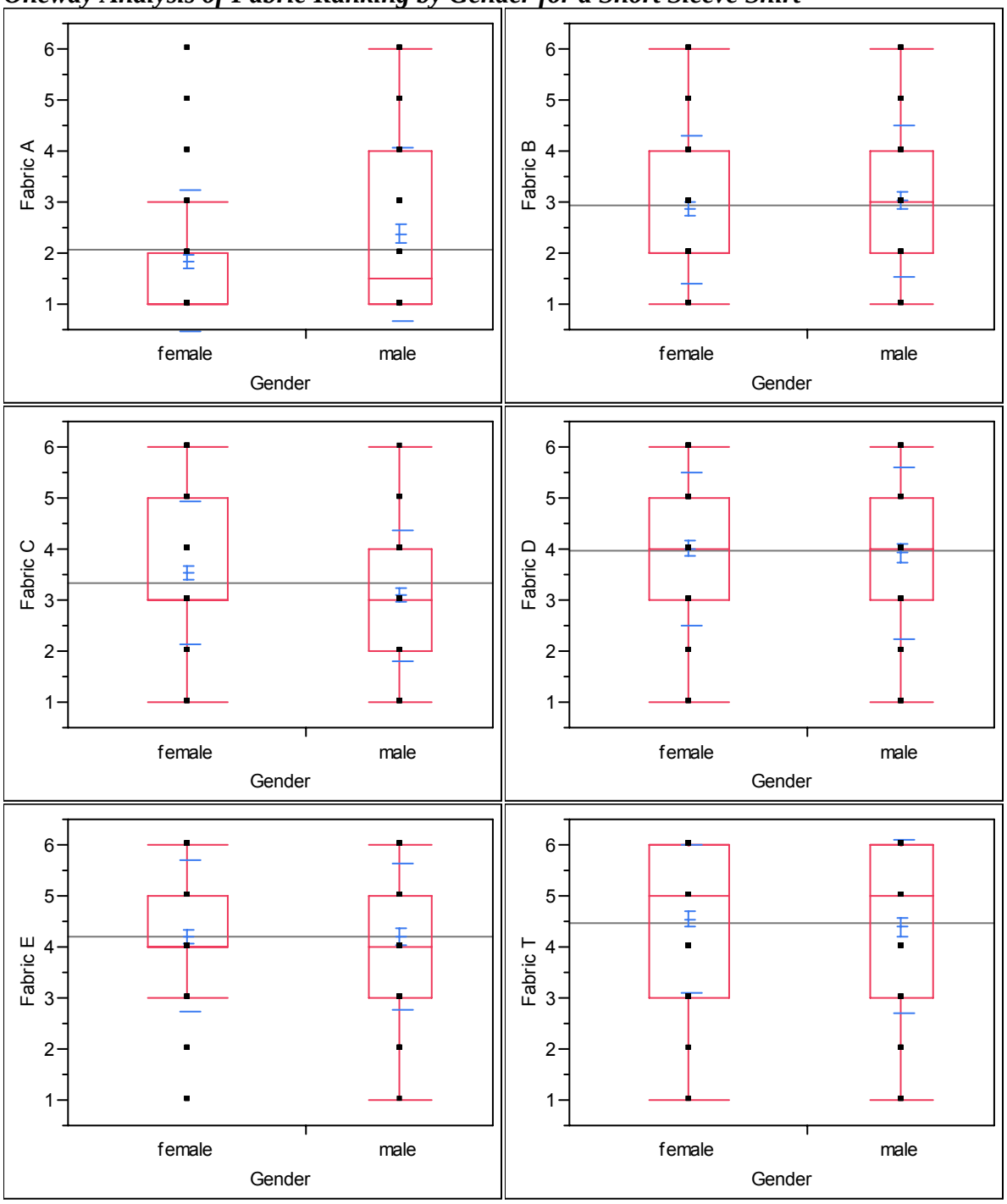


Influence of Gender on Fabric Rankings

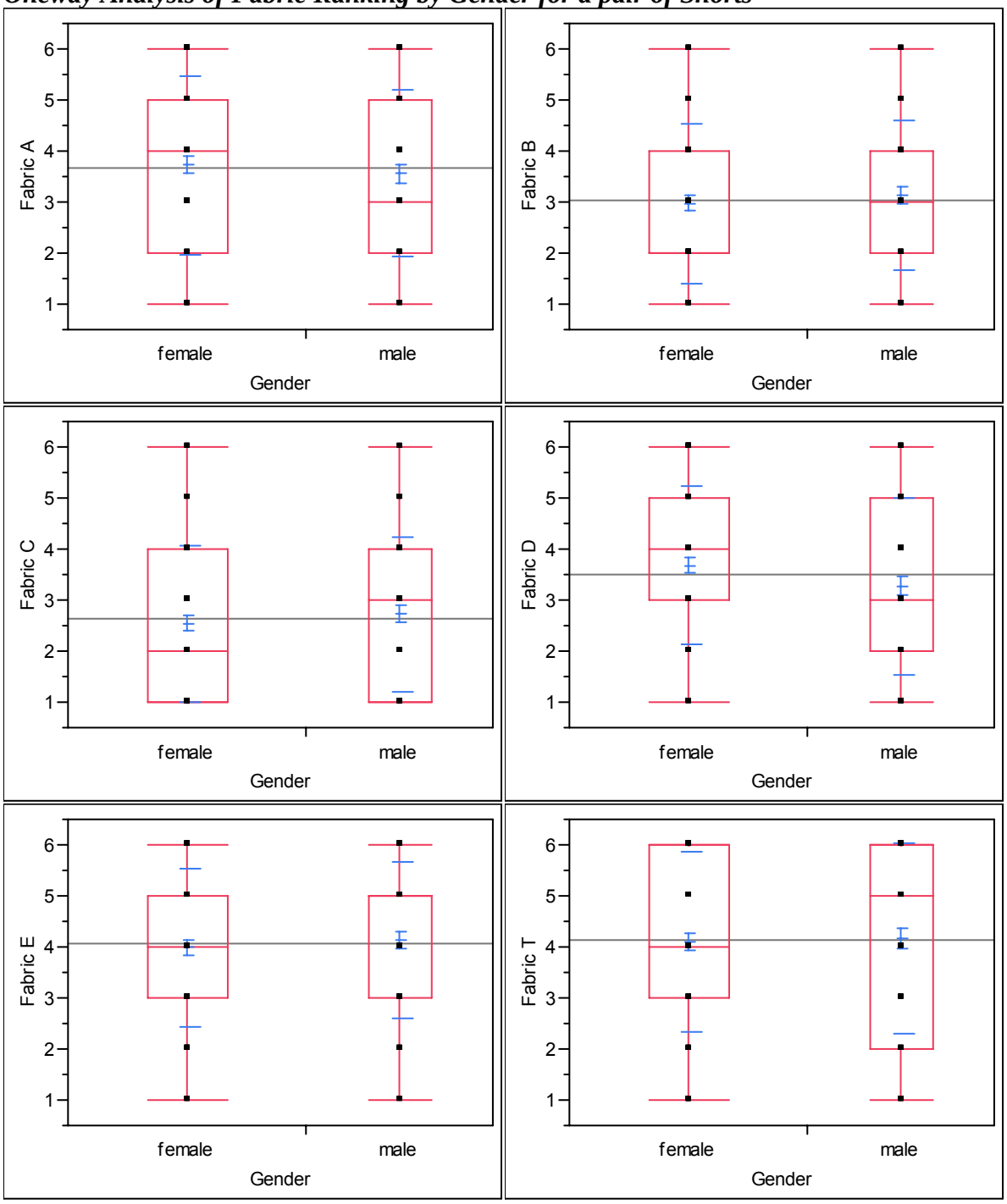
Oneway Analysis of Fabric Ranking by Gender for a Long Sleeve Shirt



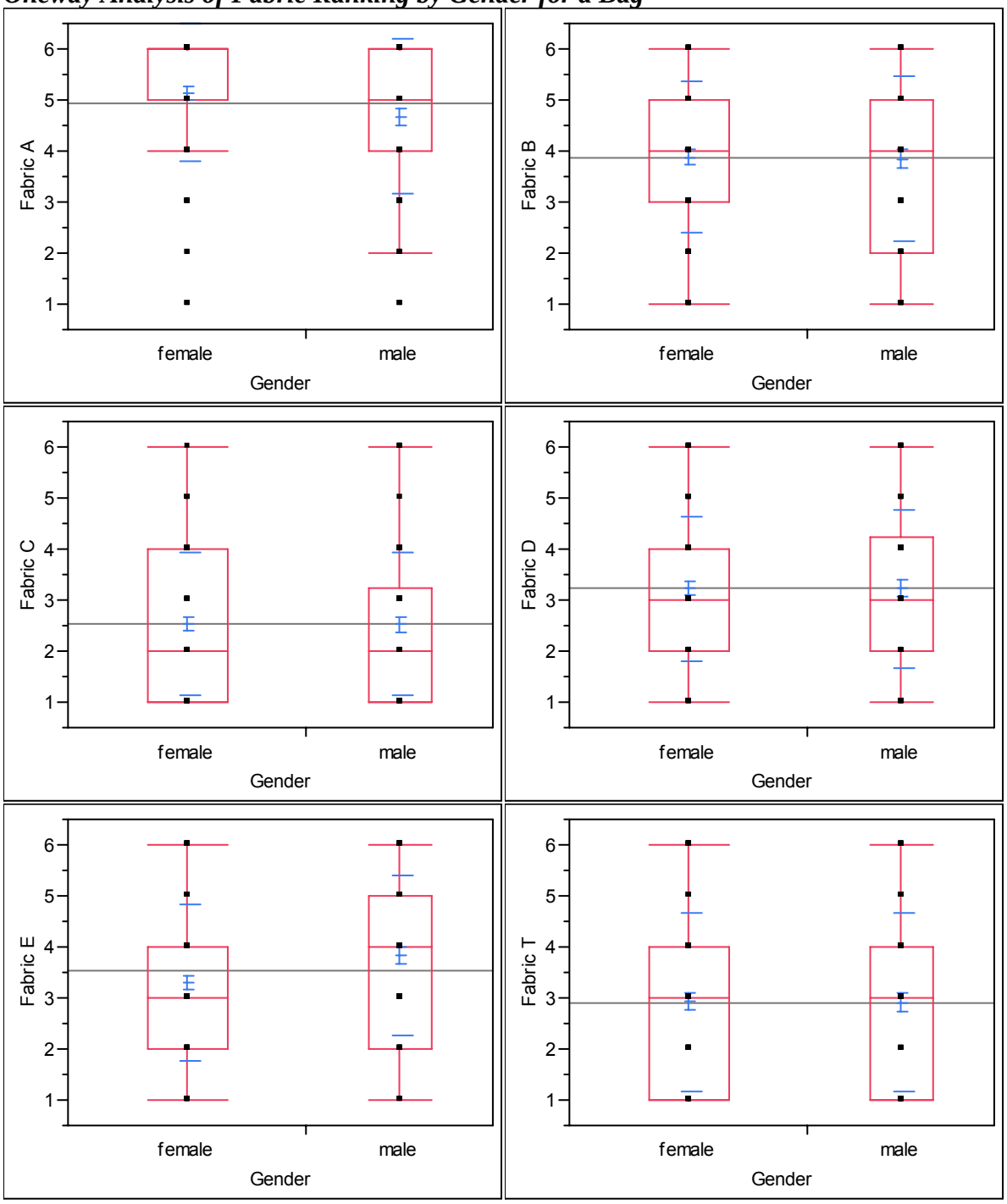
Oneway Analysis of Fabric Ranking by Gender for a Short Sleeve Shirt



Oneway Analysis of Fabric Ranking by Gender for a pair of Shorts

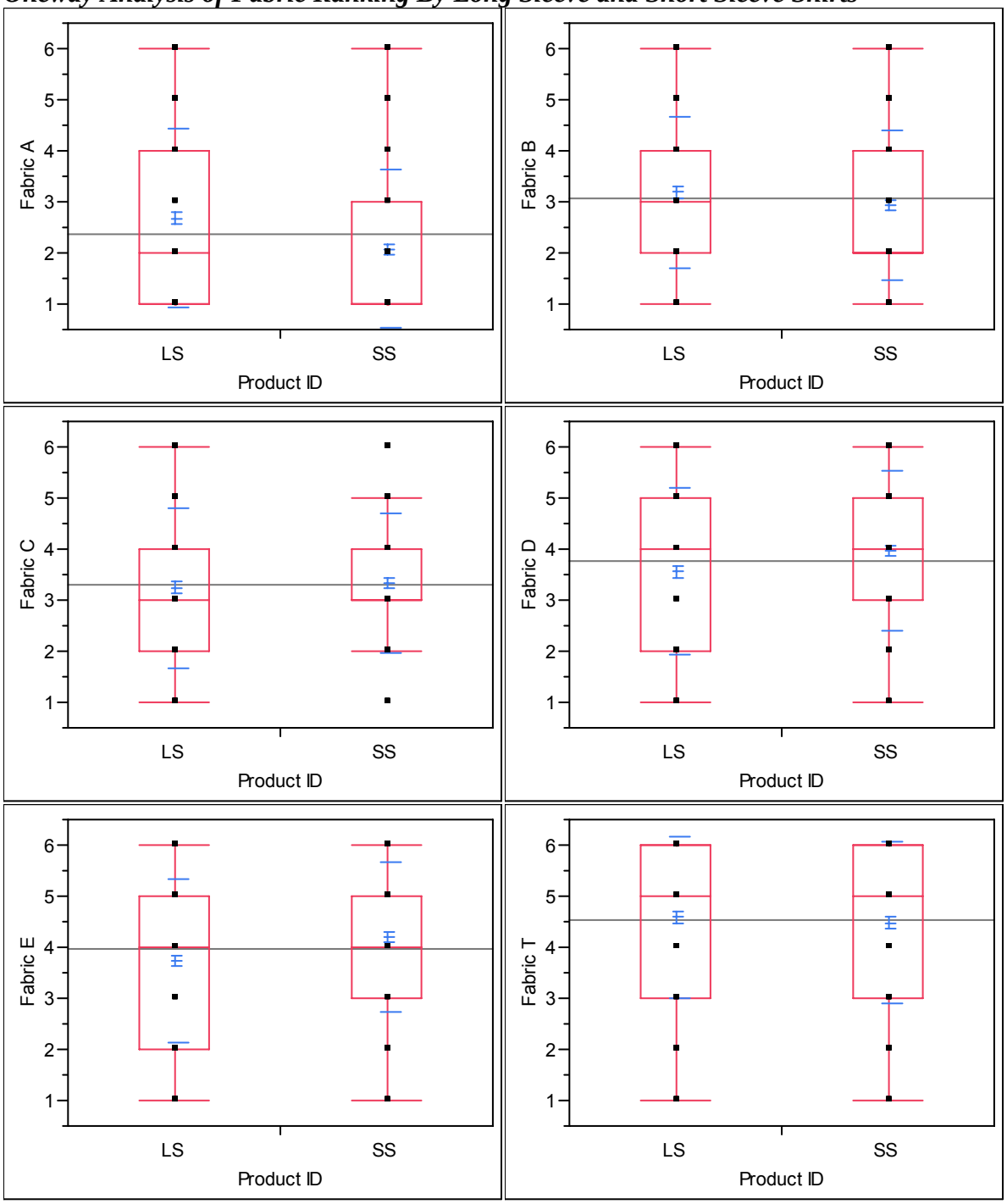


Oneway Analysis of Fabric Ranking by Gender for a Bag

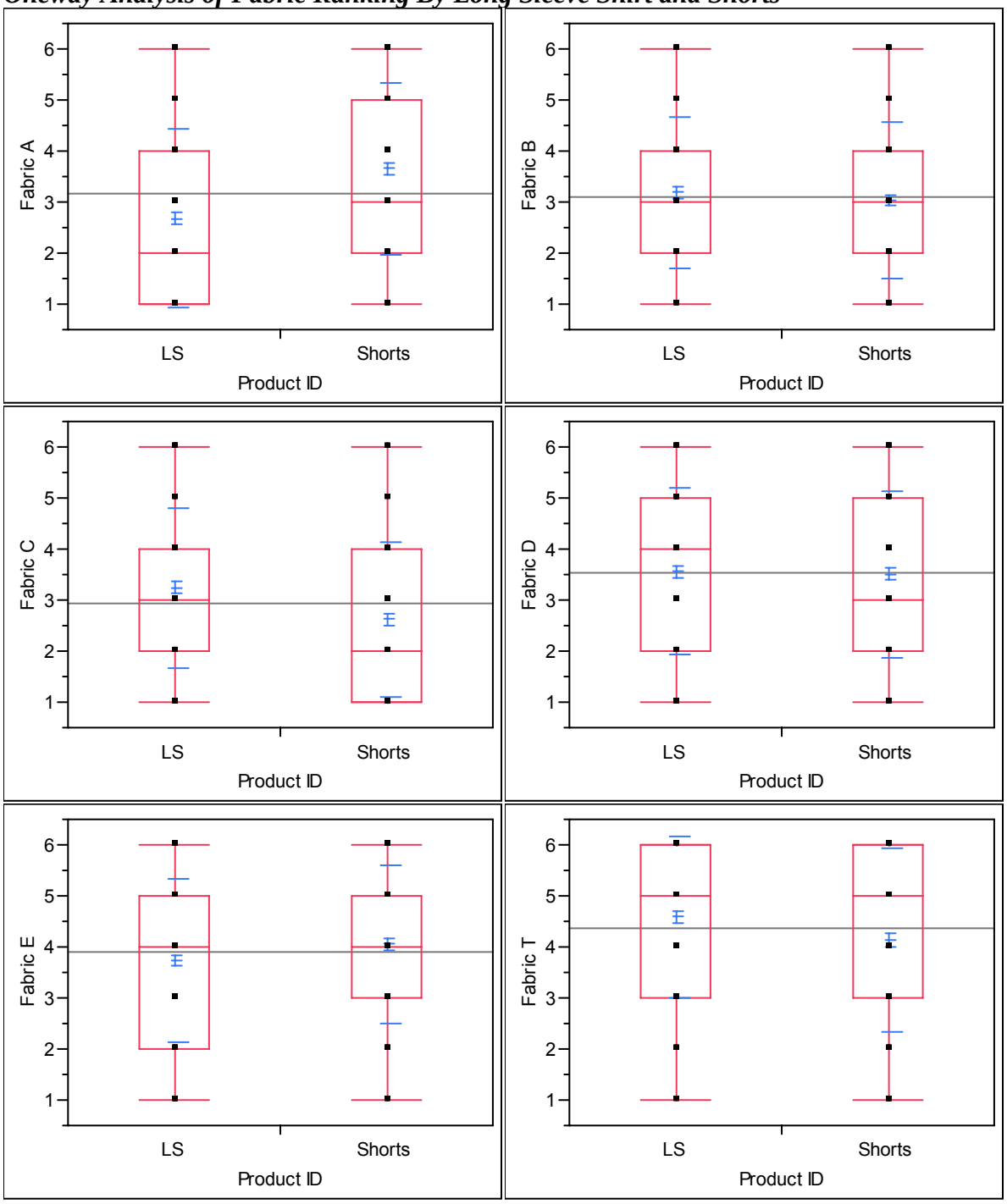


Fabric Rankings between Products

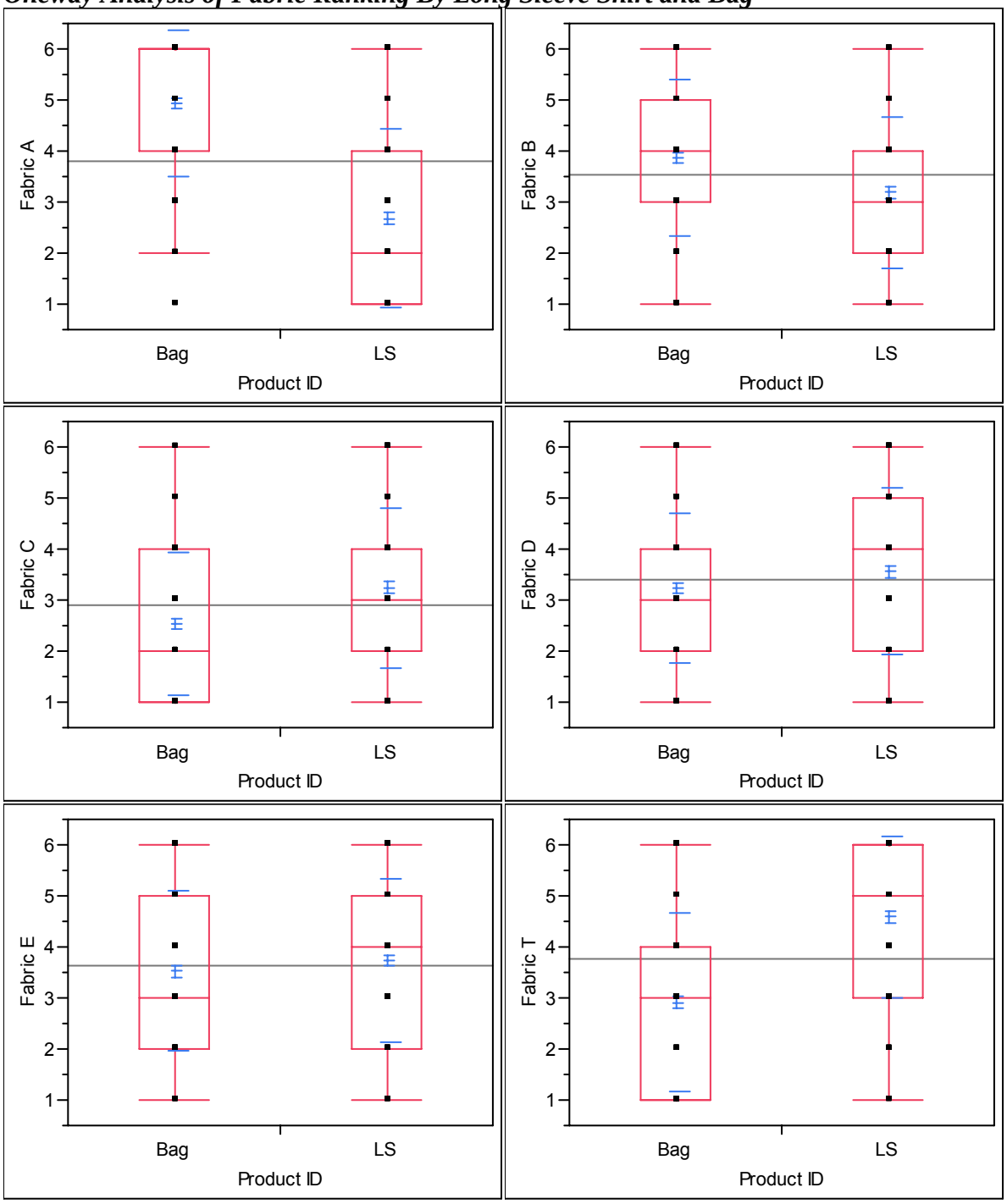
Oneway Analysis of Fabric Ranking By Long Sleeve and Short Sleeve Shirts



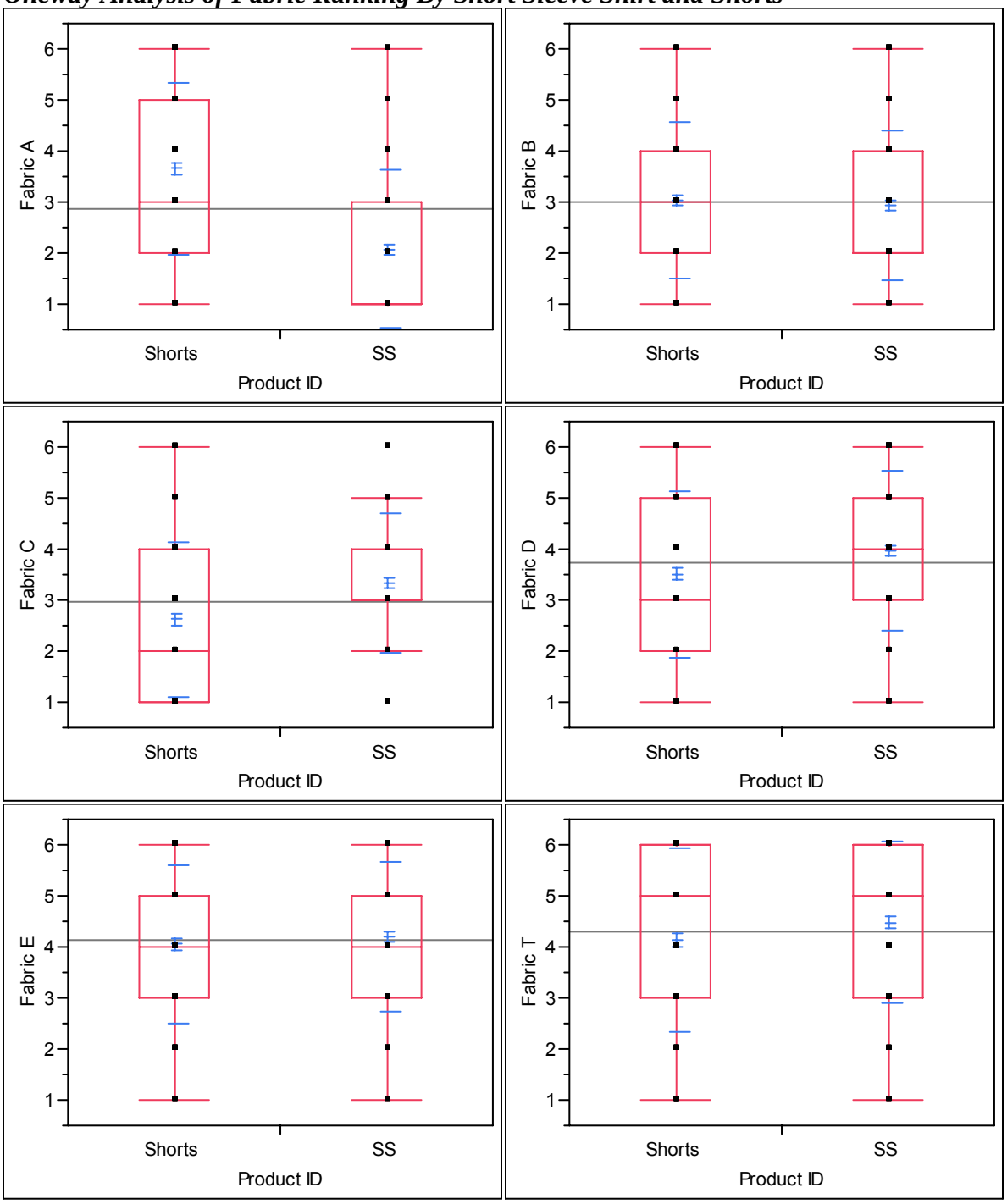
Oneway Analysis of Fabric Ranking By Long Sleeve Shirt and Shorts



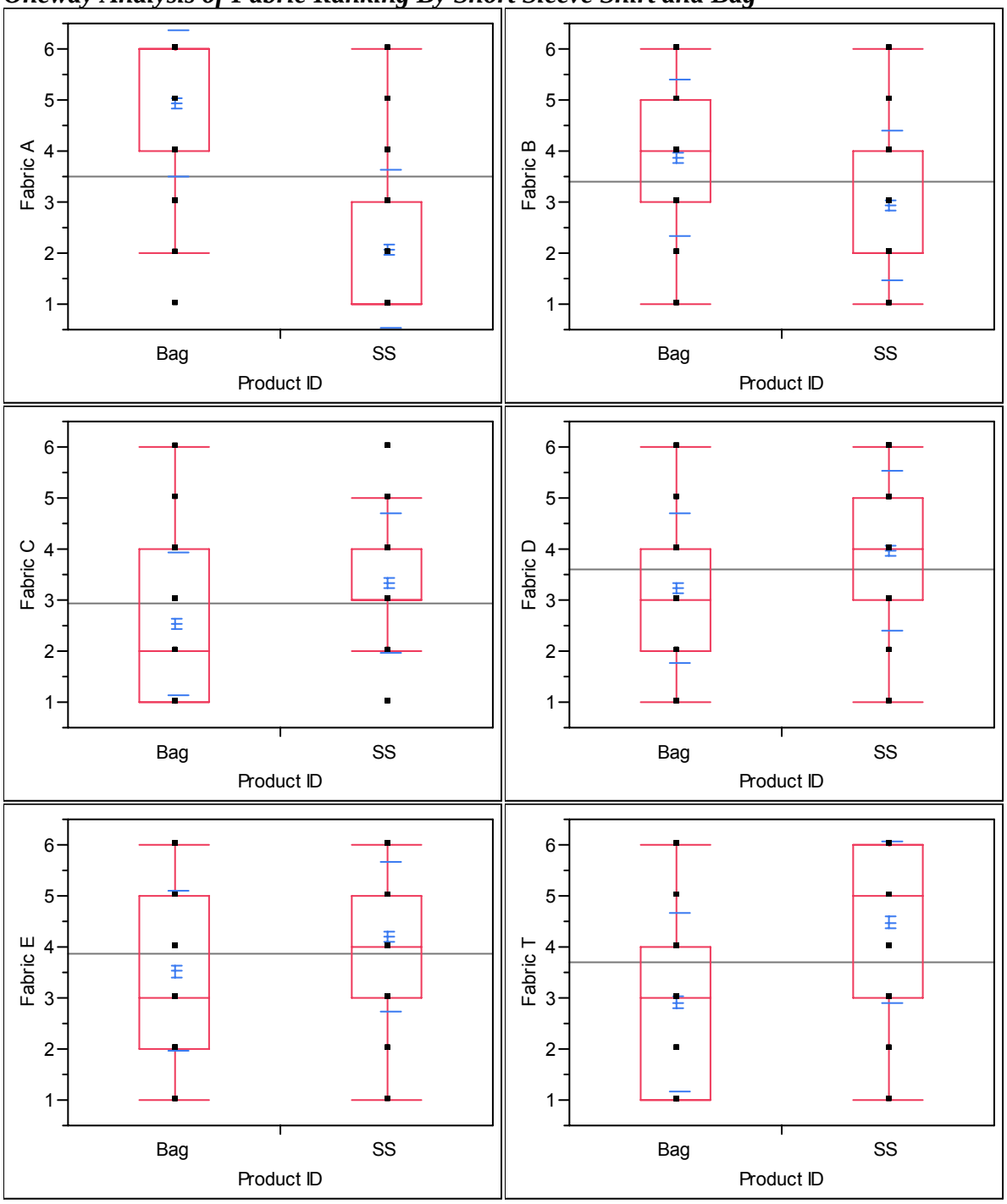
Oneway Analysis of Fabric Ranking By Long Sleeve Shirt and Bag



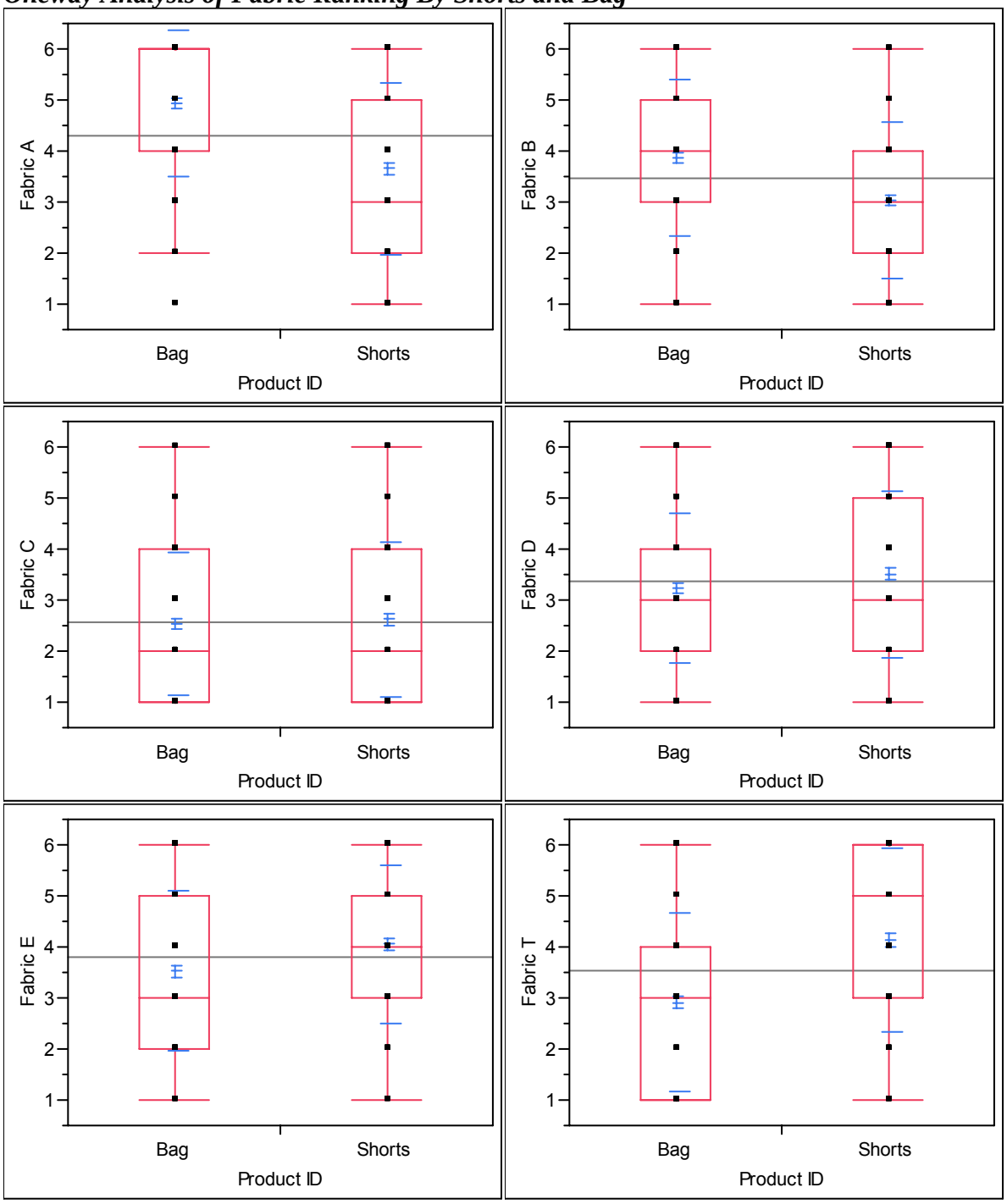
Oneway Analysis of Fabric Ranking By Short Sleeve Shirt and Shorts



Oneway Analysis of Fabric Ranking By Short Sleeve Shirt and Bag



Oneway Analysis of Fabric Ranking By Shorts and Bag



APPENDIX I

IRB Approval

North Carolina State University is a land-grant university and a constituent institution of The University of North Carolina

Office of Research and Graduate Studies

NC STATE UNIVERSITY

Sponsored Programs and
Regulatory Compliance
Campus Box 7514
2701 Sullivan Drive
Raleigh, NC 27695-7514

919.515.7200
919.515.7721 (fax)

From: Debra A. Paxton, Regulatory Compliance Administrator
North Carolina State University
Institutional Review Board

Date: February 15, 2008

Project Title: Consumer Acceptance of Nonwovens in Apparel and Accessories

IRB#: 101-08-2

Dear Ms. Dutton;

The research proposal named above has received administrative review and has been approved as exempt from the policy as outlined in the Code of Federal Regulations (Exemption: 46.101.b.2). Provided that the only participation of the subjects is as described in the proposal narrative, this project is exempt from further review.

NOTE:

1. This committee complies with requirements found in Title 45 part 46 of The Code of Federal Regulations. For NCSU projects, the Assurance Number is: FWA00003429.
2. Review de novo of this proposal is necessary if any alterations/additions are made.

Please provide your faculty sponsor with a copy of this letter. Thank you.

Sincerely,
Debra Paxton
NCSU IRB

Consent Form

North Carolina State University
INFORMED CONSENT FORM for RESEARCH

Title of Study: Consumer Acceptance of Nonwovens in Apparel and Accessories

Principal Investigator: Kathryn C. Dutton Faculty Sponsor (if applicable): Dr. Cynthia L. Istook

What are some general things you should know about research studies?
You are being asked to take part in a research study. Your participation in this study is voluntary. You have the right to be a part of this study, to choose not to participate or to stop participating at any time. The purpose of research studies is to gain a better understanding of a certain topic or issue. You are not guaranteed any personal benefits from being in a study. Research studies also may pose risks to those that participate. In this consent form you will find specific details about the research in which you being asked to participate in. If you do not understand something in this form it is your right to ask the researcher for clarification or more information. A copy of this consent form will be provided to you. If at any time you have questions about your participation, do not hesitate to contact the researcher(s) named above.

What is the purpose of this study?
The purpose of this study is to gain a better understanding of a consumer's personal preference on comfort. Fabrics will be tested to see if they are more desirable for a specific type of clothing than what is already available. This research will help us gain knowledge regarding what a customer thinks is comfortable and the fabric characteristics that make a fabric comfortable.

What will happen if you take part in the study?
First, to take part in this study you must be 18 or older and be available during the testing dates. In order to test the fabrics, you must have use of at least one hand and all fingers on that hand. The test requires that you be able to grip, grab, and squeeze the fabric.
If you agree to participate in this study, you will be asked to:

- Wash your hands before testing the fabric and not apply any lotions until you have finished the testing session.
- The test session will take between 30 - 60 minutes.
- You will be asked to touch several fabric samples. These samples will be in a box so that you cannot see what the fabric looks like.
- You will be asked to answer several questions about how the fabric feels. You will also be asked how comfortable the fabric feels. You will be asked to mark your answers on the computer software program which will record and store your response.
- Once you have felt (tested) all the fabric samples, you will be asked to wear a blindfold so you cannot see the fabrics.
- When you are wearing these goggles, you will be asked to rank all the fabrics in order of most desirable to least desirable.

Risks
There are no perceived risks with this study.

Benefits
There is no direct benefit to you in the immediate future, but knowledge gained from the research will be used to develop more comfortable clothing.

Confidentiality
The information in the study records will be kept strictly confidential. Data will be stored securely in an electronic file that will be destroyed when the research is completed. Your name will not be associated with any results. Instead an applicant identification number will be used. No reference will be made in oral or written reports which could link you to the study.

Compensation
You will not receive anything for participating but your time and help in this research is greatly appreciated.

What if you have questions about this study?
If you have questions at any time about the study or the procedures, you may contact the researcher, Kathryn Dutton, at the College of Textiles, NCSU Box 8301, Raleigh, NC 27695 or (919/515-6584).

What if you have questions about your rights as a research participant?
If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact Dr. David Kaber, Chair of the NCSU IRB for the Use of Human Subjects in Research Committee, Box 7514, NCSU Campus (919/515-3086) or Mr. Matthew Ronning, Assistant Vice Chancellor, Research Administration, Box 7514, NCSU Campus (919/513-2148)

Consent To Participate
"I have read and understand the above information. I have received a copy of this form. I agree to participate in this study with the understanding that I may withdraw at any time."

Subject's signature_____ **Date** _____

Investigator's signature_____ **Date** _____