

## ABSTRACT

**MOSER, CARRIE ALISON.** Consumer Response to Design Elements within Digitally Printed Apparel Products. (Under the direction of Dr. Cynthia L. Istook)

As an emerging technology in the textile industry, digital printing allows the capability to print photo-realistic images on fabric that were never before possible with traditional textile printing methods. The possible consumer response to apparel products with digitally printed imagery is a largely unexplored topic that may be vital to the success of digital printing in the textile industry.

The intent of this research was to determine what demographic characteristics, if any, may affect a general consumer's preferences concerning apparel products with digitally printed patterns. Eight photographic patterns were created and validated by design professionals concerning their representation of four basic design elements (*line, shape, value, texture*). An internet survey tool was developed to collect demographic data and determine general consumers' preferences for specific patterns when applied to six different gender specific apparel products. The subjects' choices were evaluated based on their pattern choices, the garments on which they were chosen, and subject demographics.

The results of this research indicated that certain consumers prefer specific design elements within a printed pattern when purchasing apparel products, as well as specific garment styles in combination with these design elements. Some variables such as subject age and garment style had a great impact on which patterns were chosen, including the design elements represented in each pattern. The results of this research indicate the importance of the product design and development process of digitally printed apparel products.

**CONSUMER RESPONSE TO DESIGN ELEMENTS WITHIN  
DIGITALLY PRINTED APPAREL PRODUCTS**

by

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## DEDICATION

This work is presented in honor of my mother and father, **Mr. James Henry and Mrs. Dorothy Fox Moser**. Their support, encouragement and love have been above and beyond anything I could imagine for all my life.

This work is also presented in memory of my grandmother, **Mrs. Lena Lutz Moser**, who was the first person to put a needle and thread in my hands.

## BIOGRAPHY

Carrie Alison Moser was born June 24, 1979 in Charlotte, North Carolina to James H. and Dorothy F. Moser. Growing up in Concord, North Carolina, Carrie graduated from Central Cabarrus High School in June 1997.

After being accepted to North Carolina State University for the fall of 1997, Carrie entered the College of Textiles in her freshman year. She completed her Bachelor of Science degree in Textile Technology and Design with a minor in Art and Design in May 2002. Upon completion of her B.S., Carrie was accepted into the M.S. program in the College of Textiles at NC State. She is currently pursuing a Master of Science degree in Textile and Apparel Technology and Management with a Design Concentration, to be completed in August 2004.

Carrie has participated in many different activities during her educational career. She was Executive Chair of the planning committee for the 2003 International Textile and Apparel Association (ITAA) Fashion Exhibition in Savannah, Georgia, under the direction of Dr. Cindy Istook. Carrie also exhibited her own original textile and apparel designs in the show.

Since being inducted into the Brotherhood of Phi Psi National Textile Fraternity in the spring of 1998, Carrie has served as both the Recording Secretary and Media Representative for the organization.

Carrie was also a performer in Drum Corps International for five consecutive years with both Magic of Orlando (1997-1999) and Carolina Crown (2000-2001).

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# TABLE OF CONTENTS

<b>LIST OF FIGURES</b> .....	<b>XI</b>
<b>LIST OF TABLES</b> .....	<b>XIV</b>
<b>CHAPTER ONE: INTRODUCTION</b> .....	<b>1</b>
PURPOSE OF STUDY .....	2
RESEARCH STATEMENTS .....	3
RATIONALE .....	3
LIMITATIONS .....	4
<b>CHAPTER TWO: LITERATURE REVIEW</b> .....	<b>6</b>
ELEMENTS OF DESIGN .....	6
<i>Basic Design Elements</i> .....	6
Line .....	7
Line in apparel aesthetics .....	8
Shape .....	8
Shape in apparel aesthetics .....	9
Value .....	10
Texture .....	11
Texture in apparel aesthetics .....	12
Color .....	12
Color in apparel aesthetics .....	13
<i>Use and Evaluation of Design Elements</i> .....	14
PHOTOGRAPHY .....	15
<i>Photography as an Art Form</i> .....	15
Basics of Black and White Photography .....	16

Why Black and White? .....	17
Image and Subject Choice.....	18
Black in Apparel .....	18
REPETITION AND PATTERN .....	20
<i>Repetition</i> .....	21
<i>Pattern</i> .....	21
<i>Patterns Designed for Printed Textiles</i> .....	21
MODULES .....	22
<i>Creating Modules</i> .....	23
<i>Creating Patterns with Modules</i> .....	23
<i>Modules Derived from Photographs</i> .....	26
<i>Photographic Patterns</i> .....	28
EARLY PHOTOGRAPHY IN TEXTILES AND APPAREL.....	29
<i>Transfer with Printing Plates</i> .....	29
<i>Wet Rubbing</i> .....	30
<i>Release Method and Skimming</i> .....	32
<i>Thermal Transfer Paper</i> .....	33
<i>Contact Paper</i> .....	33
<i>Transfer Medium</i> .....	34
<i>Transparent Base</i> .....	35
<i>Acrylic Medium</i> .....	36
<i>Solvent Transfer</i> .....	36
<i>Copy Machines, Typewriters and Paper Printers</i> .....	37
<i>Silk-Screen Printing</i> .....	38
<i>Photo-emulsion Screen Printing</i> .....	39
<i>Thermal Imagers</i> .....	41

<i>Light-Sensitive Printing</i> .....	41
<i>Stamp Printing</i> .....	43
PATTERNS DESIGNED FOR USE IN APPAREL .....	43
DIGITAL PRINTING TECHNOLOGY.....	46
<i>The Future of Textile Digital Printing</i> .....	47
<b>CHAPTER THREE: METHODOLOGY .....</b>	<b>49</b>
PHOTOGRAPHIC PATTERN GENERATION.....	49
Final Pattern Choices .....	50
DESIGN ELEMENTS WITHIN PHOTOGRAPHIC PATTERNS.....	59
Chosen Design Elements.....	59
Validation of Design Elements by Design Professionals .....	60
GARMENT FLATS.....	61
Male Flats .....	62
Female Flats.....	69
ONLINE SURVEY STRUCTURE.....	76
Assessment of Current Trends in Internet Website Functions.....	76
Survey Design.....	80
Visual Simplicity.....	80
Ease of Use.....	81
Anonymity for Subjects and Administrator.....	81
Demographics.....	81
General Categories.....	82
States and Regions.....	84
Occupation and Education.....	86
Annual Household Income.....	87
Clothing and Accessories Expenditure.....	87
Texture Mapping on Garment Flats .....	88

Placement and Scale of Patterns .....	88
Subject Comments .....	88
SURVEY ADMINISTRATION .....	89
Establishing a Domain .....	89
Publicizing the Survey .....	90
Duration of the Survey .....	91
DATA ANALYSIS.....	92
SAS Testing Methods .....	92
<b>CHAPTER FOUR: RESULTS AND FINDINGS.....</b>	<b>93</b>
SUBJECT SAMPLE SUMMARY.....	93
MALE SUBJECT SUMMARY .....	95
Research Statement Findings: Male Subjects.....	95
Research Statement 1.....	95
Research Statement 2.....	98
Research Statement 3.....	99
FEMALE SUBJECT SUMMARY.....	106
Research Statement Findings: Female Subjects.....	106
Research Statement 1.....	106
Research Statement 2.....	107
Research Statement 3.....	108
<b>CHAPTER FIVE: DISCUSSION .....</b>	<b>113</b>
SURVEY SUBJECT COMMENTS.....	113
TOPICS FREQUENTLY ADDRESSED BY SUBJECTS.....	117
Scale of Patterns.....	117
Pattern Placement on Garments .....	117
Survey Choice Options .....	117
Demographics .....	118

Data Collection .....	118
BASIC DESIGN ELEMENT EVALUATION BY DESIGN PROFESSIONALS .....	119
SUMMARY OF DATA .....	119
<b>CHAPTER SIX: RECOMMENDATIONS .....</b>	<b>121</b>
<b>REFERENCES .....</b>	<b>124</b>
<b>APPENDICES .....</b>	<b>127</b>
<b>APPENDIX A: DESIGN ELEMENT EVALUATION SHEET.....</b>	<b>128</b>
<b>APPENDIX B: DESIGN ELEMENT EVALUATION RESULTS.....</b>	<b>130</b>
<b>APPENDIX C: LIST OF FIELD SELECTIONS FOR INTERNET SURVEY TOOL .....</b>	<b>132</b>
<b>APPENDIX D: SAMPLE PAGES FROM INTERNET SURVEY TOOL.....</b>	<b>135</b>
<b>APPENDIX E: SAS STATISTICAL MODEL EXAMPLES.....</b>	<b>141</b>

## LIST OF FIGURES

FIGURE 1: GREYSCALE .....	11
FIGURE 2: ASSORTED FABRIC TEXTURE DETAILS.....	12
FIGURE 3: BLOCK OR TILE.....	22
FIGURE 4: BRICK.....	22
FIGURE 5: HALF DROP.....	22
FIGURE 6: DIAMOND.....	22
FIGURE 7: PACKED TRIANGLES.....	24
FIGURE 8: PACKED SQUARES.....	24
FIGURE 9: PACKED HEXAGONS.....	24
FIGURE 10: SEMI-REGULAR 1.....	25
FIGURE 11: SEMI-REGULAR 2.....	25
FIGURE 12: SEMI-REGULAR 3.....	25
FIGURE 13: SEMI-REGULAR 4.....	25
FIGURE 14: SEMI-REGULAR 5.....	25
FIGURE 15: SEMI-REGULAR 6.....	25
FIGURE 16: SEMI-REGULAR 7.....	25
FIGURE 17: ORIGINAL PHOTOGRAPH .....	27
FIGURE 18: TRIANGLE & HEXAGON MODULES TAKEN FROM PHOTOGRAPH AND FITTED TOGETHER TO CREATE LARGER TRIANGLE MODULE.....	27
FIGURE 19: FOUR OF THE LARGER TRIANGLE MODULES FLIPPED, ROTATED AND PACKED TO FORM A REPEAT UNIT.....	27
FIGURE 20: PATTERN CREATED FROM REPEAT UNIT .....	28
FIGURE 21: JACKET, CA. 1616, GREAT BRITAIN.....	45

FIGURE 22: CAPE, LATE 1600'S, FRENCH.....	45
FIGURE 23: AFTERNOON DRESS, CA. 1855, FRENCH .....	45
FIGURE 24: "MAY" BALL GOWN, SPRING/SUMMER 1953, CHRISTIAN DIOR, FRENCH .....	45
FIGURE 25: DIGITALLY PRINTED APPAREL PRODUCTS .....	47
FIGURE 26: PATTERN 1.....	51
FIGURE 27: PATTERN 2.....	52
FIGURE 28: PATTERN 3.....	53
FIGURE 29: PATTERN 4.....	54
FIGURE 30: PATTERN 5.....	55
FIGURE 31: PATTERN 6.....	56
FIGURE 32: PATTERN 7.....	57
FIGURE 33: PATTERN 8.....	58
FIGURE 34: MALE FLAT 1 .....	63
FIGURE 35: MALE FLAT 2 .....	64
FIGURE 36: MALE FLAT 3 .....	65
FIGURE 37: MALE FLAT 4 .....	66
FIGURE 38: MALE FLAT 5 .....	67
FIGURE 39: MALE FLAT 6 .....	68
FIGURE 40: FEMALE FLAT 1.....	70
FIGURE 41: FEMALE FLAT 2.....	71
FIGURE 42: FEMALE FLAT 3.....	72
FIGURE 43: FEMALE FLAT 4.....	73
FIGURE 44: FEMALE FLAT 5.....	74
FIGURE 45: FEMALE FLAT 6.....	75
FIGURE 46: J.JILL™ COLOR SELECTION 1, <i>PETAL PINK</i> .....	78
FIGURE 47: J.JILL™ COLOR SELECTION 2, <i>GERANIUM</i> .....	79

<b>FIGURE 48: CENSUS REGIONS AND DIVISIONS OF THE UNITED STATES.....</b>	<b>85</b>
<b>FIGURE 49: JTATM PRESS RELEASE .....</b>	<b>91</b>
<b>FIGURE 50: MALE GARMENT 1, PATTERN 8 .....</b>	<b>103</b>
<b>FIGURE 51: MALE GARMENT 2, PATTERN 7 .....</b>	<b>103</b>
<b>FIGURE 52: MALE GARMENT 3, PATTERN 3 .....</b>	<b>104</b>
<b>FIGURE 53: MALE GARMENT 4, PATTERN 5 .....</b>	<b>104</b>
<b>FIGURE 54: MALE GARMENT 5, PATTERN 3 .....</b>	<b>105</b>
<b>FIGURE 55: MALE GARMENT 6, PATTERN 5 .....</b>	<b>105</b>
<b>FIGURE 56: FEMALE GARMENT 1, PATTERN 5.....</b>	<b>110</b>
<b>FIGURE 57: FEMALE GARMENT 2, PATTERN 6.....</b>	<b>110</b>
<b>FIGURE 58: FEMALE GARMENT 3, PATTERN 3.....</b>	<b>111</b>
<b>FIGURE 59: FEMALE GARMENT 4, PATTERN 8.....</b>	<b>111</b>
<b>FIGURE 60: FEMALE GARMENT 5, PATTERN 3.....</b>	<b>112</b>
<b>FIGURE 61: FEMALE GARMENT 6, PATTERN 6.....</b>	<b>112</b>
<b>FIGURE 62: SAMPLE SELECTION OF SUBJECT COMMENTS .....</b>	<b>116</b>
<b>FIGURE 63: DESIGN ELEMENT EVALUATION SHEET .....</b>	<b>129</b>
<b>FIGURE 64: INTERNET SURVEY TOOL, HOME PAGE.....</b>	<b>136</b>
<b>FIGURE 65: INTERNET SURVEY TOOL, DEMOGRAPHICS PAGE.....</b>	<b>137</b>
<b>FIGURE 66: INTERNET SURVEY TOOL, MALE GARMENT WITH NO PATTERN APPLIED.....</b>	<b>138</b>
<b>FIGURE 67: INTERNET SURVEY TOOL, MALE GARMENT WITH PATTERN APPLIED .....</b>	<b>139</b>
<b>FIGURE 68: INTERNET SURVEY TOOL, COMMENTS PAGE .....</b>	<b>140</b>
<b>FIGURE 69: STATISTICAL MODEL EXAMPLE, FEMALE GARMENT 1.....</b>	<b>143</b>

## LIST OF TABLES

TABLE 1: AGE DISTRIBUTION OF SUBJECTS BY GENDER .....	94
TABLE 2: GEOGRAPHIC DISTRIBUTION OF SUBJECTS BY GENDER .....	94
TABLE 3: DESIGN PROFESSIONALS' EVALUATION CHOICE TOTALS.....	131
TABLE 4: PRIMARY AND SECONDARY CHOICES, PERCENT OF ALL DESIGN PROFESSIONALS' CHOICES FOR EACH INDIVIDUAL IMAGE .....	131
TABLE 5: CORRESPONDING COEFFICIENTS FOR EQUATION (1) .....	143

## CHAPTER ONE: INTRODUCTION

As an emerging technology in the textile industry, digital printing has allowed the application of never before seen images on fabrics. The color range and quality of digital printers can produce photo realistic images that are not possible with traditional methods of textile printing such as screen printing.

However, there are many negative production aspects of digital printing that are still being tested and developed, including slow production times and color quality. These drawbacks have limited the prosperity of commercial production of digitally printed textile and apparel products (Boston, 2003).

A related area of digital printing that has yet to be explored in depth is the possible consumer response to images that are, in fact, photo quality. Until now, most fabrics were printed with imagery that was obviously not photo realistic. Geometric prints, patterns designed in traditional media, and illustrated images are most common in printed textile products. All of this will change with the establishment of digital printing in the textile industry.

Also important to the future of textile digital printing is the consumer's preference as related to basic design elements within a digitally printed textile pattern. Are there specific design elements that may be more appealing or attractive? Are there elements that tend to create discomfort in the viewer's mind?

Will consumers view photo realistic patterns differently than traditionally printed patterns?

These research questions evolved from a semester study in creating repeat patterns for textiles by utilizing photographic modules. The patterns designed during this study were ultimately employed in a final garment. The variation in viewer's responses to the garment led to an interest in why consumers prefer specific types of repeat patterns in textiles and apparel.

This research focuses on the future of digital printing in apparel design and production by assessing consumer response to patterns created from photographic modules used in specific garments. Surveying a sample of U.S. consumers (with no limits on their demographic characteristics) to determine their preferences for basic design elements within a textile pattern led to an initial consideration of what would be most accepted or desired by a population.

### **Purpose of Study**

The intent of this research was to investigate general U.S. consumer response to patterns created for digitally printed apparel products. Additional interests included consumer preferences for specific patterns, the basic design elements represented within those patterns and the garment styles on which those patterns were used.

## **Research Statements**

The following principal research statements were used as the focal points of analyzing the data gained from this research.

1. *What demographic or other related factors are influential in a typical U.S. male/female consumer's choices concerning digitally printed repeat patterns for textile apparel products?*
2. *What are a typical U.S. male/female consumer's preferences concerning basic design elements within digitally printed repeat patterns for textile apparel products?*
3. *What demographic factors are influential in a typical U.S. male/female consumer's choices concerning the combination of a specific garment style and a digitally printed textile repeat pattern?*

## **Rationale**

Though it is still far from being a mainstream technology seen in apparel design and production, the advancement of digital printing in the textile industry is inevitable. Improvements are constantly being made to push the technology further towards becoming a common method of commercial production. However, there is little published information available concerning the expected response of the most important role in the long-term success of digital printing: the consumer.

Images produced through digital printing will have an advantage over traditionally printed textile images, as consumers will be able to choose products

with a look that appears realistic and true to life. Photographs on fabric can materialize into actual people, places and objects. Images will seem real enough to touch. The quality of these images and fascination of the consumer will verify the certain success of digital printing in textiles.

### **Limitations**

The photographs, patterns and images used in this research were the original works of one designer. Therefore, they do not represent the entire availability of patterns and images for digital printing.

Only U.S. consumers were surveyed in this research. This restriction was an attempt at acquiring more precise data in the research. The survey was only created in the English language so it would not accommodate any international consumers who did not speak or read English. Additionally, the sample would not have been as narrowed or specific if other countries were included.

Subject matter was also a limitation. Although most of the imagery is hidden or disguised in the repeat patterns, the individuals surveyed may have been affected by a shape or image they recognized within a pattern (Hunt, 2002).

Another limitation was the sole use of black and white photography. To direct the focus more towards the actual imagery and design elements and away from the boundless variable of color quality, the designs in this study included strictly black and white photographic images, or greyscale images. For this reason, some evaluations may have been biased for or against black and white media.

In this study, the subjects surveyed made choices based only on images of digitally printed apparel products and were not shown actual physical garments. Their responses or choices may have been different if they had seen a tangible object rather than an image on a computer monitor.

Finally, the designer's choice of apparel products for pattern application may have had an influence on the opinions of those surveyed. The flat sketches of the garments were chosen based on their intended classic simplicity to appeal to a wider audience, as they were typical garment shapes which appear in technical flat sketching software for apparel applications such as Micrografx Designer.

## CHAPTER TWO: LITERATURE REVIEW

The following chapter is a review of all previously written and/or published literature that is relative to the research conducted in this study. The areas of investigation include the elements of design, photography, repetition and pattern, modules, early photography in textiles and apparel, and textile digital printing.

### Elements of Design

Design means many things to many people. In her book, *Design: Elements and Principles*, Dorthea C. Malcolm defines the act of *designing* as “relating elements, whether they are similar or contrasting, and visually arranging an interesting unity with them”, or, in short, “arranging things to create a single effect” (Malcolm, 1972, p. 7). Wucius Wong states, “Design is a process of purposeful visual creation”, in his book, *Principles of Form and Design* (Wong, 1993, p. 41). Wong also believes that design is a visual language, and that in order for someone to use design to solve a problem, it is important to grasp this visual language. The first step in understanding the language is to understand the aforementioned elements of design.

### Basic Design Elements

Although it is widely agreed that design theory consists of various simple elements, experts often have a slightly different list of what these elements should be (Malcolm, 1972; Wong, 1993; Oei & De Kegel, 2002). In reviewing several

different resources, the elements of focus in performing this research were *line*, *shape*, *value* and *texture*. *Color* was also evaluated in the initial research, but was not chosen as one of the final elements used in the Methodology.

## **Line**

A *line* can be represented in many different ways. It can be no more than a simple mark created with any instrument or tool. A line indicates direction, as it leads to another point or location. Many lines may be used together to create multiple directions or directional changes (Malcolm, 1972).

Lines have many qualities which affect the way they are perceived. The length of a line can influence the viewer's assessment. Short, quick lines divide the flow of vision, while long, flowing lines allow the eye to travel along the line smoothly. The width of a line, or its thickness, and the weight of a line can have an effect on the viewer's perception. Line uniformity is also influential in a line's appearance. Lines which are arranged in a very uniform fashion can communicate a sense of control or organization to the viewer (Fiore & Kimle, 1997). The direction of a line is also important. Lines may travel in many directions, including up, down, around, back, forward, or diagonally. There may be direction changes within one line. Lines may curve or contain sharp points where the direction changes suddenly (Malcolm, 1972).

Lines can be used to emulate motion or movement of another object. They can also be used to enclose other objects or images (Malcolm, 1972).

**Line in apparel aesthetics.** The human body is an example of line in a natural form. Lines are apparent in the face, body, and hair. Lines on a body are constantly changing as the body is in motion. During movement, the shape and length of garments on a human body are also changing and moving. The physical effects on a garment while sitting are much different than the effects on the same garment while running (Fiore & Kimle, 1997).

Outer lines in apparel create a frame around the body, separating it from the environment. Inner lines in apparel divide the garment and the body into smaller parts. Apparel designers may carefully consider all the lines that will be apparent in a garment when worn on the body in order to achieve the most flattering fit on a human form.

Line can be used to complement the objective of a garment. For example, smooth, flowing lines on a long evening gown can enhance the femininity of the garment (Fiore & Kimle, 1997).

## **Shape**

When lines are used to completely enclose an area, that area becomes a *shape*. A shape is considered positive and occupies positive space. The area around a shape is considered the background and occupies negative space. Shapes may be created with unclear lines or boundaries, making it difficult to determine where the shape ends and the background begins. Alternatively, a shape may be well-defined with clear, concise edges or boundaries.

Shapes can be regular, as in a square or circle, or they can be very irregular. Multiple flat shapes, or planes, may be represented separately or they may overlap to create other shapes. Shapes can utilize many different elements of design working together (Malcolm, 1972).

Shapes can typically be described as either geometric or organic. Geometric shapes are characterized by angular lines or simple forms. Organic shapes are more likely to have curved lines with more of a free form (Fiore & Kimle, 1997).

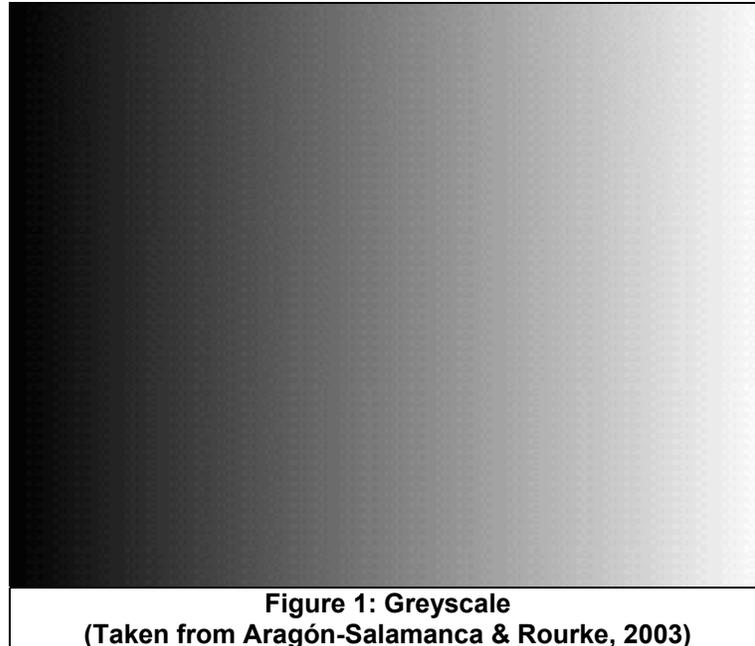
**Shape in apparel aesthetics.** Shape in apparel aesthetics is commonly referred to as a *silhouette*, which defines either the outer shape of a garment on a human form or the shape of the human form itself. The variation in silhouettes of the human body has recently been reviewed by many researchers in the area of apparel sizing standards and fit. The defined female silhouettes in recent dissertation research at North Carolina State University by Dr. Karla Simmons include *hourglass, oval, triangle, inverted triangle, rectangle, spoon, diamond, bottom hourglass, and top hourglass* (2002).

The expressive qualities of shape in apparel are affected by the qualities of the lines or surfaces that encompass the shape. The behavior of the boundary between the garment and the surrounding environment can also affect the way the body's silhouette appears (Fiore & Kimle, 1997).

## **Value**

*Value* refers to the range of lightness and darkness between true black and true white. *Value* may also represent the lightness or darkness of any color. The measure of *value* can be determined by evaluating the *contrast*, or “the difference in darkness or density between one tone and another” (London, Upton, Kobre & Brill, 2002, p. 411) between different colors. For example, the level of contrast between true black and true white is extremely high. However, the level of contrast between true white and a very light grey is not as high (Malcolm, 1972).

The greyscale (Figure 1) is a tool often used to assess images in black, white and grey tones, or to determine if a color is high-value or low-value. Photographs in black and white, for example, are typically evaluated by the successful range of grey apparent in the photograph. Photos with a low contrast between darks and lights can look flat, while photos with an extreme contrast in darks and lights can look very sharp or harsh (London, Upton, Kobre & Brill, 2002).



Value is directly affected by the value or values of darkness or lightness surrounding it. Dark values typically appear to come forward out of an image while light values appear to draw back into an image (Malcolm, 1972).

### **Texture**

The physical quality of a surface is called *texture*. Textures can be described as smooth, rough, shiny or dull, just to name a few. Texture can be evaluated through both touch and sight. Sometimes texture is more easily felt than seen. Other times, texture may only be evaluated through sight, such as in a photograph.

Rough textures, such as sandpaper or jagged rocks, can create a very different sensual reaction than softer textures, such as a fleece blanket or a baby's skin. Different textures can be combined to create new textures, or to emphasize the distinct difference between various textures (Malcolm, 1972).

**Texture in apparel aesthetics.** Texture has a significant effect on the aesthetic satisfaction of a textile or apparel product (Eckman, Damhorst & Kadolph, 1990). Tactile texture in apparel and garments is primarily influenced by the garment's fabric construction (Figure 2). Fabric finishes, fiber content and yarns used can give the fabric a specific hand. Details in the garment construction, such as a seam type or pleating effects, can create new surfaces and textures. Trims or notions, such as buttons or piping, can also alter the surface and texture of a garment.



**Figure 2: Assorted Fabric Texture Details  
(Moser, 2004)**

Texture can also be implied or visual, meaning it is not validated through touch, but rather it is seen. This can be made possible by certain design effects within a pattern that cause the fabric to appear to have an uneven surface (Fiore & Kimle, 1997).

### **Color**

*Color* can be described as “a sensation which causes stimulation of the eye” (Malcolm, 1972, p. 49). It can also be described, more technically, as the manner in

which “light is reflected to and perceived by the eye from the surface of a shape or form” (Wong, 1993, p. 345). Color is perhaps the most dynamic of all design elements, having the most powerful expressive potential and the greatest impact on one’s perception (Fiore & Kimle, 1997).

A person’s reaction to color is essentially psychological. The reaction varies depending on the color in question and the viewer. Many peoples’ association with color stems from their experiences with color as a child. Emblematic representations in color can determine the way a color might be interpreted. For example, concerning the birth of a child, light blue usually symbolizes a baby boy while pink symbolizes a baby girl. Holidays are represented by certain standard colors, such as red for Christmas and green for Saint Patrick’s Day. Foods are traditionally certain colors, such as brown chocolate or purple grapes. Color conditioning, or the way a color has been presented throughout history, can also be a factor (Malcolm, 1972). Colors may mean very different things among different cultures. For example, black is the traditional color worn to symbolize mourning in many Western cultures when someone has passed away. However, white is the color traditionally worn when mourning a death in many Eastern cultures (Mahnke, 1996).

**Color in apparel aesthetics.** Color has a strong impact on a consumer’s perception when purchasing apparel products. All colors have varied symbolic and expressive qualities that can affect the viewer’s choice. Viewing the same exact dress in a bold red versus a light blue will invoke very different moods in the same

viewer and most likely appeal to different consumers. Additionally, many consumers' perception of color is extremely different. Two people's ideas of the color *avocado* are unlikely to be exactly the same. This is because color names are not specific or systematic enough to be defined in exactly the same manner by different people (Fiore & Kimle, 1997).

Color forecasting is an important step in planning and producing a line of garments in the apparel industry. Assessment of current trends is important for apparel designers to create products that will appeal to a specific consumer. Designers in all stages of the apparel production chain should be up to date on color trends in the market (Fiore & Kimle, 1997).

### **Use and Evaluation of Design Elements**

Evaluating and recognizing specific design elements within an object or image requires consideration of these elements as part of a whole. Elements may be distinguished by sight, as in color, or by touch, as in texture (Fiore & Kimle, 1997). Sharp observation can lead to the appreciation of and ability to identify successful design elements within a composition. Artists and designers are more likely than non-designers to show an interest in the creative process and how something was conceived and created, in addition to their attention to the final product. However, anyone has the ability to learn and implement basic design elements (Malcolm, 1972).

## **Photography**

Besides its appreciation as an incomparable art form, photography has historically been used as a communication tool and resource, and has been established as a distinctive way of expressing ideas and emotions (Kemp, 1973). Photographs convey an exact instant in time. Viewers of a photograph can, in a sense, experience a moment in time as if they were actually there.

There are many types of photographic processes, but the focal point of this research involves black and white printed media.

### **Photography as an Art Form**

The word *photography* is derived from the Greek and means “writing with light.” First appearing in 1839, photography has become one of the most impartial means of reproduction and representation in today’s society. Daval (1982) maintains that photographic representation in art implies a series of choices, including subject choice and how the subject will be visually realized. From a positive outlook, these choices will ultimately define the symbolic element of the image to the viewer. On the downside, viewers are usually content accepting a picture as real life. Humans see only what they are capable of seeing, depending on their cultural background and their own life experiences (Daval, 1982).

The human eye can be described as a camera that is capable of taking about 10 pictures per second and sends part of each picture to the brain (Thomas, 1997). Actions and events can be a thing of the past as humans try to compile the pieces of

those 10 pictures and remember how something appeared, or how it happened. Photographs seize the instant in time and allow viewers to recollect and store the image in their mind, exactly as it was at that moment.

Daval reacts, “But if photography amounted to no more than the act of taking pictures which reduce all realities to the same level and the same format, the quality of a photograph would be limited to the quality of the subject represented and to the technical competence of the operator” (Daval, 1982, p. 10).

Two distinct characteristics of photography have had a great impact on society: its power to expose things which are invisible to the naked eye, and its power of confronting viewers with images of unfamiliarity (Daval, 1982). Before photographs, peoples’ life experiences were limited to what they had seen with their own eyes or heard from others about the unknown world beyond personal experiences or relationships. Unlike looking at a painting or drawing, viewing a photograph translated objects or scenes into a realistic experience (Daval, 1982).

### **Basics of Black and White Photography**

A technically successful black and white photograph relies on the exposure of the film that is being used. Exposure is controlled by the *aperture* of the photographic lens (or how much light is allowed to reach the film) and the *shutter speed* (or the length of time that light is allowed to reach the film). Metering is the process of combining aperture and shutter speed to achieve the optimum exposure in an image. In black and white photography, basic exposure metering is generally compared with middle grey. Meters are designed to calculate an exposure that

would produce the overall light level as a middle grey tone in a black and white photograph (London, Upton, Kobre and Brill, 2002). This process of metering ensures that the photograph has an even range of the greyscale, from black to white and every shade in between. In most cases, this balanced range is the goal of the photographer. However, metering can also be used to achieve harsh contrast in a photograph, or to increase the greyness of an image, depending on the artistic or visual intentions of the photographer.

### **Why Black and White?**

Despite the achievement of color photography in 1861, and its commercial introduction in 1907, the fascination with black and white photographs still endures today (London, Upton, Kobre and Brill, 2002). Black and white images seem to distance themselves from everyday, colorful life, creating a mysterious and nostalgic feeling within the viewer. They can generate a sense of retrospect, as they remind one of earlier, more simple times. Black and white photographs are often associated with documentation of historical events and journalism, giving them a factual aspect and evoking a sense of truth in the viewer (Larg & Wood, 1999).

The choice of black and white may also be dependent on desired technical qualities such as tone, grain, line, form and texture. These qualities are also evident in color photography, but black and white photographs are more reliant on the use of graphic form, and these technical qualities can be more apparent and convincing in an image without color (Larg & Wood, 1999).

## **Image and Subject Choice**

Choosing a subject to photograph is the first step towards a successful image. Photographers may first decide what the photograph will be about, or what it should say to the viewer. Should it evoke a certain feeling or emotion? Is there a piece or part of the subject that should be highlighted?

Before making an exposure, it is important to visualize the way a subject will look as a print, confined within the viewfinder of the camera. Photographers may move around the subject or scene to evaluate it from all angles.

It is also important to notice how the subject matter is being communicated, and how a three-dimensional image will look when transferred onto a 2-dimensional surface. What the photographer sees with their own human eye is more realistic than how the print will ultimately appear since they are actually experiencing that moment as a part of the environment (London, Upton, Kobre and Brill, 2002).

Black and white photography is a popular choice for portraiture. The absence of color can impose a certain timeless quality, where a person's character or real self shows through above all else in the photograph. Color can often date a portrait or detract from the subject matter (Larg & Wood, 1999).

## **Black in Apparel**

In fashion and apparel, black often symbolizes power, drama, strength and sophistication. Traditionally worn for mourning, and for religious, academic and ceremonial situations, black acquired a feature of cosmopolitan style after World War I. Pioneering its fashionable display, black was favored by the Spanish

aristocrats of the sixteenth and seventeenth centuries and only the daring American and European women of the late nineteenth and early twentieth centuries. In the early twentieth century, Parisian and British designers began to create black pieces for their wealthiest clients, which were considered very bold and extravagant for that time (Mendel, 1999).

In the early 1900's, designer Coco Chanel made her mark as a designer when she authenticated black as a pivotal point for fashion. While many raved at her exploitation of black in women's clothing, other critics referred to her style as "poverty *de luxe*" or "poor girl fashion", implying that Chanel's creations allowed even the most average women 'to walk around like millionaires'. Many other designers, including Christian Dior and Balenciaga, followed suit into the 1950's, developing entire collections in black and receiving a positive response from the fashion world (Mendel, 1999).

Black and white movies, featuring stars like Marlene Dietrich and Rita Hayworth dressed in valiant black gowns and shiny black frocks, gave black another runway to display its power and worth in fashion. The image of Audrey Hepburn in the black Givenchy gown in 1961's *Breakfast at Tiffany's* is an enduring cultural icon of the twentieth century (Mendel, 1999).

Fashion magazines reported on the black phenomenon: 'The little black suit that starts out in the afternoon and continues on to dinner' [*Harper's Bazaar*, Nov. 1946]; 'Invest your all in one good little black dress' [*Woman and Beauty*, 1951]; 'Many tones of black – one sure allure' [*Vogue*, Nov. 1951] (taken from Mendel,

1999, p. 13). Besides the prevalent use of black in evening wear, a well-tailored black suit, when worn in a predominantly male business environment, created a certain authority and power for women and was a preview to the 1980's power suit (Mendel, 1999).

In the youth revolution of the 1960's, the black attire formerly dominated by a mature group of women, aged 25 and over, was seized by a younger, more expectant group of sophisticates. The birth of the Pop Art movement, with its bright colors and creamy pastels, competed with black in the new short skirts and basic styles. However, when black teamed up with white, the Op Art movement reintroduced the extreme use of black in fashion trends (Mendel, 1999).

In the 1970's, black emerged in the discos and dance clubs in the new body-hugging dresses and clinging evening wear. Following into the early 1980's, black outsold every other color despite the continual blows by critics. Many maintained that black was boring and merely a safety net for women who were too afraid to be fashionably daring and original. However, consumers didn't agree and black remained a staple into the twenty-first century (Mendel, 1999).

### **Repetition and Pattern**

Repetition and pattern are often described similarly in the evaluation of basic design elements and principles. Though there are differences between the two terms, they have comparable qualities and characteristics.

## **Repetition**

Repetition occurs within a design when similar elements are repeated in a regular or an irregular fashion, often creating a rhythm or harmony within the design (Malcolm, 1972; Wong, 1993). Repetition can also be represented through the recurring use of a unit form. The consistent presence of a unit form can create unity within a design. Unit forms should be fairly simple so the unity of the forms within a repetitive design is not jeopardized (Wong, 1993).

Repetition is a common method used in various types of design. Structural elements of architecture and rhythm seen in fabrics or interior coverings are familiar examples of repetition. Considerations such as the size of a unit form or the number of times it is used can influence the resulting repetition (Wong, 1993).

## **Pattern**

A pattern can be created by arranging many shapes or units together. Patterns can be ordered or random. Ordered patterns, such as a check or plaid, include shapes or units that are placed at regular distances from each other. Random patterns, such as abstract tie dyes, have no consistency in their placement or distance from each other (Fiore & Kimle, 1997).

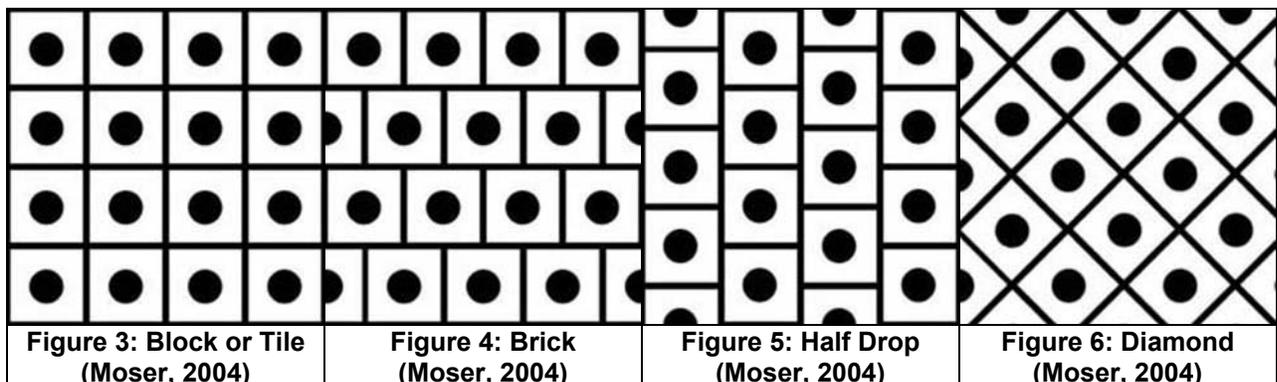
### **Patterns Designed for Printed Textiles**

Print patterns designed specifically for textiles are usually created using a *repeat*. A repeat is a “basic unit of design in the decoration of fabric by printing

techniques... Repetition of the basic unit should create a rhythmic flow over the whole fabric” (Johnston & Kaufman, 1981, p. 56).

The size of the repeat should be considered, as it will greatly affect the outcome of the fabric. Larger repeats may require more fabric to fully display the repeat as a continuous pattern. Smaller repeats may become lost or indistinguishable when repeated over a large area of fabric. The size of the repeat may also determine the resulting fabric’s appropriate end use (Johnston & Kaufman, 1981).

There are many ways in which the repeat can be arranged to create a pattern. Four examples are shown below.



## Modules

Creating repetition in design can be achieved many ways. In most methods of generating patterns, there is a single unit form or repeat. Aside from the methods used in designing printed patterns for textiles, there are other methods which utilize repeats that are more dynamic than a simple rectangle in a tiled or half-drop pattern.

## **Creating Modules**

Patterns can also be created by using a *module*. A module is “a single basic unit that is repeated to produce a pattern” (Joyner, 1992). A module may also be referred to as a *motif* or *unit form*. Modules are usually smaller parts extracted from a larger work or image. A basic single module appears as one of three equilateral geometric shapes: triangle, square, or hexagon. Repetition of a module can create a sense of unity within a whole. Modules are most effective when the imagery within it is simple, the positive and negative spaces are similarly distributed, and they are asymmetrical (Joyner, 1992). *Asymmetrical* implies that if an object or image was divided into two equal halves, they would not be mirror images of each other (Wong, 1993).

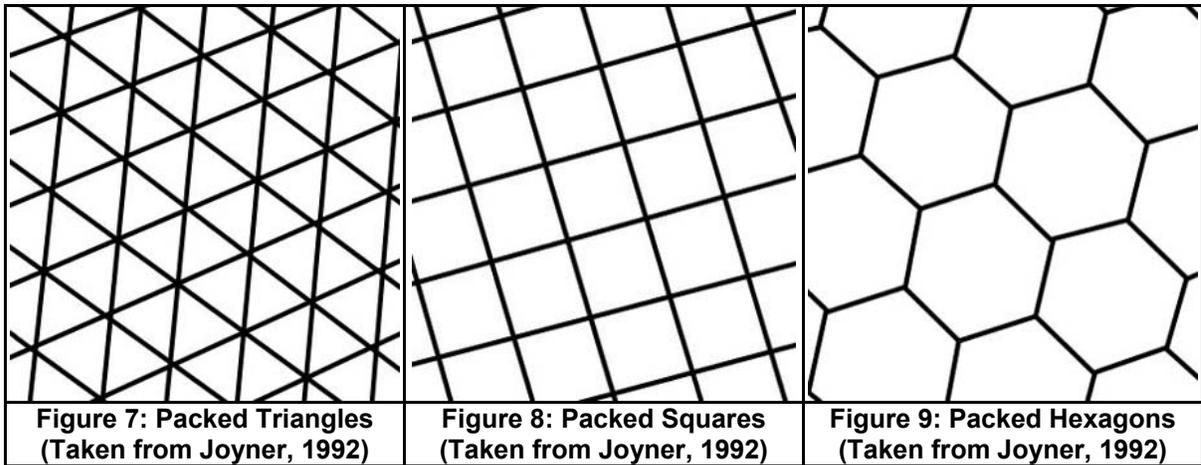
Choosing which specific piece or part of an image will be a module is important when considering how the module will interact with itself when replicated as a pattern.

## **Creating Patterns with Modules**

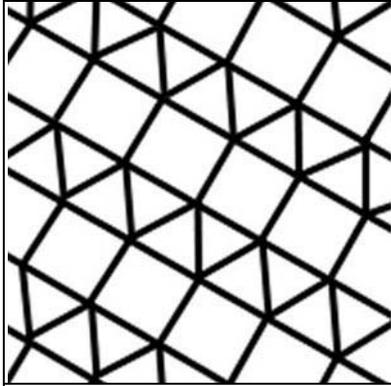
Patterns are normally repeated and distributed in such a way that the entire space in question is filled with no voids or spaces. Completely filling a 2-dimensional space around a single point requires a 360° image or pattern.

There are three regular patterns that can be created using modules in the form of an equilateral triangle, square, or equilateral hexagon. These shapes, when

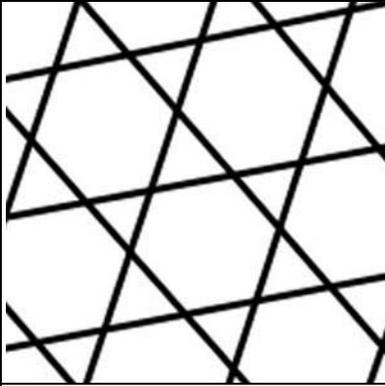
packed together with more shapes of their exact kind, can create patterns with no voids (Joyner, 1992).



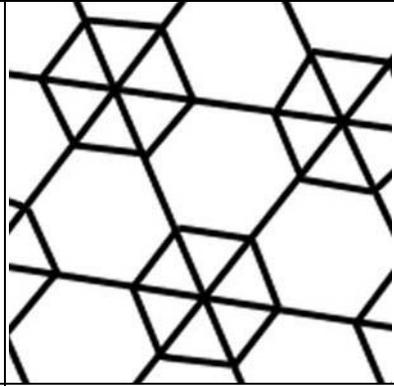
Patterns created with modules can also be constructed of more than one kind of these three geometric shapes. Joyner maintains that there are only ten ways to pack equilateral triangles, squares and hexagons with equal length edges around a point in such a way that there are no voids. Three of these are shown in the above regular patterns (Figures 7-9). The remaining seven semi-regular patterns, which utilize more than one of the three shapes at a time, are shown in Figures 10-16 (Joyner, 1992).



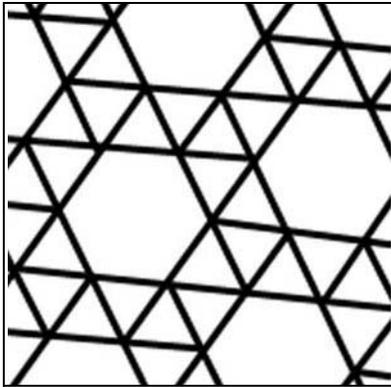
**Figure 10: Semi-regular 1**  
(Taken from Joyner, 1992)



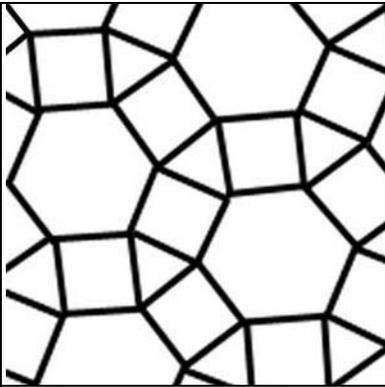
**Figure 11: Semi-regular 2**  
(Taken from Joyner, 1992)



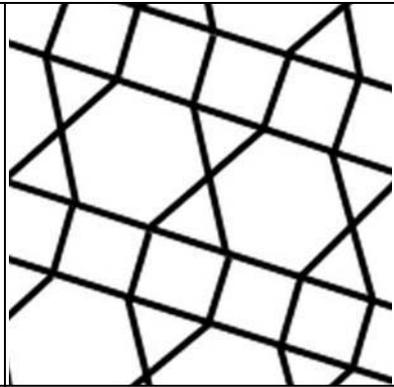
**Figure 12: Semi-regular 3**  
(Taken from Joyner, 1992)



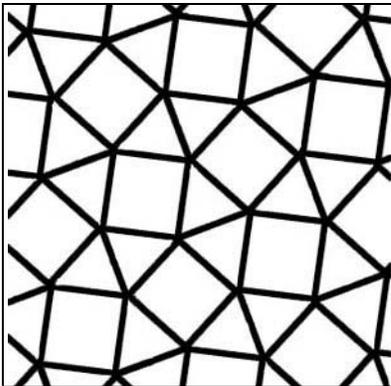
**Figure 13: Semi-regular 4**  
(Taken from Joyner, 1992)



**Figure 14: Semi-regular 5**  
(Taken from Joyner, 1992)



**Figure 15: Semi-regular 6**  
(Taken from Joyner, 1992)



**Figure 16: Semi-regular 7**  
(Taken from Joyner, 1992)

## **Modules Derived from Photographs**

Modules can be created from photographs by choosing a piece or part of the image and extracting it in the shape of an equilateral triangle, square or equilateral hexagon (Joyner, 1992). Because of the wide range of tones in a photograph, and the infinite possibilities for color and gradient, modules derived from photographs can be very dynamic. As previously mentioned, asymmetrical modules usually yield patterns that are more energetic and seem to take on a life of their own (Joyner, 1992). This is especially true in modules taken from photographs. The module can be flipped or rotated within the pattern to create more diverse patterns.

Figures 17-20 show a step-by-step example of how modules were derived from an 8"x10" black and white photograph that was scanned into Photoshop® 7.0, and how the modules were used as repeat units or motifs in a pattern.



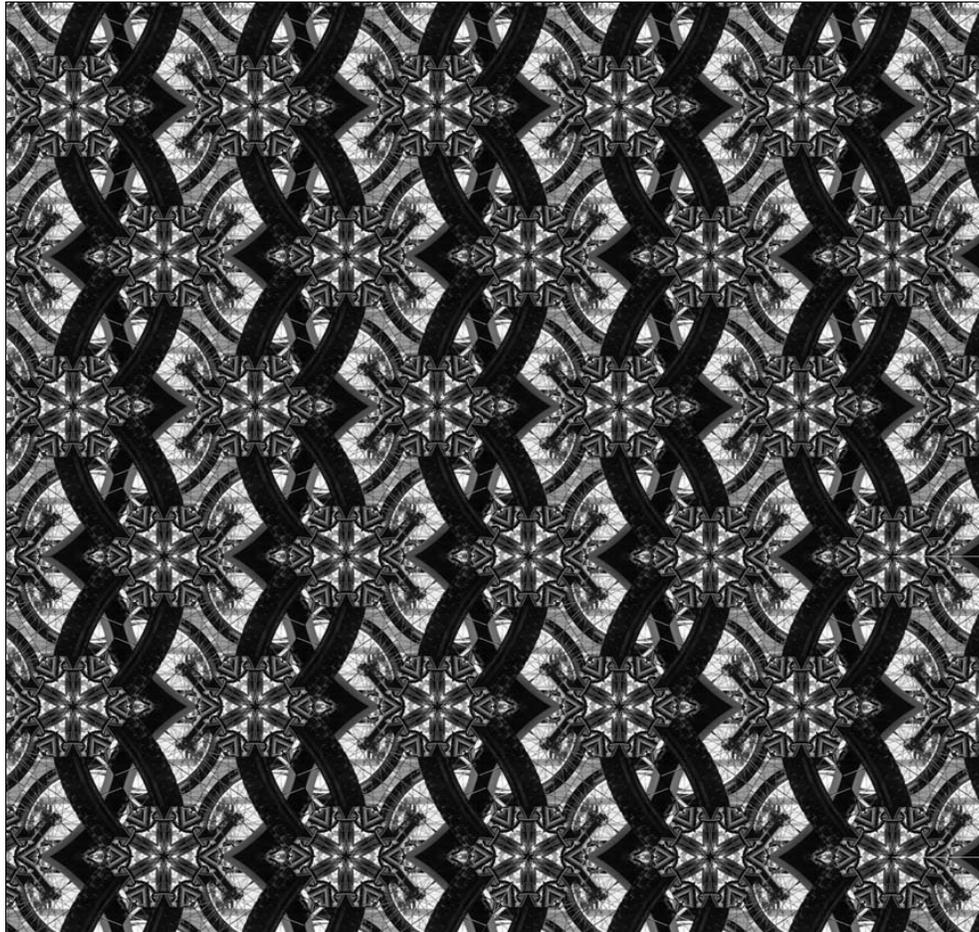
**Figure 17: Original photograph  
(Moser, 2002)**



**Figure 18: Triangle & hexagon modules taken from photograph and fitted together to create larger triangle module  
(Moser, 2002)**



**Figure 19: Four of the larger triangle modules flipped, rotated and packed to form a repeat unit  
(Moser, 2002)**



**Figure 20: Pattern created from repeat unit  
(Moser, 2002)**

### **Photographic Patterns**

Since photographs already have a life-like quality or appearance, this liveliness or movement can be further enhanced through patterns constructed of photographic modules. Choosing which part of the photograph to use as a module is important in the outcome of the pattern. It is also important to visualize how

multiple copies of the module will look when packed together. How will the outstanding design elements within the module interact with each other? Where will lines meet? Will new shapes emerge? What new colors or tones will be created?

It is up to the designer as to whether the imagery in the original photograph will still be distinguishable in the resulting pattern. It is possible to choose a module which will allow the original photograph to be recognizable, but one may also choose a module that, when packed together, disguises the photographic image. The resulting pattern can even create a new image.

### **Early Photography in Textiles and Apparel**

The following methods explain simple, non-technical ways of printing photographs directly onto fabric.

#### **Transfer with Printing Plates**

Printing photographs onto fabric with printing plates (mending fabric in this case) is relatively easy and inexpensive, and works best when printing black and white photographs. In this dry method of transfer printing, color images can be used, but Croner (1989) maintains that black and white images usually provide the greatest detail, especially if the contrast of the image is fairly high. Transfer printing with this method requires only a household steam iron, lightweight iron-on mending fabric, a photocopy of the original photograph (the contrast may be increased to enhance the lines in the image for a clearer final print), and the final fabric on which it will be printed (Croner, 1989).

Using the iron on a “steam” setting, the iron-on mending fabric is pressed onto the photocopy. Then the mending fabric is peeled away. The adhesive on the mending fabric should pick up the image from the photocopied paper, but in reverse. The mending fabric now acts as a “printing plate”. Applying the image and removing the mending fabric in this way is called the release method (Croner, 1989).

Next, the mending fabric printing plate is ironed onto the final fabric. The mending fabric is then peeled away, leaving the adhesive with the photographic image on the final fabric, facing the direction in which the photograph originally appeared (Croner, 1989).

The transfer sheet and printing plate method can also print text created with inked typing ribbons, colored and lead pencils, crayons, chalk, pastels, and acrylics. This is beneficial for printing images that have been drawn or written (Croner, 1989).

### **Wet Rubbing**

Wet rubbing is an alternative method of transfer printing that works best for transferring colored images from magazines or any other papers with a smooth surface, and darker photocopies of black and white images. However, it should be understood that the original images used in this process will be destroyed. Also, with the wet rubbing process, the image may transfer easily onto the mending fabric “plate” and then wash off the plate if the final transfer isn’t done quickly (Croner, 1989).

Materials should be prepared as they are for the dry method of transfer printing, only the iron should be on a dry “wool” setting. The mending fabric is heated onto the image for one minute, with the iron tilted and rubbing the edge of the plate. The fabric should be allowed to cool completely (Croner, 1989).

The following supplies should be assembled for the next step: soap solution (one part dishwashing liquid, 4 parts warm water) in a shallow bowl, warm (not hot) rinse water in a wide bowl, and old bath towel, and a cotton rag. All these supplies should be arranged close to one another near a sink (Croner, 1989).

To remove the top paper layer, dip the cooled plate, paper side up, in the soap solution and remove the paper before it is well soaked. Next, put the plate, image side up, on the folded towel and remove any leftover bits of paper by scraping with fingertips or a fingernail. The transferred image should be recognizable through a fuzzy, soapy layer of paper fibers. Do not rub the plate with fingers or against the bottom of the bowl, as the image is soft when it is warm and wet (Croner, 1989).

The printing plate is then submerged, image side up, in the warm rinse water to remove any remaining paper fibers with fingers. The rinse water should be changed as needed. The plate is then removed and placed on the towel, image side up. Once more, any remaining paper fibers should be removed. Finally, the plate is rinsed under cold running water to remove all soap. Again, place the plate on the towel, image side up, and lightly squeegee off any standing water by hand. Once the plate is dry, transfer the plate image to the final fabric by the release method as used in the previously described dry transfer printing (Croner, 1989).

## **Release Method and Skimming**

Skimming is another way of transferring an image onto the final fabric when using dry transfer plates or wet rubbing. The release method as described in the two previous sections is called “release” because it transfers the entire image, including any color on the plate, as well as the adhesive from the mending fabric (Croner, 1989).

The strength and stiffness of the transferred adhesive can be beneficial, in that it makes sewing easier and helps the printed image hold its shape. However, the stiffness of the remaining adhesive can also be a drawback if the fabric is intended for uses that require softness such as pillows, quilts or clothing. The fabric can be slightly softened by stretching it on the bias to break the adhesive bond. Constantly working with the print and manipulating it by hand will also soften it (Croner, 1989).

Alternatively, skimming is another technique that does not transfer the adhesive to the final fabric. Though it is slightly more difficult and unpredictable than the release method, skimming can produce one medium-dark print or multiple prints from one printing plate. This process works best with black and white photocopies (Croner, 1989).

One skimming method involves using the tip of the iron as a pencil. The dark areas of the photocopy are traced with the tip until transferred. This can be done on fabrics that are more fragile under heat, such as velvet or nylon (Croner, 1989).

There is another skimming method that works best for images that will later be painted, embroidered, or embellished in some manner. Using the “wool” setting on the iron, iron the final fabric alone until it’s hot. Place the printing plate face down on the final fabric and rub the back of the plate by the heel of the hand, with a rolling pin, or another cool, hard object. Peel up a tiny corner of the plate to inspect the transfer. If the entire image does not transfer, quickly and lightly run the iron over the plate and then peel away the plate (Croner, 1989).

### **Thermal Transfer Paper**

Thermal transfer paper can be used to print images on fabric. This type of paper can be bought in sheets at many copy stores or office supply stores, and is used in laser copiers. This paper is coated with a polymer emulsion that can be heat set onto fabric. The process is similar to transfer printing with a printing plate (Laury, 1992).

The image is copied onto the thermal transfer paper through the laser copier, in color or black and white. The paper is then heat set onto the final fabric, image side down, for 10 to 20 seconds on a high iron temperature with high pressure. The paper is then peeled away and the image is left on the fabric (Laury, 1992).

### **Contact Paper**

For this process, Laury (1992) recommends using clear, self-adhesive shelf or contact paper, a large piece of glass or masonite, and acetone. First, the image to be printed is photocopied relatively dark. A piece of the contact paper is peeled

from its backing and pressed to the inked side of the photocopy. A rolling pin or the heel of the hand can be used to press firmly and ensure a good contact between the photocopy and contact paper. Next, the excess photocopy paper and contact paper can be cut away to minimize the area of the image to be printed. The photocopy is then peeled from the contact paper, leaving the inked image on the sticky side of the contact paper. The contact paper is pressed firmly onto the final fabric and pressed firmly with the heel of the hand or a rolling pin (Laury, 1992).

The fabric with the contact paper still attached should then be taken outdoors and placed paper side down onto the glass or masonite. Wearing rubber gloves, a small cloth moistened with acetone should be dabbed over the fabric until it is moist. After pressing with the rolling pin once more, the fabric is allowed to dry completely for several hours, and may then be heat set with a medium-hot iron with the printed side placed down on clean paper. Continue pressing until all the emulsion is removed from the fabric (Laury, 1992).

### **Transfer Medium**

According to Laury (1992), transfer medium can be used to aid in printing photographs onto fabric. The medium consists of a thick, non-toxic liquid that is painted onto plain color or black and white photocopies to assist in their transfer. Fabric used in this process must not have any finishes previously applied. Another important point about this process is that the resulting image will be a reversal or mirror of the original image (Laury, 1992).

Place the final fabric over wax paper or clear plastic wrap on a flat surface and pin it down to prevent slippage. Cut out the photocopied image that is to be transferred and place it face up on another piece of wax paper. Paint the photocopy with an even, thick layer of the medium (about  $\frac{1}{8}$  inch thick). Lift the wet print and place the coated side down on the fabric. Cover the fabric and print with wax paper and press firmly with a rolling pin or by hand from the center out to the edges to remove air bubbles, and press with hands or the rolling pin again. Allow the fabric and print to dry for 24 hours, or longer in high humidity. Cover the fabric and print with a press cloth and heat set with an iron on a medium setting. Remove the photocopy paper by sponging with a wet cloth or sponge and rubbing. When the print is clean, meaning all the paper has been rubbed off and the image is clear, a few more drops of the transfer medium can be rubbed on the image to seal it (Laury, 1992).

### **Transparent Base**

Transparent base, a gel-like medium that is commonly used as an extender for oil paints or watercolor, can be used as a printing ink for transferring images to fabric. A photocopy of the original image should be made on a copy machine that deposits powdered toner. The photocopy is then coated with a thin layer of the base using a soft brush with even, smooth strokes. Immediately place the photocopy face down on the final fabric and cover with newsprint. Use a hot iron with high pressure and press the iron on both sides of the fabric. Excess base that is pushed out the

sides should be wiped away. Next, peel the photocopy away steadily while it is still hot to leave an evenly colored image on the fabric. Allow the fabric to dry for 24 hours (Laury, 1992).

### **Acrylic Medium**

Acrylic or polymer mediums can be used to lift color from smooth or clay-coated magazines or newspaper and transfer to fabric. The ink is lifted from the image within a thin film of the medium and it can be applied to the fabric using more of the medium to secure the image (Laury, 1992).

First, the image to be transferred should be brushed with a thin layer of the medium and allowed to dry. This coating is then repeated anywhere from four to eight times using different brush strokes in each application. Next, the paper is soaked in warm to hot water for a few minutes. After being removed from the water, the paper can be rubbed away, leaving a thin film of acrylic containing the image. The medium will take on a white foggy look while wet, but will turn clear again when it dries. To transfer the image to fabric, coat the back of the film again and place on the fabric while it is still wet. Press firmly with a rolling pin to remove air bubbles and allow it to dry (Laury, 1992).

### **Solvent Transfer**

The transfer of images using solvents can be potentially hazardous to the user, as the solvents contain dangerous chemicals and fumes. Transfer printing with solvents should be done in a well-ventilated area while wearing protective

gloves and masks. Solvents that can be used include turpenoid (odorless paint thinner), mineral spirits, or acetone (Laury, 1992).

A photocopy of the intended image should be made, with the final fabric cut slightly larger than the image and placed right side up on a large piece of cardboard. Fabric edged can be taped down to prevent slippage. The photocopy is then placed face down on the fabric and taped only at the top. Saturate a small cloth with a little of the solvent and wipe over a small section of the photocopy, allowing the paper to soak up the solvent. Quickly press firmly on the saturated area of the paper to assist the transfer of the image onto the fabric. Pull up a small corner of the paper to ensure the image has been transferred. If the image looks blurry, use less solvent. Continue with the solvent over the entire image, and then remove the paper from the fabric. Allow at air dry for 24 hours, and heat set with an iron (Laury, 1992).

### **Copy Machines, Typewriters and Paper Printers**

There are other transfer methods that involve creating direct transfer images on transfer paper in a copy machine, typewriter or paper printer (dot-matrix or laser). Images can be printed, typed or photocopied onto a heat transfer paper, and then heat set onto fabric with an iron. Additionally, some fabrics can actually be passed through these machines for a direct print. These direct printing fabrics usually have a peel-away paper backing for stability while passing through the copier or printer, or a backing can be added using laminated freezer paper. For passing through a

typewriter or printer, fabric can be stiffened with a spray fixative, spray adhesive, spray starch or sodium alginate (Laury, 1992).

Though it may appear much easier and less involved than some of the previously described processes, copy machines, printers and typewriters don't generally cooperate well when printing on fabric. It is easy to jam a printer or copier, especially when the fabric is laminated (Laury, 1992).

### **Silk-Screen Printing**

Silk-screen printing by hand allows the direct printing of images onto fabric using a mesh polyester screen stretched across a rectangular wooden or metal frame, or screen. Images can be printed using water-based paints, acrylics, and other substances (Laury, 1992).

Preparation of the screen for printing is a tedious and fairly expensive process. Screens can be purchased pre-stretched with the mesh, or they can be built by the user (Laury, 1992). Mesh comes in many different sizes defined by the space between the holes in the weave structure. Mesh can be purchased in monofilament polyester or multifilament polyester (Dick Blick, 2004).

*Monofilament* polyester mesh is woven of a single thread and is very uniform in weave, allowing a smooth ink flow when printing. The mesh count of monofilament is determined by the number of threads per linear inch. Monofilament fabric sizes are denoted by a number (Dick Blick, 2004).

*Multifilament* polyester is woven with a strand of many filaments twisted together. It is less uniform in weave than monofilament mesh. The coarseness of the mesh is designated by a number followed by an XX. Smaller numbers mean the mesh is finer (Dick Blick, 2004).

Prior to printing, the mesh on the screen is pre-treated with a degreaser or other cleaner and allowed to air dry (Laury, 1992). A degreaser can greatly reduce the risk of failure in the stencil or screen making process and can extend the stencil longevity and endurance through multiple printings. Degreasing helps remove oily ink residue and solvents from prior printings and prepares it for the application of a photo-emulsion chemical (see next section) if being used (Ulano, 2004).

There are various ways of using silk-screens for printing, including photo-emulsion printing, thermal imagers and light-sensitive printing, which are explained in the following three sections.

### **Photo-emulsion Screen Printing**

Silk-screen printing with a bichromate photo-emulsion is a direct contact method, which means that some type of opaque substance must come between the emulsion and the exposing light source. In this method, the screen itself is made photo-sensitive when it is coated with a light-sensitive emulsion (such as those made by the Ulano Corporation) and allowed to air dry. The coating and drying should be performed in a darkroom or a location with very low lighting so as not to

expose the emulsion. The screen is then stored in a light-safe area until it is ready to use (Laury, 1992).

The screen can be exposed using a timed light source which coincides with the specific emulsion with which the screen is coated (Ulano, 2004). The intended image for the screen should be an opaque image which does not allow light to pass through it. The opaque image is placed between the light source and the coated screen. The screen is exposed for a set amount of time, and then removed from the light source. The areas which were not exposed (or covered by the opaque image) can then be washed out of the screen by spraying water on the screen, and the areas which were exposed will leave an outline or stencil of the image. Inks or paints can then be pushed through the screen with a squeegee (Laury, 1992). A squeegee is a tool that is comprised of an upper handle (usually wood or aluminum) and a lower blade made of rubber or a rubber-like material. The squeegee is passed across the screen and pushes the ink or paint through the mesh (Dick Blick, 2004).

There is also an indirect method of using photo-emulsion to prepare a silk-screen for printing. The indirect emulsion process utilizes a photo-stencil film that is water-soluble and can only be used with oil-based inks. The exposure is made on the film, which is then transferred onto the screen (Laury, 1992).

## **Thermal Imagers**

Thermal imagers, traditionally used to produce stencils and thermal copies, can be used to create very detailed stencils for thermal screen printing. Thermal imagers work particularly well for printing text and lettering, photographs, sketches, and very linear drawings or images. The drawn or photocopied image used to create the stencil must contain carbon for the process to work correctly (Laury, 1992).

The process for creating a thermal screen is similar to creating a silk-screen as described in the previous section. The original image is placed face up and centered between the backing sheet and the polyester stencil of the thermal screen. The stencil is bonded with a fine film of plastic. The screen, with the image still placed, is exposed by inserting the three layers (screen, image and backing) into the thermal copy machine. The machine burns the image into the plastic film, leaving an etched copy of the image. After the original image is removed from the copier, the screen can be peeled away to reveal the etched image. The screen is then attached to a frame, if it is not already, and used as in regular screen printing (Laury, 1992).

## **Light-Sensitive Printing**

Light-sensitive printing is a process that uses fabrics treated with a light-sensitive chemical solution that can be exposed by ultraviolet light. As in printing a photograph, a negative or block-out image that prevents light from passing through it is placed on top of the fabric while it is exposed. The areas covered by the negative

are left unexposed, thus leaving the negative image on the fabric. There are a few different methods for creating a light-sensitive print, including Cyanotype (blueprint), Van Dyke (brownprint), Kwik-print and Inko print (Laury, 1992).

Cyanotype, or blueprinting, uses a chemical solution to coat the fabric. When exposed to ultraviolet light, the areas that are uncovered are exposed and turn blue. Color may range from a light blue-green to deep blue. Fabrics can be treated with slightly different chemical solutions to achieve other colors in this process, such as browns and violets (Laury, 1992).

Van Dyke or brownprinting is very similar to Cyanotype. The color of the exposed areas ranges from a pale brown to a deep brown. Brownprinting is especially effective when used to print portraits, as it gives an added depth to the image (Laury, 1992).

A wide range of color can be achieved when using a Kwik-print, as several colors can be painted onto fabric at once. With Kwik-print, there is no need for mixing chemicals. The product is packaged as a pre-mixed emulsion that is brushed onto fabric to make it light-sensitive, and then the fabric is exposed (Laury, 1992).

Similar to Kwik-print, Inko print is available in a liquid form in a wide range of colors. In this process, the image can be exposed by either ultraviolet light or heat (Laury, 1992).

## **Stamp Printing**

Stamps for fabric printing can be created commercially using a personal photograph. Laury (1992) maintains that deeply-etched stamps work best on fabrics since fabrics are typically not as smooth as paper. The stamp is simply coated with ink or paint, using a brush or stamp pad, and pressed onto the fabric. The fabric can then be heat set after drying to secure the image (Laury, 1992).

## **Patterns Designed for Use in Apparel**

Designing repeat patterns for use in apparel end products is very different from designing patterns for other artistic or creative media. In art applications such as ceramics, a decorative pattern is typically incorporated during or after the construction of the piece. However, in fabric pattern design, the pattern is usually applied to the garment parts (or fabric) before the garment is actually constructed. The pattern to be used in a garment is an integral part of its entirety and the ultimate relationship between the pattern and garment shape (Knight, 1972).

A key difference between garments and other objects with pattern is that the fabric on which the pattern will be incorporated is viewed as a 2-dimensional rather than a 3-dimensional surface, although it will ultimately become a 3-dimensional form. There are also specific concerns when designing patterns for garments that are not always evident in pattern design for other applications. For example, when the fabric is cut and sewn to create a garment, there are breaks in the flow of the pattern at the seams. This may result in distortion of the pattern design, and should

be considered when designing for a specific garment shape and/or construction (Knight, 1972).

Patterns are designed for apparel applications for a number of reasons. Historically, patterns have often been used for religious or cultural symbolism, communication of a thought or idea, drawing attention to a specific part of the body, or symbolize a social rank (Knight, 1972).

The shape or structure of a garment may also affect or be affected by the application of a pattern. Prior to the late 1700's, fashion designers tended to use pattern on every part of an ensemble in a sort of chaotic manner (Figures 21-22). More recently, designers use patterns in a more complementary way, emphasizing the shape of the figure and the line of the body and garment (Figures 23-24) (Knight, 1972).



**Figure 21: Jacket, ca. 1616, Great Britain  
(Taken from The Costume Institute,  
Metropolitan Museum of Art, 2004)**



**Figure 22: Cape, late 1600's,  
French  
(Taken from The Costume Institute,  
Metropolitan  
Museum of Art, 2004)**



**Figure 23: Afternoon dress, ca. 1855,  
French  
(Taken from The Costume Institute,  
Metropolitan Museum of Art, 2004)**



**Figure 24: "May" ball gown,  
spring/summer 1953, Christian Dior,  
French  
(Taken from The Costume Institute,  
Metropolitan Museum of Art, 2004)**

## **Digital Printing Technology**

Frank Cost (1997) defines a digital printer as “any printing device that inputs a digital data stream and outputs printed pages” (p. 79). He has organized the current digital printing processes into four categories: silver halide, thermal, ink jet and electrostatic. Most digital printing applications for textiles are ink jet, and are categorized as either a continuous process or drop-on-demand process. Drop-on-demand is the most commonly used of these two methods.

The ink jet printing process uses vibrations to deposit individual “drops of ink in a precisely controlled manner onto a substrate to create an image” (Fralix, 2000, p.58). Important factors to consider in ink jet printing are the intended image resolution, production speed of the printer and the width of the substrate (Fralix, 2000).

The advantage of digital textile printing is the capability to produce images that are photo quality, or photo realistic. This is achieved through the dithering process. Dithering is “used to simulate colors that are not in the set color gamut” (Lawrence, 2002, p.107). Tiny drops of ink from the available colors are placed onto the substrate at different values to simulate the appearance of additional colors (Lawrence, 2002). With infinite color availability, digital printing can allow an image to be applied to fabric and viewed with clarity that was never before possible.

## **The Future of Textile Digital Printing**

A market research study released in 2003 by Web Consulting, a leader in the consultation of digital and analog printing and imaging companies, estimates that the worldwide volume of digitally printed textiles will surpass 44 million square meters by 2005, based on current trends in the industry. This production level would be almost a 50% increase over the volume produced in the year 2000 (Byrne, 2003).



**Figure 25: Digitally Printed Apparel Products  
(Taken from Print Unlimited website, 2003)**

The report also estimates that the number of digital textile printers will increase from 833 units sold worldwide in 2000 to almost 1,400 units sold worldwide in 2005 (Byrne, 2003). The digital textile printing market is becoming largely dominated by piezo drop-on-demand systems, which account for over 80% of units sold in 2005. There is also a recently developed role for high productivity piezo and continuous inkjet systems (Byrne, 2003).

The inevitability of digital textile printing's success lies in recent technological advances such as the DReAM® digital textile printing machine. Created through collaboration between Reggiani Macchine S.p.A., Aprion Digital and Ciba Specialty Chemicals, the DReAM® combines Reggiani's substrate-covering system, Aprion's six-color inkjet heads and Ciba's newly developed reactive inks to perform claimed production runs of up to 150 m<sup>2</sup>/hour on fabric up to 1.6 meters in width (Reggiani/Aprion/Ciba SC, 2003). The DReAM® can produce prints at resolutions up to 600 dpi at these high speeds (Ciba Specialty Chemicals, 2003). If implemented successfully, this technology could be an enormous advance from the current printing speeds of only 10-50 m<sup>2</sup>/hour on sample strike-offs and short production runs (Reggiani/Aprion/Ciba SC, 2003).

## **CHAPTER THREE: METHODOLOGY**

The purpose of this research was to investigate general U.S. consumer response to patterns created for digitally printed apparel products and what basic design elements are most commonly preferred within a repeat pattern. Related areas of investigation included the basic design element choices as related to the garment style and shape, and specific demographic assessment of the consumer groups and their top design element choices.

Data was collected through an internet survey targeting general U.S. consumers. The survey employed a function which allowed various photographic patterns to be modeled on garment flats; consumers were then asked to choose which patterns they preferred on specific garments. Their choices were then analyzed statistically for patterns and outstanding characteristics within the acquired data.

This chapter explains the steps taken to choose and design the internet survey material, the structure of the survey, how the survey was administered, and how the acquired survey data was analyzed.

### **Photographic Pattern Generation**

The photographic patterns were generated using Adobe Photoshop® 7.0. Multiple black and white photographs were scanned into the program either as an 8"x10" print or as a 35mm negative. Many Photoshop® tools were used to extract

modules from the photographs, including the rectangular marquee tool, the crop tool, the rectangle shape tool and the polygon shape tool. The modules that were extracted were placed on a blank canvas and evaluated for placement, including rotation and flipping of the module. Some patterns were created using only one type of module, as in the three regular patterns (Figures 7-9, p. 24), and some modules with different shapes were combined to create a pattern, as in the seven semi-regular patterns (Figures 10-16, p. 25).

The initial development of the photographic patterns began with an in-depth study in producing patterns using these modules derived from photographs. After many patterns were created and recreated, and the patterns were evaluated together, eight final patterns were chosen to ultimately represent the basic design elements used in this research.

### **Final Pattern Choices**

The following patterns (Figures 26-33) labeled as Patterns 1-8 were the eight photographic patterns chosen for use in this research. The patterns were chosen based on characteristics such as their uniqueness, depth, variation, and successful exploitation of dynamic form and imagery.

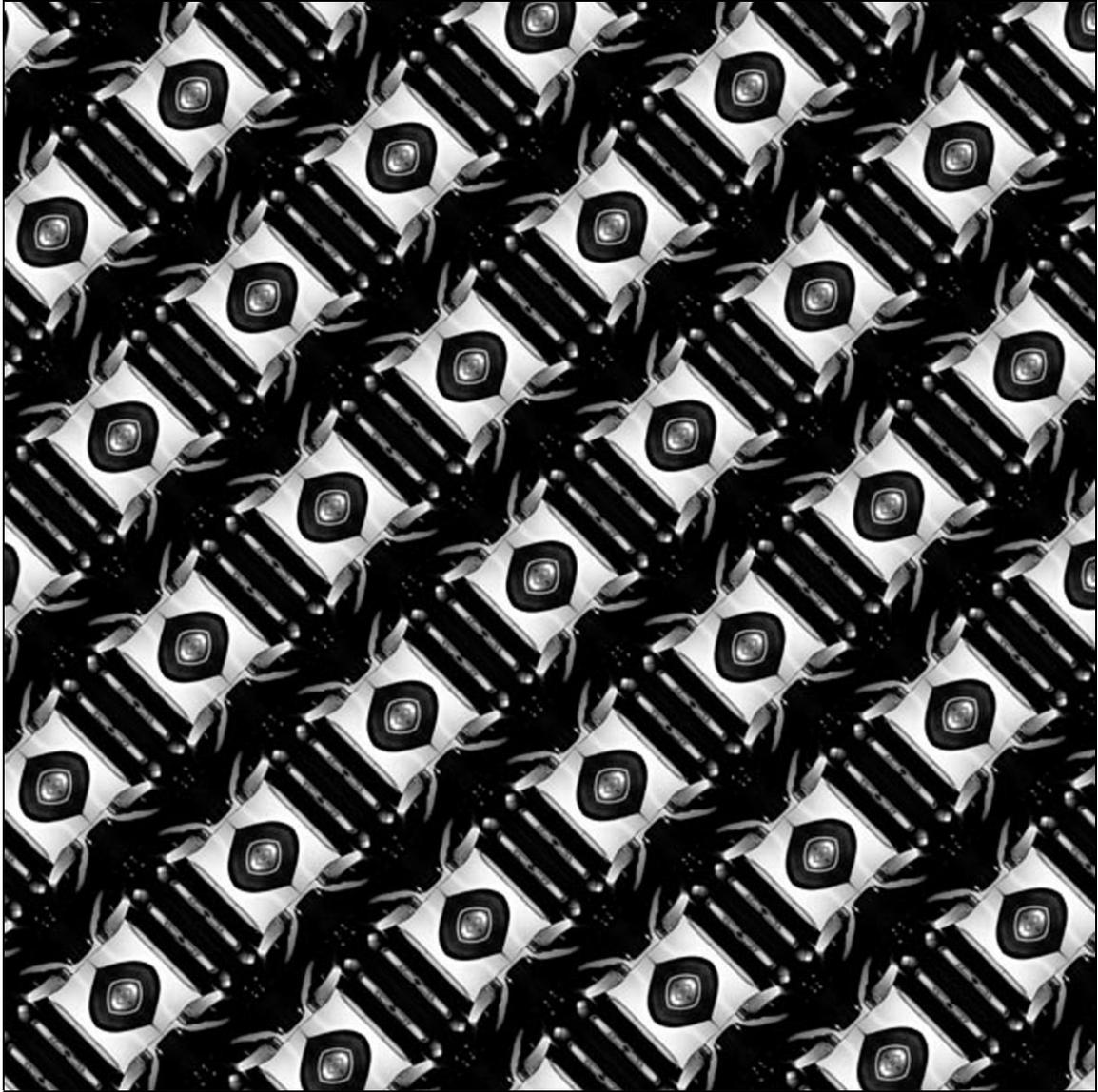
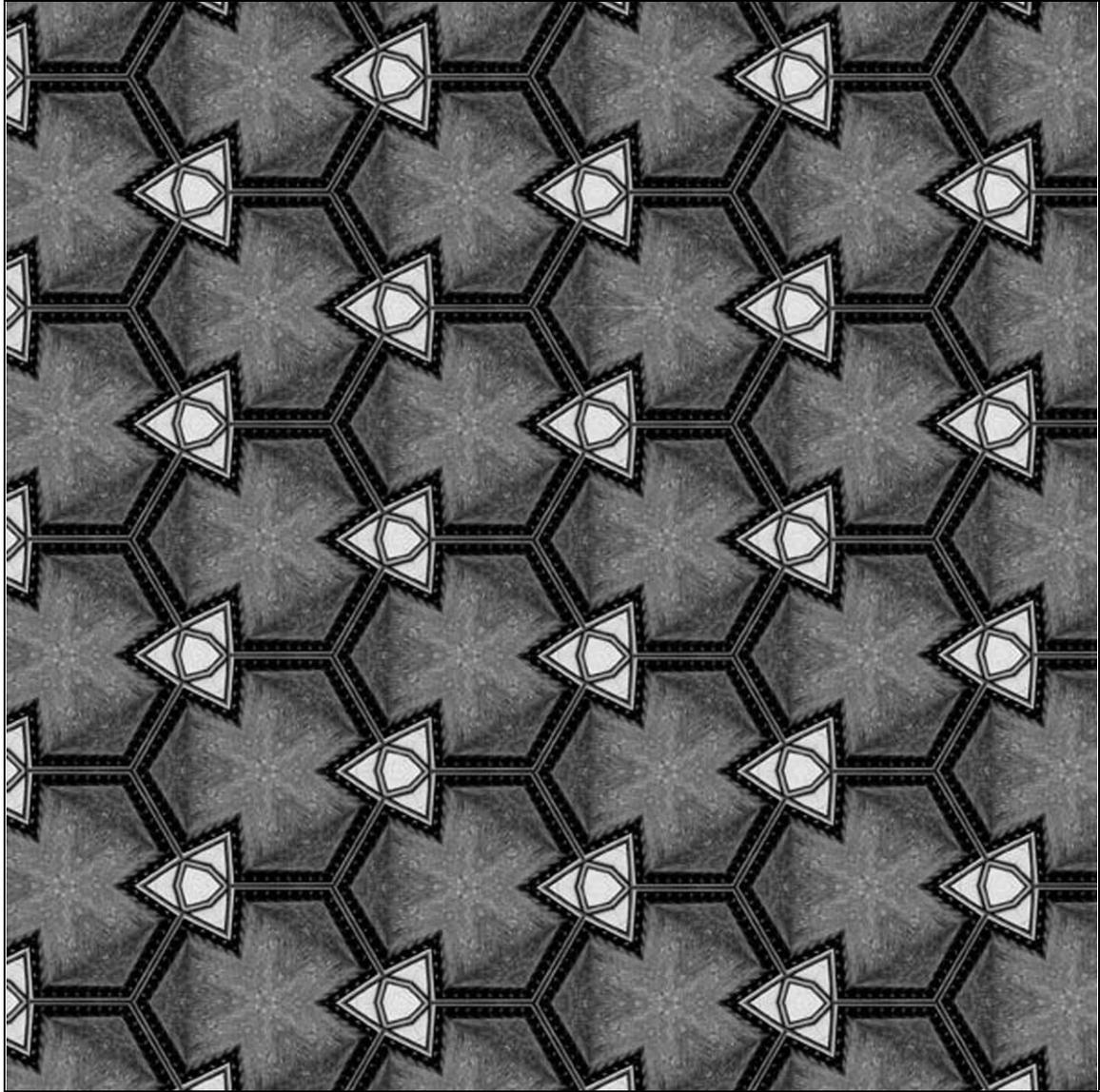


Figure 26: Pattern 1  
(Moser, 2002)



**Figure 27: Pattern 2  
(Moser, 2002)**

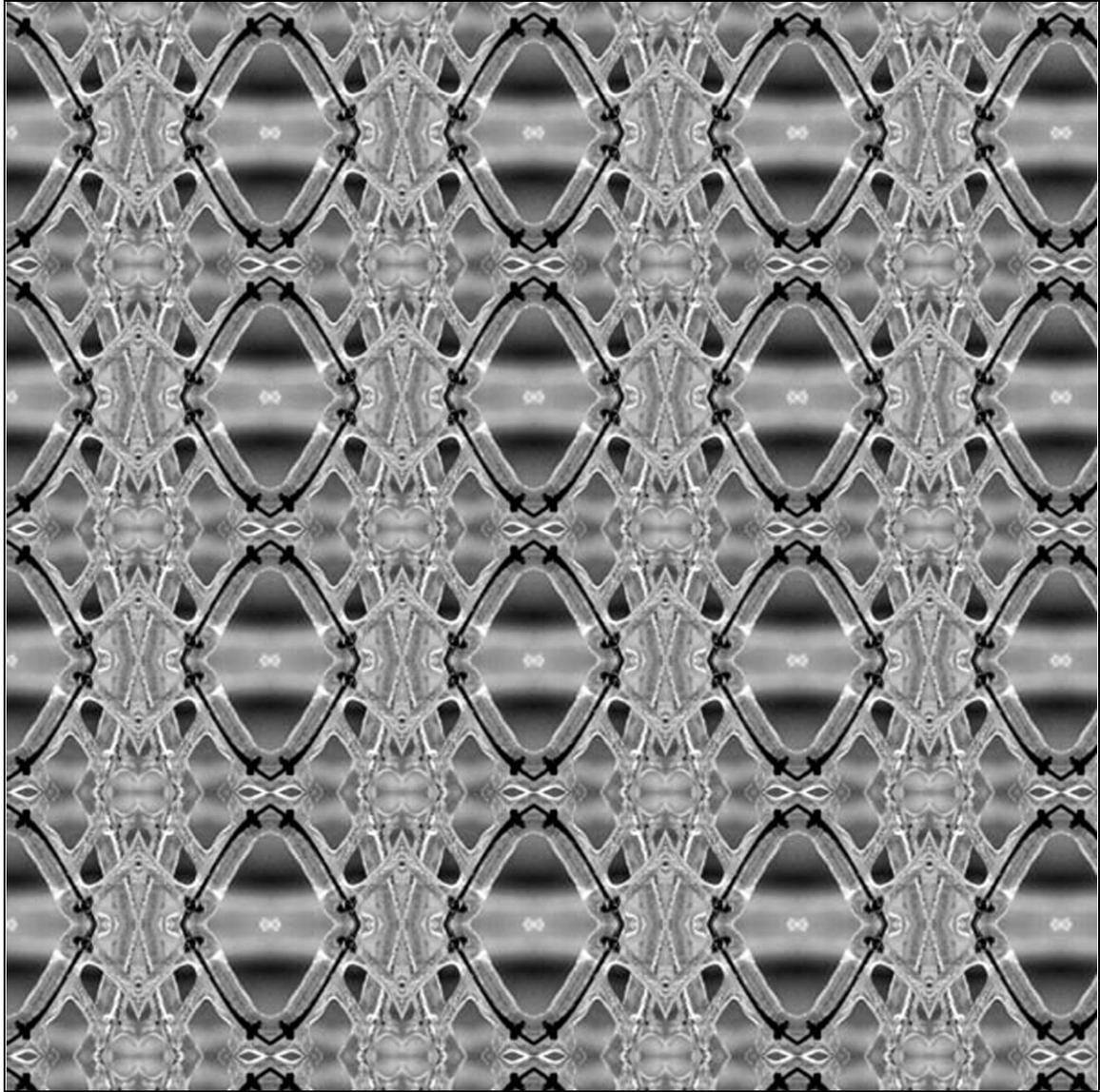
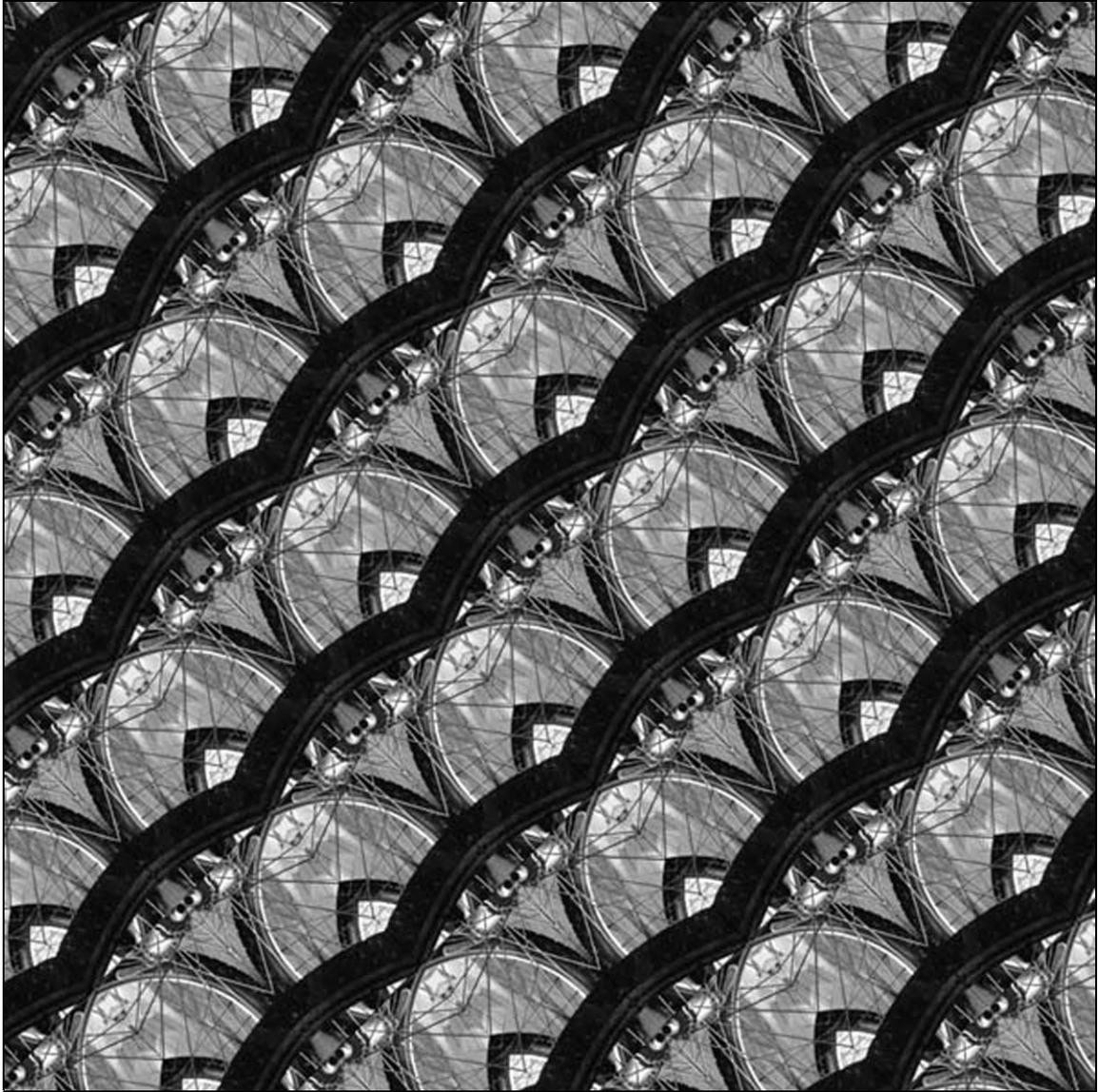
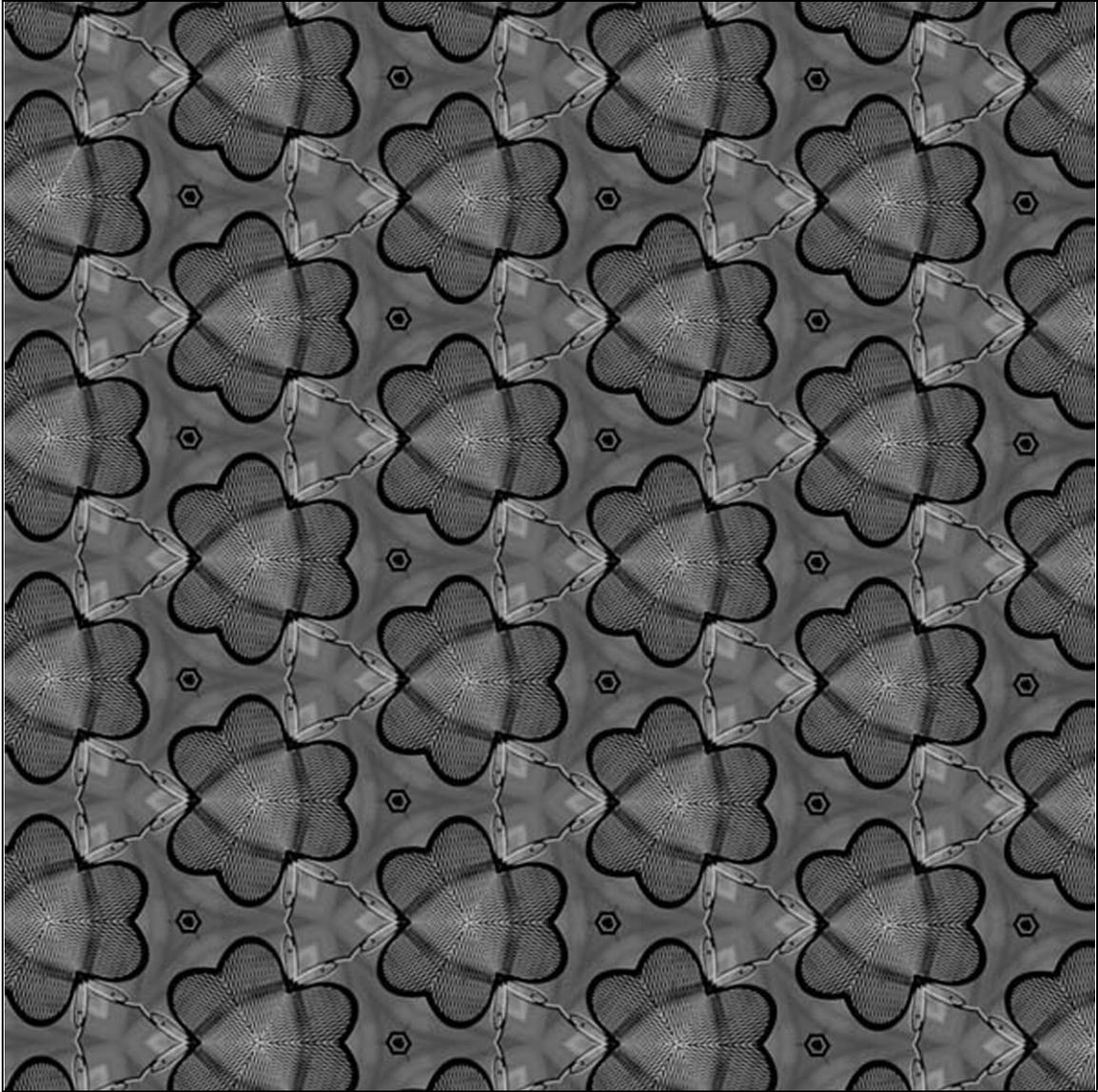


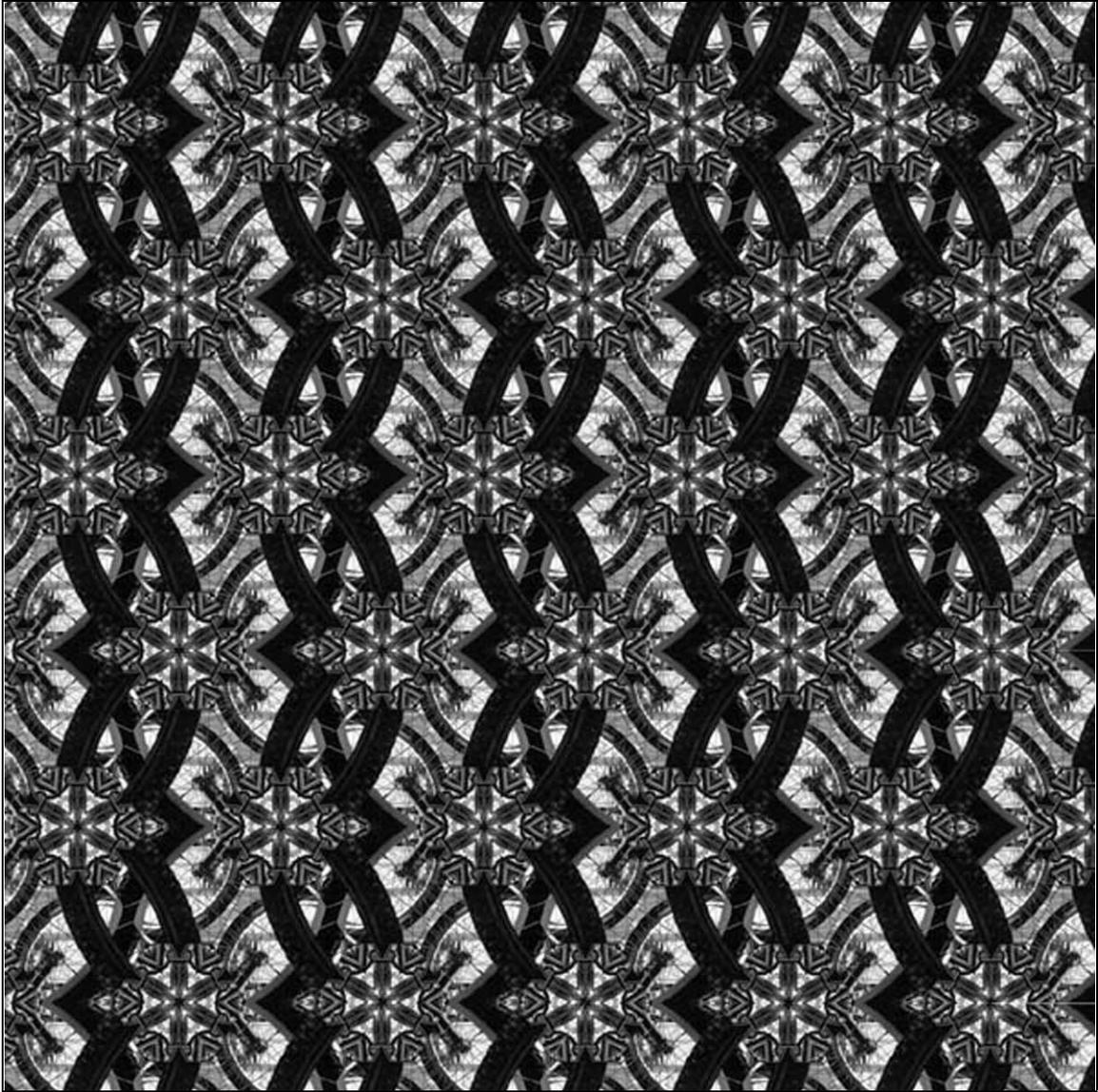
Figure 28: Pattern 3  
(Moser, 2002)



**Figure 29: Pattern 4  
(Moser, 2002)**



**Figure 30: Pattern 5  
(Moser, 2002)**



**Figure 31: Pattern 6  
(Moser, 2002)**

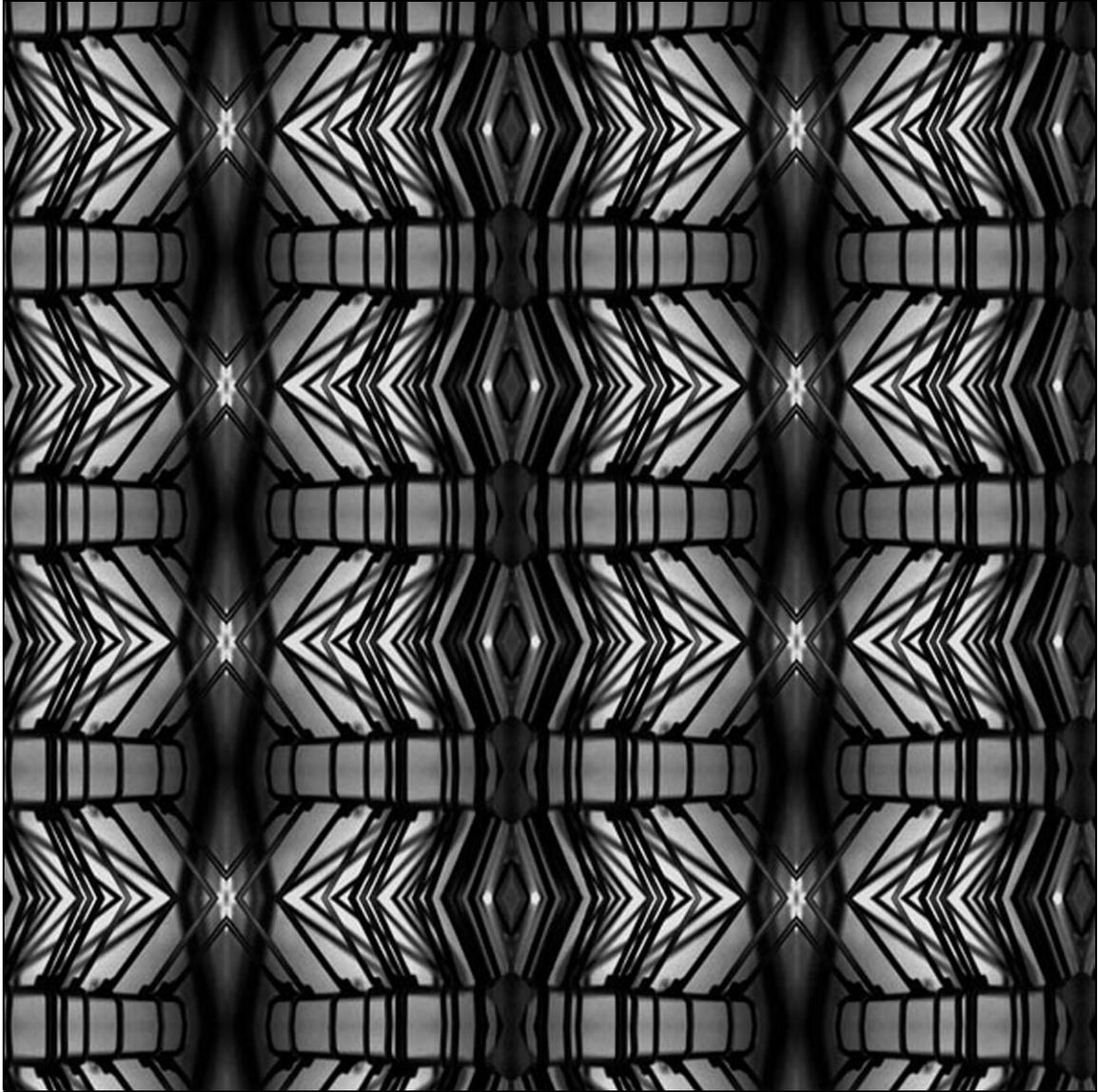
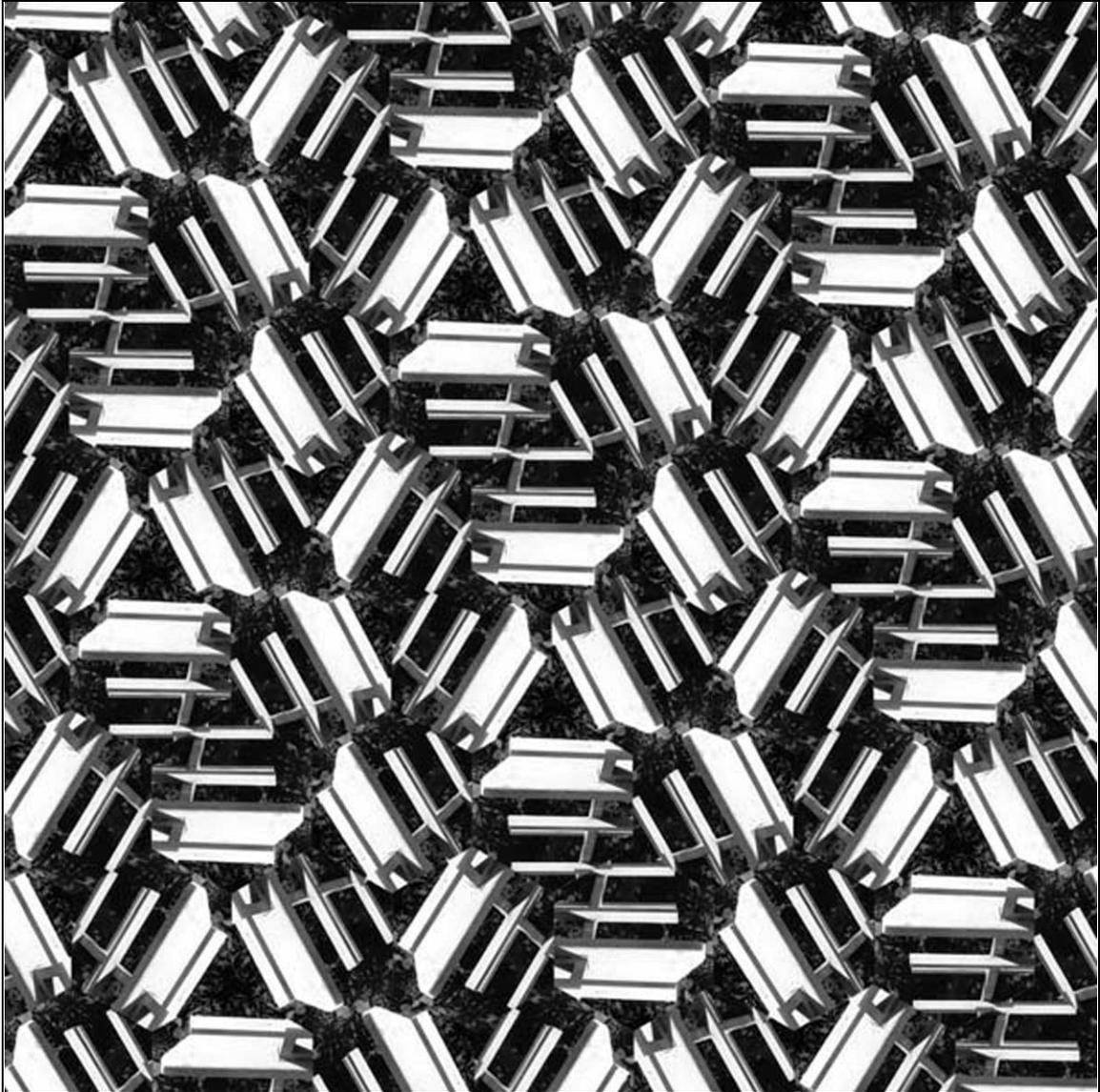


Figure 32: Pattern 7  
(Moser, 2002)



**Figure 33: Pattern 8  
(Moser, 2002)**

## **Design Elements within Photographic Patterns**

In order to evaluate the eight photographic patterns for their representation of basic design elements, the intended design elements had to be chosen and then validated for use in this research.

### **Chosen Design Elements**

After reviewing several resources on basic design elements and principles, four of the five previously reviewed design elements were chosen to be represented by the patterns in this research: *Line*, *Shape*, *Value* and *Texture*.

The exclusion of the element *color* was due, first and foremost, to the fact that all of the photographs used in generating the photographic patterns were made with black and white film. Secondly, color was eliminated because of its extreme dynamic qualities, including the variation in color interpretation among individuals, and its varying effect on viewers.

Color was also eliminated while looking ahead to the setup of the internet survey tool. Software and hardware used to create and evaluate color, such as computer monitors (employing programs such as Adobe Photoshop), printers and scanners all read and display colors very differently. While scanners and monitors measure color in RGB (red, green, blue) mode, typical four-color printers produce color in CMYK (cyan, magenta, yellow, black). This difference is currently a key problem in the textile dyeing and printing industries, as designers and colorists

struggle to communicate color effectively to manufacturers and producers of textile products (Chapman, 2002).

### **Validation of Design Elements by Design Professionals**

In order to assign the four chosen design elements to each of the eight photographic patterns, the representation of the elements within the patterns was first validated by a panel of eight design professionals. The defining aspects for each person to be considered a design professional included their background and education in design, as well as the current utilization of their design knowledge. Each of the professionals is presently an educator in Design Fundamentals and/or Textile Design at the university level. A survey tool was developed, which included an individual “Design Element Evaluation Sheet” for each of the professionals (see *Appendix A*).

Each of the eight patterns was digitally printed on a Hewlett Packard Designjet, mounted as a 6”x6” square on 8.5”x11” white cardstock, and labeled as Images 1 through 8 (Figures 26-33). Each 6”x6” square was large enough to contain eight or more repeat units within the pattern. The scale of each pattern was considered before surveying the professionals, including the clarity of the imagery and details of each pattern. However, this would not necessarily be the final scale used in the internet survey tool.

The professionals being surveyed were presented the eight patterns and an evaluation sheet. The instructions were to consider the patterns and the four design elements provided (*Line, Shape, Value, and Texture*). For each of the eight

patterns, evaluators were to assign the two elements that were best represented in that pattern. The assignments were to be made in such a way that each element was used only four (4) times, and each pattern was assigned only two (2) elements. This would allow each element to be equally represented among the patterns, which would be important for data analysis of the internet survey tool.

Each professional was surveyed individually, and was not allowed to consult with anyone else about their assignments. They were only allowed to ask the administrator logistical questions which were relative to the survey format and completion of the survey.

After all eight professional subjects had completed the survey, their answers were statistically evaluated to determine which design elements would be represented by each of the eight photographic patterns. Since the professionals chose two elements for each pattern, their choices were combined and evaluated so that each pattern had a 1<sup>st</sup> choice and a 2<sup>nd</sup> choice variable. The 1<sup>st</sup> choice was the element that was chosen the greatest number of times among all the subjects. The 2<sup>nd</sup> choice was the element that was chosen the next greatest number of times among all the subjects (see *Appendix B*).

### **Garment Flats**

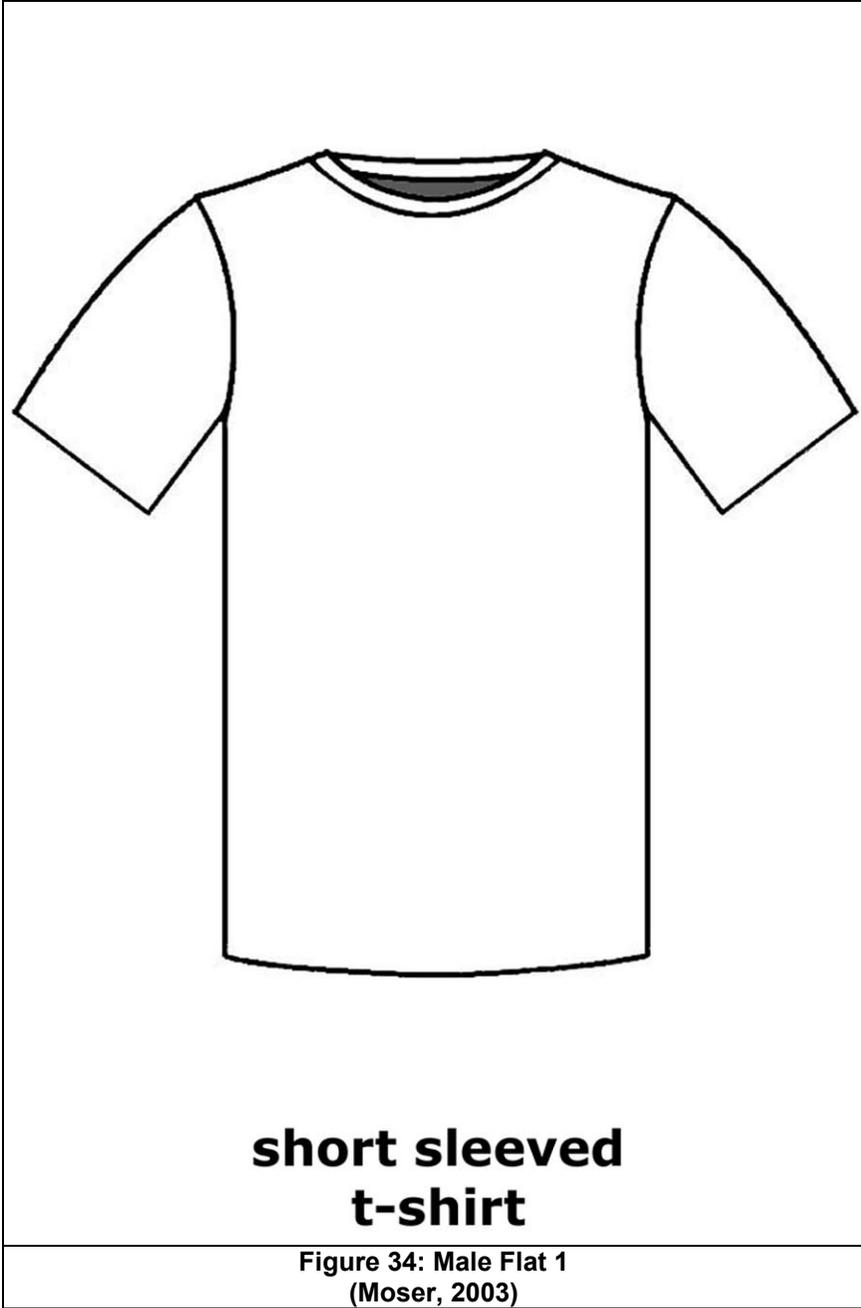
The internet survey tool, which was the primary tool used in this research, employed the use of the eight photographic patterns by allowing subjects to choose a pattern and view it “modeled” or applied to a garment flat. The survey was divided

into two different sections for male and female subjects. Male subjects were presented with six garments traditionally worn by male consumers, while females viewed six garments traditionally worn by female consumers.

The garment flats were created in Micrografx Designer® Version 7.1 software. The administrator intended to use basic garment flats in classic shapes. 12 garment flats (6 male and 6 female) were designed in Micrografx® using images from its database of generic flats, importing the flats into Adobe Photoshop 7.0, and altering them according to the desires of the administrator.

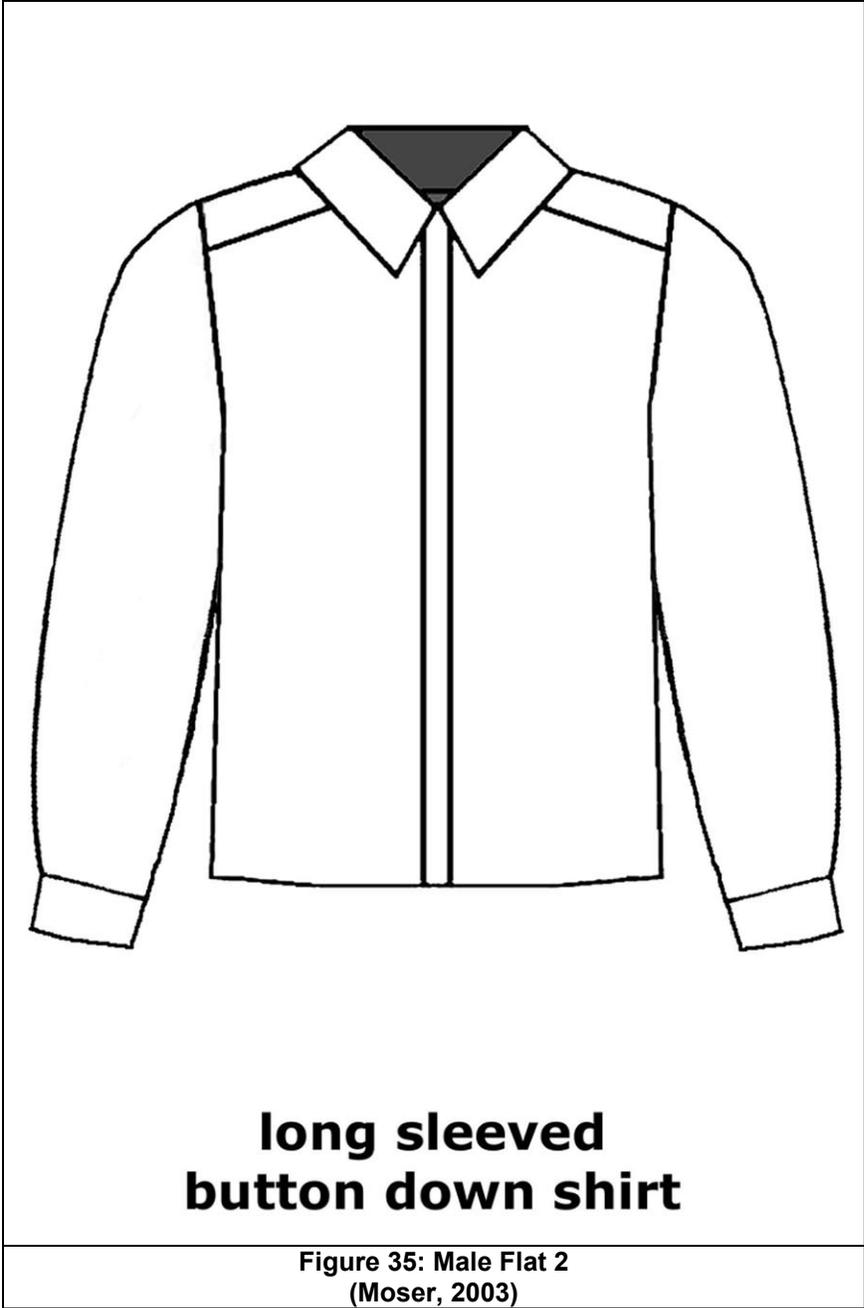
### **Male Flats**

The six garments presented to the male survey subjects (Figures 34-39) were chosen based on their traditional use in male clothing, as well as for their clean lines and basic shape. These garments were designed with the intent to appeal to a broad range of tastes, using both short and long sleeves, shirts with a collar and no collar, and both pullover and button-down styles. Each flat was titled with a descriptive name.



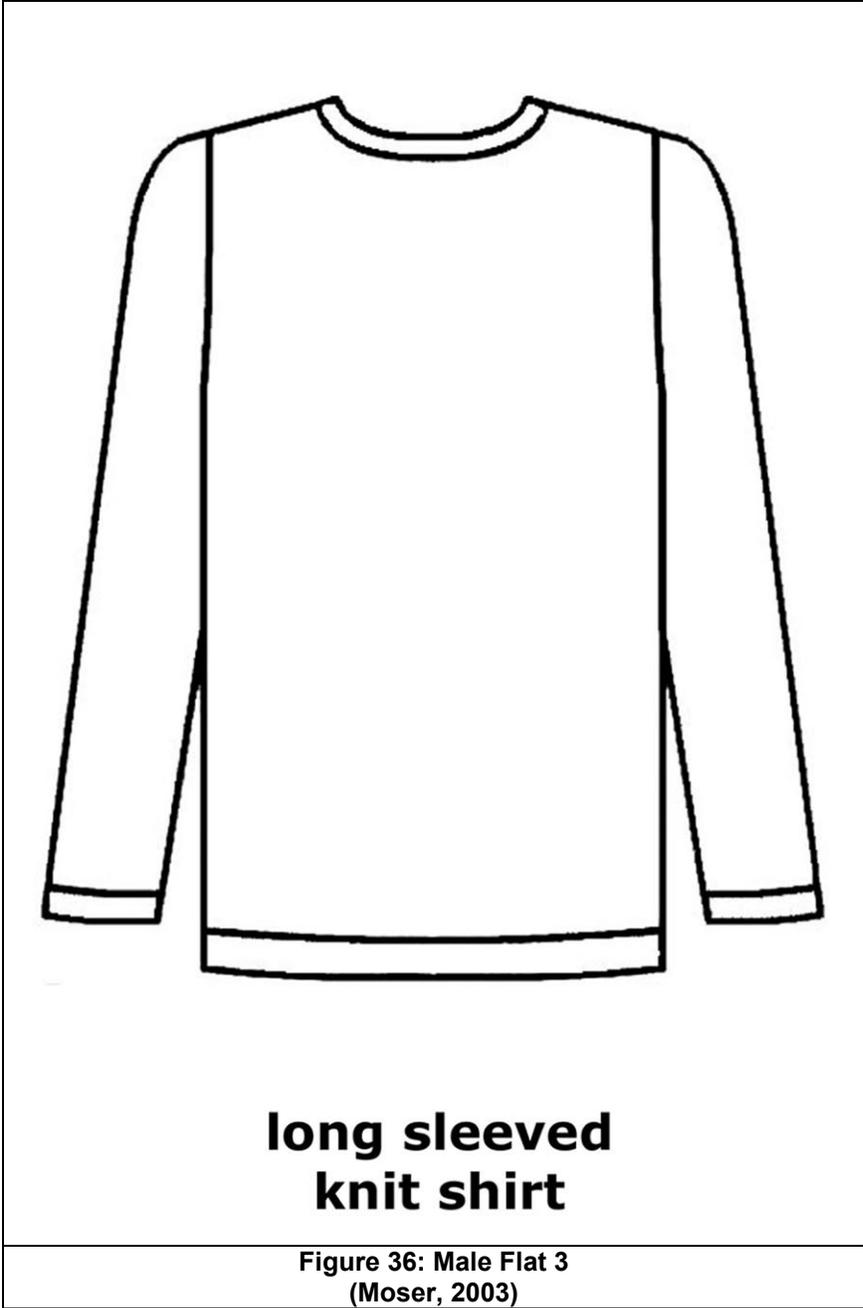
**short sleeved  
t-shirt**

Figure 34: Male Flat 1  
(Moser, 2003)



**long sleeved  
button down shirt**

Figure 35: Male Flat 2  
(Moser, 2003)



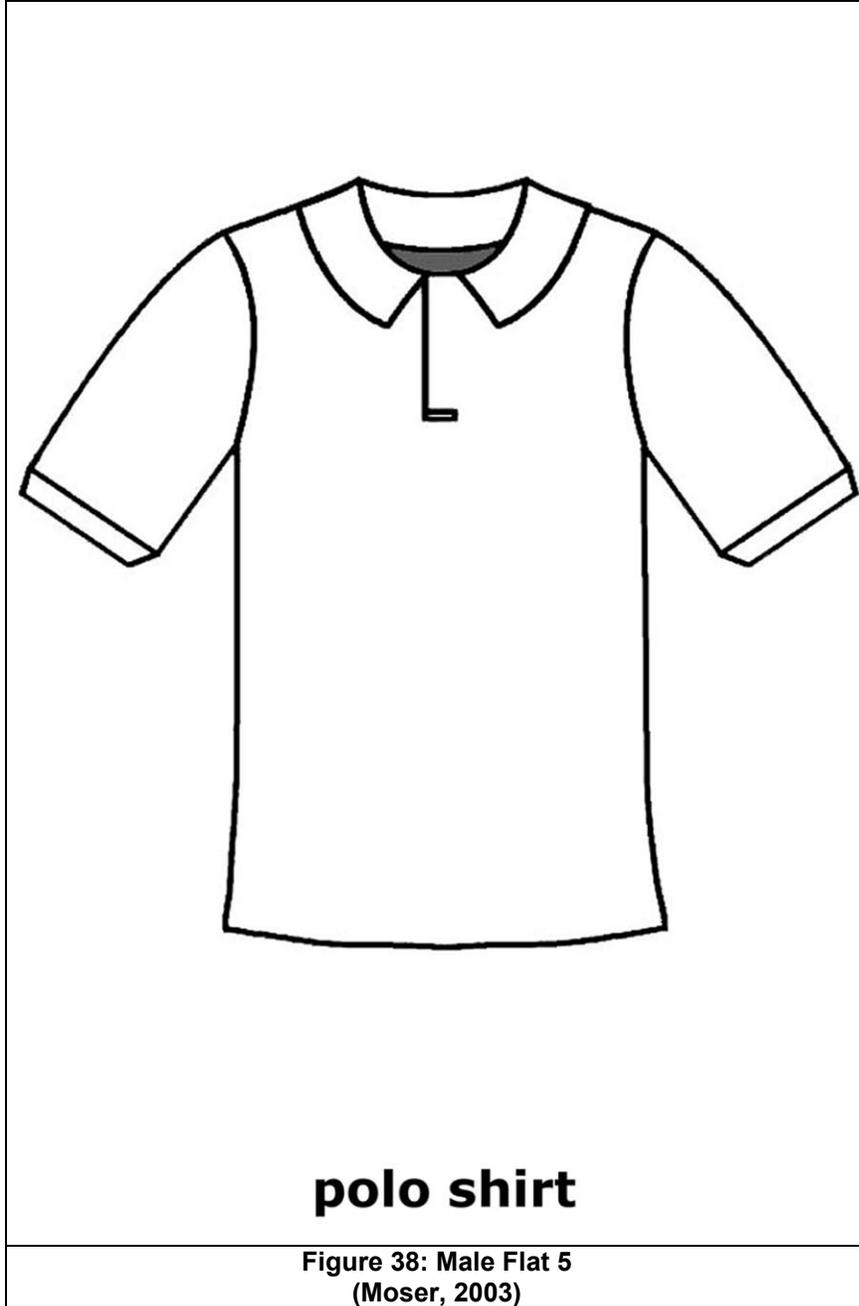
**long sleeved  
knit shirt**

Figure 36: Male Flat 3  
(Moser, 2003)



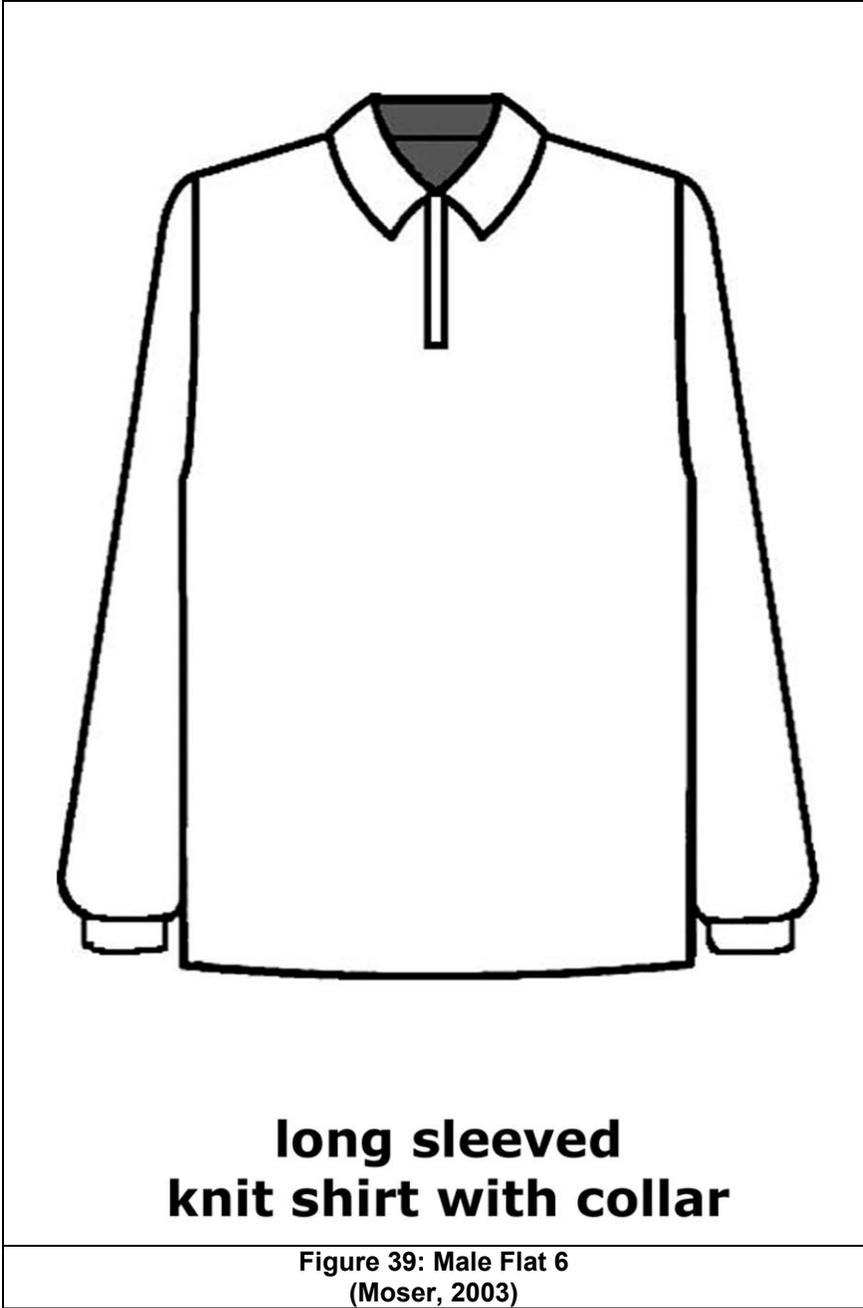
**v-neck  
t-shirt**

Figure 37: Male Flat 4  
(Moser, 2003)



**polo shirt**

Figure 38: Male Flat 5  
(Moser, 2003)

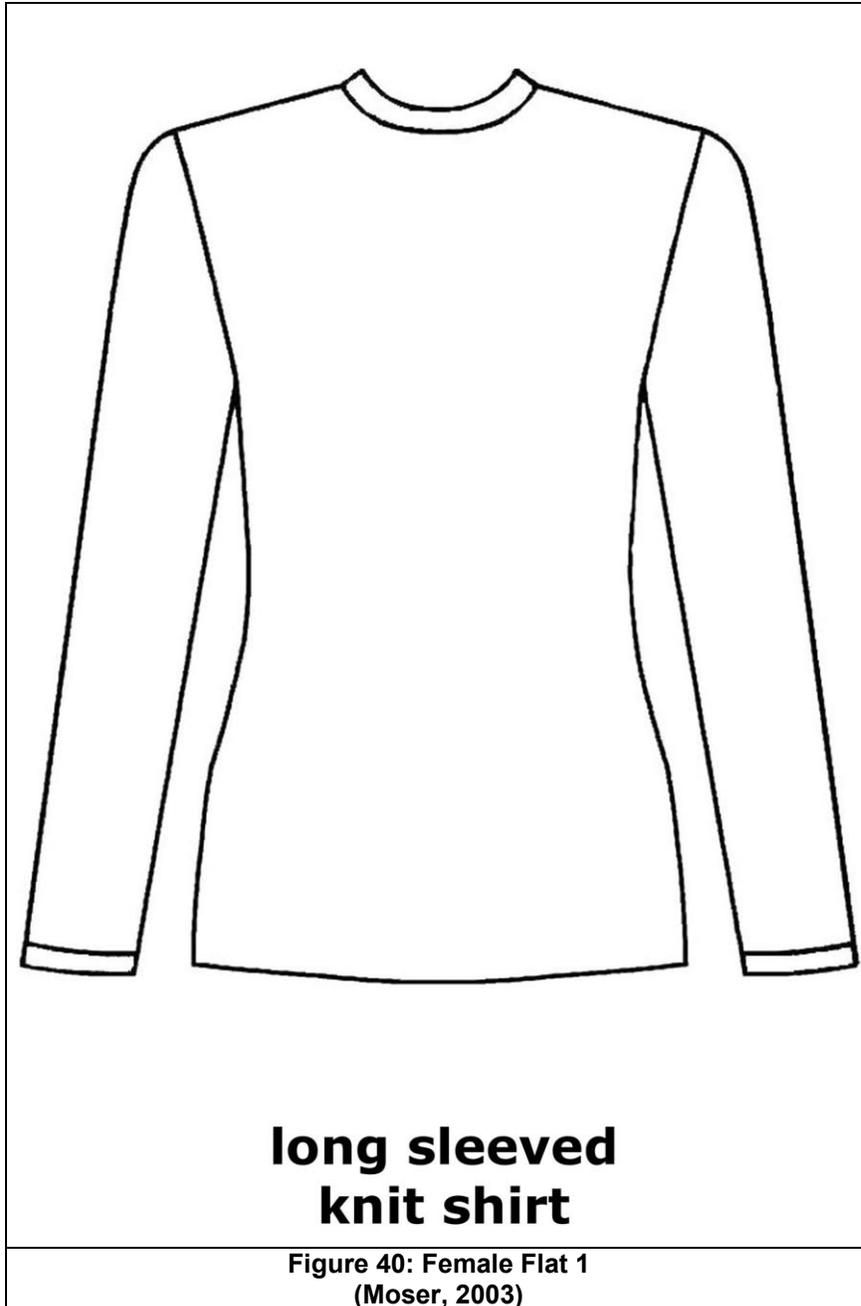


**long sleeved  
knit shirt with collar**

Figure 39: Male Flat 6  
(Moser, 2003)

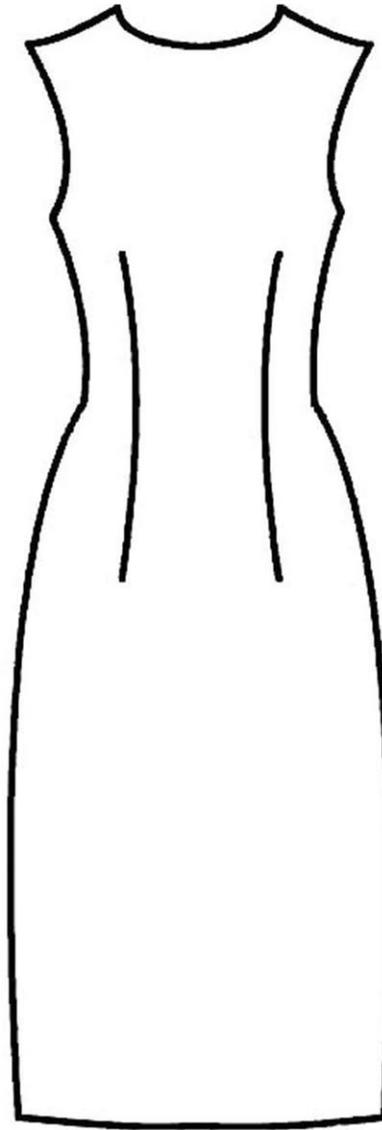
## **Female Flats**

The six garments presented to the female survey subjects (Figures 40-45) were, like the male flats, chosen based on their traditional use in female clothing, as well as for their clean lines and basic shape. These garments were designed with the intent to appeal to a broad range of tastes, including garments with both short and long sleeves, and garments with a wide variety of shapes in response to the variations in female figure types (Simmons, 2002). Each flat was titled with a descriptive name.



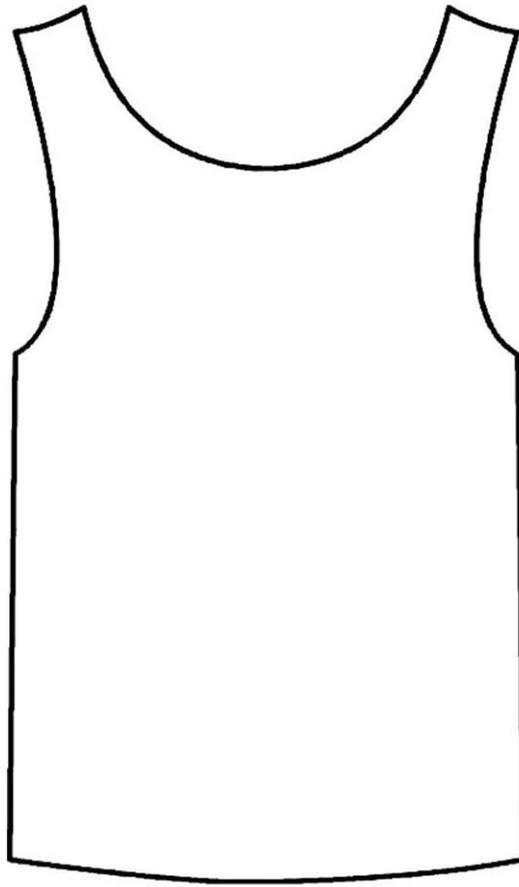
**long sleeved  
knit shirt**

Figure 40: Female Flat 1  
(Moser, 2003)



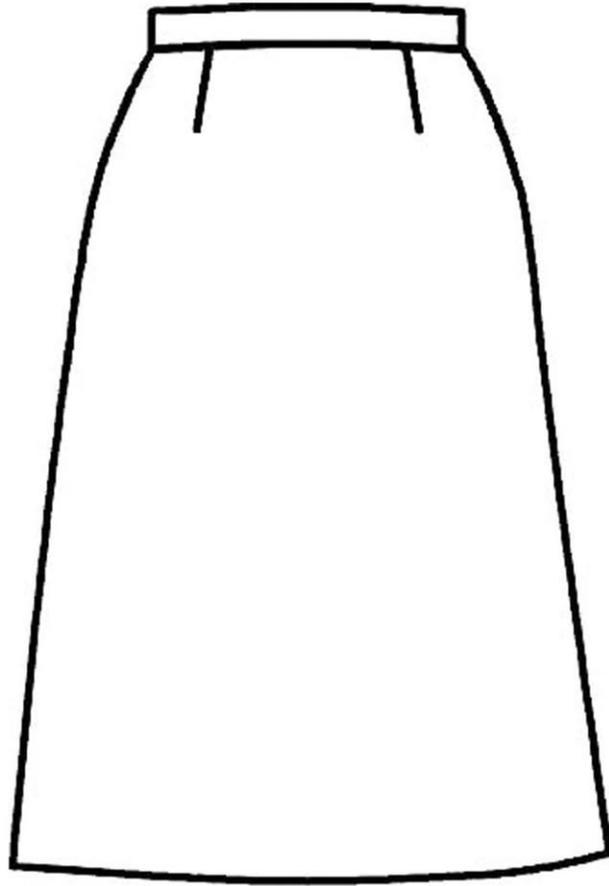
**sheath dress**

Figure 41: Female Flat 2  
(Moser, 2003)



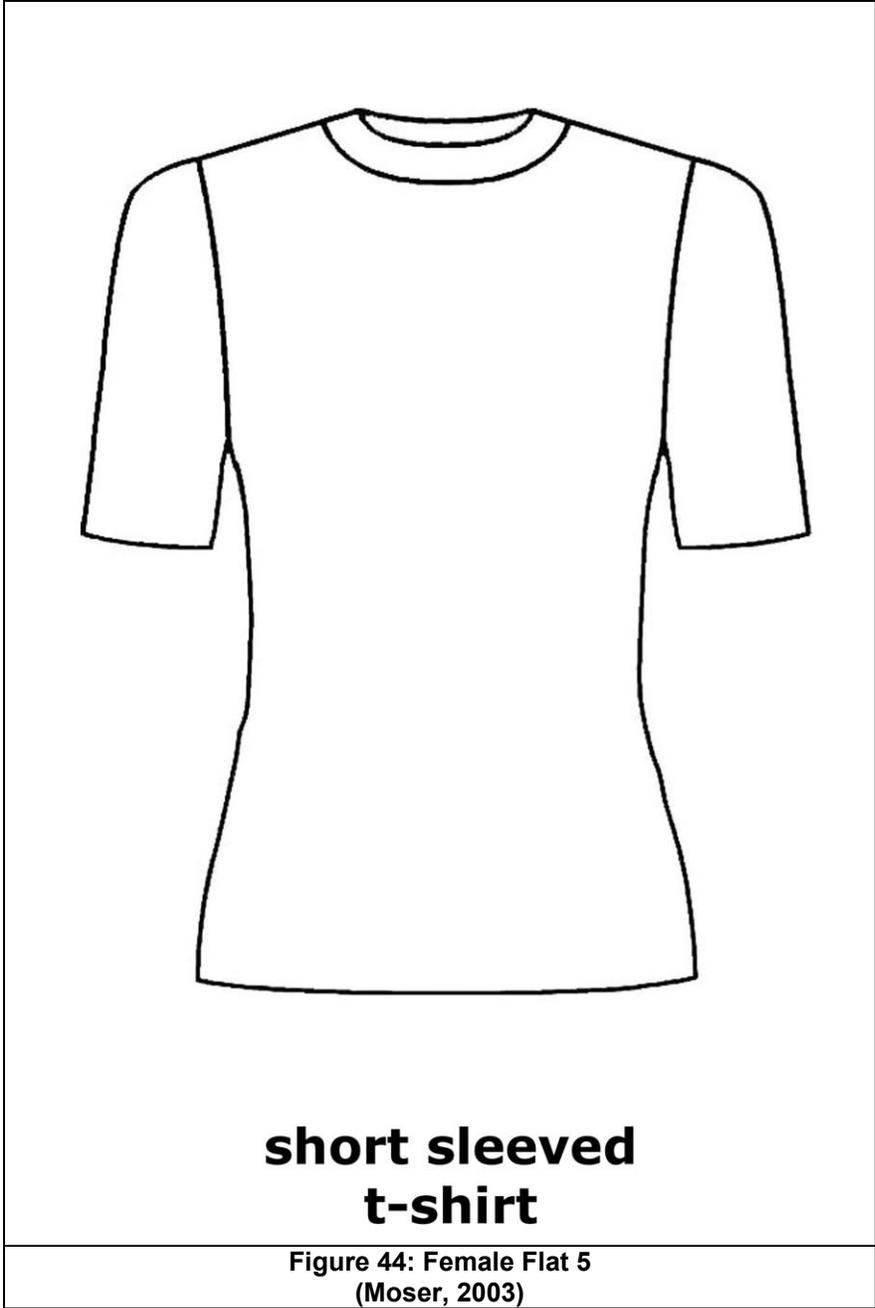
**tank top**

Figure 42: Female Flat 3  
(Moser, 2003)



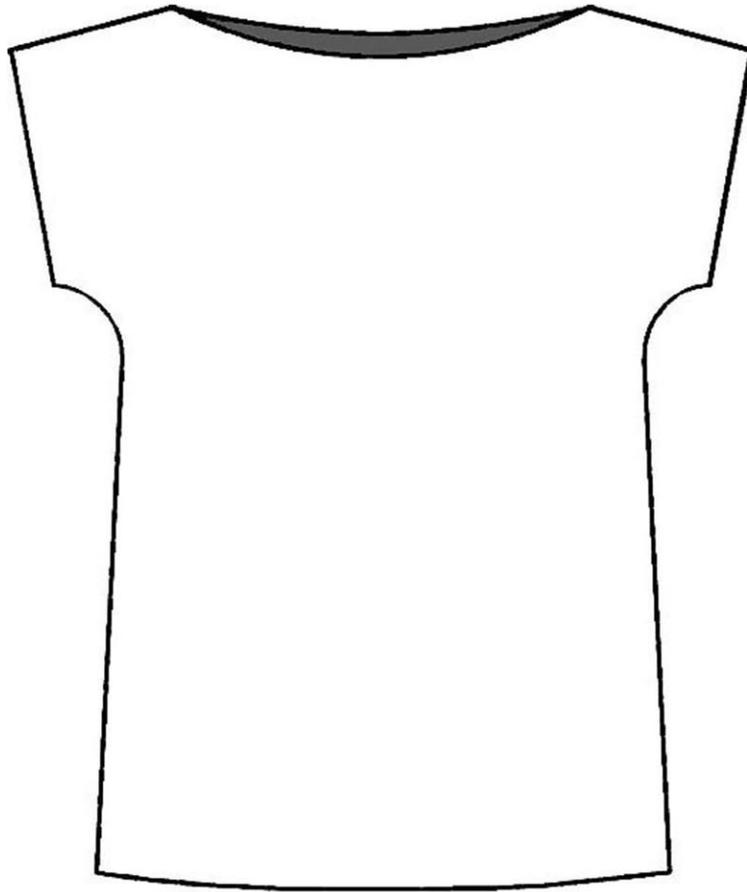
## **A-line skirt**

Figure 43: Female Flat 4  
(Moser, 2003)



**short sleeved  
t-shirt**

Figure 44: Female Flat 5  
(Moser, 2003)



**short sleeved  
boatneck t-shirt**

Figure 45: Female Flat 6  
(Moser, 2003)

## **Online Survey Structure**

The internet survey tool was designed and built with the assistance of a webmaster, Shawn Dunning, using Macromedia Dreamweaver® MX. While the author was the primary designer of the survey layout, the webmaster was responsible for all implementation of the design into Dreamweaver®, and for consistent maintenance of the survey throughout its duration.

The webmaster also created and maintained the data collection from the survey. The survey employed a function in which the data was immediately transferred to a database spreadsheet upon each subjects' completion of the survey. For sample pages from the survey, see *Appendix D*.

### **Assessment of Current Trends in Internet Website Functions**

The goals in creating the internet survey tool included the desire for a user-friendly site with easy-to-use functions and minimal content. Users would have a clear and concise understanding of how to complete the survey.

When researching current trends in websites for inspiration and ideas, one site that was outstanding among many others as a user-friendly and easily navigated site was that of women's apparel retailer J.Jill™.

J.Jill™ allows viewers to choose a garment and change the applied color or pattern by clicking different fabric swatches. An example is shown in figures 46-47. A knit sweatshirt is shown in "petal pink" when the fabric swatch of the same name is clicked. When the next fabric swatch, "geranium", is chosen, the sweater displays the new color.

It was evident that the internet survey tool used in this research could benefit from the same type of function. Subjects could click on one of the eight patterns and immediately view it modeled on a garment. The pattern choice could be changed by clicking a different pattern.

J. Jill - product detail: lightweight stretch terry sweatshirt - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Media Print

Address http://www.jjill.com/ShopJJillDetail.asp?SID=&AreaID=OL&SizeID=1&txtprod

**J. Jill** order now, pay nothing

home online catalogs

misses' petite women's tall

### knit tops & tees

previous | next



**lightweight stretch terry sweatshirt**  
Ultrasoft comfort. Cotton voile with eyelet trims the sleeves and inset. Oversized fit. Overlock stitching. 23 1/2" length, 22" petite, 25" women's. In pure cotton touched with spandex for ease. Machine wash. Imported.

> [view larger](#)  
> [view on model](#)

click a swatch to change product color

			
petal pink	geranium	ivory	snow pea

**Figure 46: J.Jill™ color selection 1, *petal pink***  
(Taken from JJill.com online retail website, 2004)

J. Jill - product detail: lightweight stretch terry sweatshirt - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Media Print

Address http://www.jjill.com/ShopJJillDetail.asp?SID=&AreaID=OL&SizeID=1&xtpro

*J. Jill* order now, pay nothing

home online catalogs

misses' petite women's tall

knit tops & tees

← previous | next →



**lightweight stretch terry sweatshirt**  
 Ultrasoft comfort. Cotton voile with eyelet trims the sleeves and inset. Oversized fit. Overlock stitching. 23 1/2" length, 22" petite, 25" women's. In pure cotton touched with spandex for ease. Machine wash. Imported.

> [view larger](#)  
 > [view on model](#)

click a swatch to change product color

			
petal pink	geranium	ivory	snow pea

**Figure 47: J.Jill™ color selection 2, geranium**  
 (Taken from JJill.com online retail website, 2004)

## **Survey Design**

The goals of the survey design and layout were to create a user-friendly site that would require the minimum amount of time to complete, and be easy for the viewer to understand. The visual appearance of the survey, including text, colors and images, would be simple and non-threatening to viewers.

Since the desired data acquired from the survey included a general consumer profile, the survey would require the subjects to answer some basic demographic questions (see p. 81 for more on demographics). Additionally, the subjects would be allowed to contribute their own questions or feelings regarding the survey through a comments section on the last page of the site.

**Visual Simplicity.** The survey tool was designed exclusively in a greyscale layout. This choice was made primarily on the grounds that all of the photographic images were black and white. The elimination of color was intended to help prevent biased or swayed opinions based on a subject's personal and psychological reaction to a particular color.

All text was in black Arial font, with a medium grey background on all pages in the survey. There were no images or symbols used in the survey other than the eight photographic patterns (Figures 26-33) and the 12 garments (Figures 34-45) in question.

The survey included a copyright statement on every page, reminding subjects and viewers of the proprietary use of all images and designs by the administrator.

The copyright statement was as follows:

*All images on this site under copyright 2003-2004, all rights reserved.*

**Ease of Use.** In order to create a survey that would be user-friendly and simple to understand, all menus and choice functions were created in Macromedia Dreamweaver® MX using buttons, radio buttons, list menus, checkboxes, and text areas. The survey also included a function that prevented subjects from progressing in the survey without making a choice for every existing field.

**Anonymity for Subjects and Administrator.** It was important that both the administrator and the subjects remained anonymous throughout the duration of the survey. The anonymity of the administrator and any related affiliates would prevent a biased or swayed opinion by the subjects.

The survey was located at a privately purchased domain that was not linked to any recognized organization or affiliate. No names or titles appeared on the survey. At no point were subjects required to disclose personal contact information including their name, mailing address, email address, phone number, or similar data. Subjects were, however, given the option to make comments at the closing of the survey before submitting their answers. Comments could include whatever information, questions or suggestions they wished. Subjects were informed that should they leave contact information and request a reply from the administrator, they would be contacted after the research was completed.

### **Demographics**

In order to profile a specific consumer and their preferences as related to this research, it was necessary to include a demographics section in the survey.

*Demographics* are defined by Kaiser & Garner as “statistics about a given population with respect to age, gender, marital status, family size, income, spending habits, occupation, education, religion, ethnicity, and region” (2003). The demographics included only information which was relative to general consumer profiling, based on several resources and texts.

The following five sections describe the demographics information required of the subjects. Only consumers who currently live in the U.S. were evaluated in the research. Refer to Appendix C for a complete list of field choices from each demographic category in the survey.

**General Categories.** Consumers were first asked to indicate their gender. Men’s shopping habits differ significantly from women’s, and the priorities are very different as well (Kaiser & Garner, 2003).

Next, subjects were to choose their age group. Many apparel products today are designed to be targeted at a specific aged consumer. Defining the age group of a target market is important when developing a new apparel product, since, for example, it is highly unlikely that a 13-year-old and a 33-year-old would prefer the same styles and trends in clothing (Kaiser & Garner, 2003).

The ten age groups used in this research were determined by assessment of the *generational cohort groups* which are active in today’s consumer market. A cohort group is defined by Kaiser & Garner as members of a generation who “are linked through shared life experiences of their formative years” (2003). These experiences may include pop culture, world events, celebrities, and political events.

The *Matures* are the eldest cohort group, comprised of those born between 1909 and 1945 (Kaiser & Garner, 2003). Because of its wide age range, the Matures were divided into the Upper Matures (ages 77-95) and Lower Mature (ages 59-76). Next are the *Baby Boomers*, born between 1946 and 1964 (Kaiser & Garner, 2003). Again, because of its large span, this cohort group was divided into the Upper Boomers (currently ages 49-58) and Lower Boomers (currently ages 40-48). The next cohort group is *Generation X*, including those born between 1965 and 1978 (Kaiser & Garner, 2003). This group was divided into the Upper Gen X (currently ages 33-39) and Lower Gen X (currently ages 26-32).

The youngest cohort group, called the *Generation Y* or *Echo Boomer*, consists of those born between 1979 and 1996 (Kaiser & Garner, 2003). This cohort group was defined by those who are currently ages 8-25. The wide age range of this group would create difficulty in evaluating the differences in opinion among this group. It is very unlikely that a 25-year-old will have the same tastes as a 10-year-old. To alleviate this problem, the group was divided by ages at which consumers reach significant turning points in their lifetime. The first group singled out was ages 18-25, accounting for young college-aged consumers who have just finished high school through young adults entering adulthood. Next, ages 12-17 were separated to account for pre-teens to teenagers. The lowest age group was defined as anyone under the age of 12.

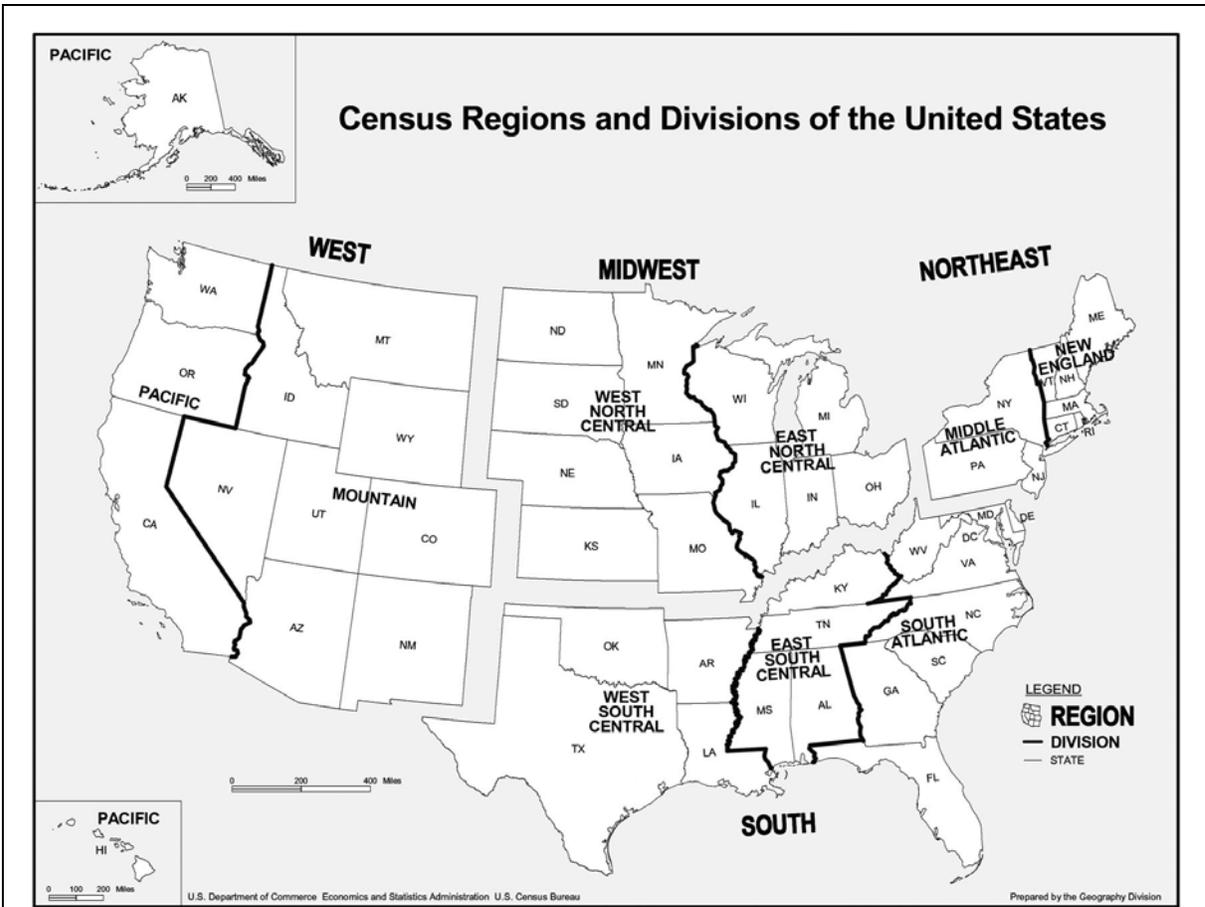
Although these cohort groups covered the majority of current age ranges, there remained the group of people born prior to 1909, who were simply categorized as “95 or older” in the survey.

Subjects were then asked to define their marital status. Marital status greatly affects the way a consumer spends his or her money. Single consumers are typically more interested in fashion and entertainment, and are willing to allocate more of their income towards these interests than are married consumers. Married couples are more likely to consider other expenses such as family before spending on themselves (Kaiser & Garner, 2003).

The size of a family, or the number of dependent minors living in a household, has a great effect on the amount of money needed for purchasing apparel and related items. A family with one child is far less likely to spend as much money as a family with 4 children. Additionally, the age range among siblings in one family may affect the kinds of trends and fashions to which that family is exposed (Kaiser & Garner, 2003)

**States and Regions.** In order to obtain a more dense portrayal of the surveyed U.S. consumers’ geographical locale, the 50 U.S. states, including the District of Columbia, were divided and grouped into nine regions based on the Census Regions and Divisions of the United States (U.S. Census Bureau, 2002). The nine divisions were New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain and Pacific (Figure 48). The grouping of states into regions allowed for a broader view of

consumer habits as related to their general location within the U.S. Geographical location can affect the trends and styles preferred by consumers from a particular region (Kaiser & Garner, 2003). The weather of a region dictates the clothing worn in that region as well. Regions with a wide variety of ethnicities or nationalities must be recognized and acknowledged when planning specific styles of garments, as well as the languages and symbols used in the advertising and supplements that coordinate with their apparel products (Kaiser & Garner, 2003).



**Figure 48: Census Regions and Divisions of the United States  
(Taken from U.S. Census Bureau, 2002)**

**Occupation and Education.** A consumer's occupation can have a direct effect on the amount of money he or she can spend on apparel and similar items. It can also dictate what kinds of clothing are suitable for that person, depending on whether they go to work, school, or other (Kaiser & Garner, 2003).

The list of choices for occupation was created as a checkbox section which allowed subjects to choose one or more occupational descriptions, since many jobs cover a broad range of responsibilities, skills and expertise. The list of occupations was derived from the Standard Occupational Classification (SOC) System. Acquired from the Bureau of Labor Statistics through the U.S. Department of Labor, the SOC system is "used by all Federal statistical agencies to classify workers into occupational categories for the purpose of collecting, calculating, or disseminating data. All workers are classified into one of over 820 occupations according to their occupational definition" (U.S. Dept. of Labor, 2002).

To lessen the depth and make the occupational choices more realistic for a survey of this magnitude, a modified version of the SOC system list of Major Occupational Groups from 2002, used by the Bureau of Labor Statistics, was substituted in place of the 820 occupations outlined in the complete SOC system.

Subjects were also given the choices of *student*, *retired* and *unemployed*, and a free text area titled "other", in which they could explain a different occupation if they felt the given choices did not include their personal situation.

The educational background of a consumer is also directly related to their apparel needs in the workplace, including their income and lifestyle (Kaiser &

Garner, 2003). Education can also affect a consumer's perceived importance of the level of work and effort put into designing and manufacturing the apparel products, as well as the functionality and serviceability of the item (Kaiser & Garner, 2003).

**Annual Household Income.** Analyzing a consumer's disposable income can help determine what brands are affordable to that consumer. However, the request for subjects to disclose their annual household income in this survey was expected to be met with some resistance. With the understanding that subjects who were turned off or offended by such a question could choose not to participate in the survey or even give inaccurate information, it was a question that was deemed necessary when considering the demographic profiling of a consumer. A person's income can directly affect the way he or she spends their money on apparel products, as well as what kinds of apparel products the consumer might need on a daily basis (Kaiser & Garner, 2003).

**Clothing and Accessories Expenditure.** As stated before, the amount of money a consumer makes can dictate how much he or she spends on apparel products. Spending habits are also directly affected by the ever-changing income levels of an economy. The federal government uses special methods of demographic profiling to assess the fluctuation in prices of specific product categories, and how the changes affect consumers. This can also help form an idea of what consumers will or won't spend in specific regional areas (Kaiser & Garner, 2003).

For the internet survey, subjects were asked to indicate approximately how much money they spent each month on clothing and accessories. The responses to this question could suggest that a certain type of consumer (i.e., specific age, gender, regional location, etc.) might be willing to spend specific amounts of money on apparel products.

### **Texture Mapping on Garment Flats**

In order to prepare each garment for use in the survey (6 female flats, 6 male flats), each of the eight photographic patterns needed to be mapped or modeled onto the twelve flats. This would be necessary for subjects to sample each pattern applied to all flats, so they could choose the pattern they preferred on each garment.

**Placement and Scale of Patterns.** Each of the eight patterns was modeled or mapped on each of the twelve flats in Adobe Photoshop 7.0. This resulted in 96 different mapped flats which would ultimately be used in addition to the initial twelve basic flats with no pattern.

Placement and scale of the patterns on the flats was considered, although the responses or feelings of subjects as related to the pattern scale and location of repeats was yet unknown. Patterns were scaled to sizes which left the photographic imagery indistinguishable, while allowing details and a wide range of greyscale to be seen in the pattern.

### **Subject Comments**

The final page of the internet survey tool was a comments page for subjects. If a subject wanted to make comments or suggestions concerning the survey, they

were allowed to do so in a text area box before submitting their answers. As stated previously, subjects were reminded of their option to submit any information, questions or suggestions they wished. They were informed that they would eventually receive a response from the administrator when the research was completed. However, subjects who did not wish to leave comments could choose a “no comments” option button and end the survey.

The comments box was created by the webmaster with a function which allowed the administrator or webmaster to utilize and complete the survey multiple times without submitting their false answers to the database of actual subject answers. If the word *test* was typed alone in the comments box before submitting the survey answers, the entry was automatically deleted from the database. This function allowed the administrator and webmaster to view parts of the survey for technical evaluation without disrupting the database and having to delete any false entries manually.

### **Survey Administration**

In order to administer the survey and reach a wide variety of subjects, the survey was presented in a number of different ways to different people.

#### **Establishing a Domain**

Every computer on the Internet has an individual address called an *Internet Protocol* (IP) address. The *Domain Name System* (DNS) was created to replace these IP addresses (which typically appear as "232.105.X.X") with actual names,

since they are easier to recall. If the suffix of a domain is seen as *.com*, *.net*, and *.org*, then it is a *Top Level Domain* (TLD). A national TLD refers to a registry that is located in the country of origin, such as *.co.uk* for the United Kingdom (LCD, 2001).

A provider of internet domains called Low Cost Domains (LCD) was used to search for and purchase the domain for the internet survey tool. This website uses a search engine to find out whether your preferred domain name is available or already taken. LCD was not the provider of the web space used to house the survey, but rather the provider of only the domain name (i.e., the URL, or *Uniform Resource Locator*). Once purchased, the domain name is stationed at a temporary web address until a site is built and ready to be posted by the purchaser. A *web host* is used to actually provide the space for the survey to be posted under the domain, and in this case, the host was the website of the administrator's affiliate establishment (LCD, 2001).

The domain used to post the survey on the internet was not linked in any way to specific affiliates or organizations relative to the survey administrator or the research. In order to promote unbiased responses by subjects, the domain was independent of any recognizable name or person. The chosen domain, <http://www.design-survey.com>, was purchased from LCD at a cost of \$24 for one year of ownership, paid by the survey administrator.

### **Publicizing the Survey**

In order to obtain a wide range of responses from a preferably broad range of general U.S. consumers, the internet survey was released and promoted in a

number of different ways. The survey was announced in a short press release through the online *Journal of Textile and Apparel, Technology and Management* (JTATM, Volume 3, Issue 4) at <http://www.tx.ncsu.edu/jtatm/> under the *Graduate Research Project* section. The press release appeared as follows:

As an emerging technology in the textile industry, digital printing has introduced the capability of producing photo-realistic images on fabric that were never before possible with traditional textile printing methods. While it is expected that this achievement in technology will be appealing to consumers, how will designers and retailers know what kinds of images are most engaging? More importantly, how will they know what underlying basic design elements are most often preferred? Do consumers themselves even know?

The following research survey was designed to learn more about the preceding questions and other related issues. This survey is very simple and brief. Please click on the link below to begin.

[www.design-survey.com](http://www.design-survey.com)

**Figure 49: JTATM Press Release  
(JTATM, 2004)**

Personal and professional contacts of the administrator and research committee members were also notified by mass emails, and encouraged to pass the survey along to others who may have been willing to participate. Announcement of the survey was also posted on various online message boards.

### **Duration of the Survey**

The survey was officially posted online and fully functional on the afternoon of Friday, January 16, 2004 and closed on the afternoon of Monday, April 12, 2004.

The data collection occurred over a period of 12 weeks and 4 days. During this time, the survey accumulated 456 responses, although not all responses were

complete and finished. This was due to subjects who only partially completed the survey and did not finish and submit their finished answers at the end.

### **Data Analysis**

Analysis of the collected data was performed with the assistance of a statistical advisor, Ming Xiong, who used the SAS system.

### **SAS Testing Methods**

For analysis of the present factors in this research, a statistical model was constructed using a backward variable selection technique. The GEE (Generalized Estimating Equations) method was used to consider covariance between the six garment/pattern choices made by each individual subject. The responses were dichotomized for each image pattern, i.e. choosing or not choosing image pattern *i* (M. Xiong, statistical advisor, personal communication, April 2004). An example of how the statistical model was constructed and utilized can be found in *Appendix E*.

Additionally, the GENMOD (Generalized Linear Model) procedure was used to determine logistic regression for specific choices made by the subjects through a Chi-square test. This helped to define possible links between subject descriptives and their choices, such as whether demographics like age or regional location had an impact on their pattern and garment choices (M. Xiong, statistical advisor, personal communication, April 2004).

## CHAPTER FOUR: RESULTS AND FINDINGS

The results obtained from the internet survey tool were categorized and analyzed according to the gender of the subject. The male subjects were evaluated individually, as were the female subjects.

First, the specific gender of the subjects was assessed for its relationship, if any, to other details of the population surveyed. This analysis was performed by (1) evaluating the patterns most often preferred as well as (2) evaluating their respective represented design elements and by (3) evaluating the preferred patterns as related to the garments on which they were selected.

### **Subject Sample Summary**

There were 456 total subject responses to the internet survey. This total included 333 female subjects and 123 male subjects. The age range of the subjects surveyed included 8 of the 10 possible groups. Age groups not accounted for by the subjects were the highest and lowest possible age groups, *under 12* and *95 or older*. The majority of subjects surveyed fell into the age group 18-25 (Table 1). The geographic distribution of the subjects included all 10 regions while the responses were heavily weighted in the South Atlantic region (Table 2).

Age Groups	Responses by Gender		Total Reponses	Percent
	Female	Male		
under 12	0	0	0	0
12-17	28	5	33	7.24
18-25	152	81	233	51.10
26-32	50	11	61	13.38
33-39	22	5	27	5.92
40-48	32	8	40	8.77
49-58	33	8	41	8.99
59-76	15	5	20	4.39
77-95	1	0	1	0.22
95 or older	0	0	0	0
<b>Total</b>	<b>333</b>	<b>123</b>	<b>456</b>	<b>100%</b>

**Table 1: Age Distribution of Subjects by Gender**

Geographic Regions	Responses by Gender		Total Responses	Percent
	Female	Male		
Middle Atlantic	9	2	11	2.44
East North Central	11	3	14	3.11
West North Central	21	2	23	5.11
New England	9	4	13	2.85
Pacific	11	2	13	2.89
South Atlantic	242	109	351	76.97
East South Central	4	0	4	0.89
West South Central	17	1	18	4
Mountain	9	0	9	2
<b>Total</b>	<b>333</b>	<b>123</b>	<b>456</b>	<b>100%</b>

**Table 2: Geographic Distribution of Subjects by Gender**

Not all of the 456 responses were able to be used in all areas of statistical evaluation because of some responses with incomplete answers in the six pattern selections. In these cases, the response was evaluated only for the choices which had been completed by the subject in question. For example, if a male subject had only made the first four pattern choices and had not chosen patterns for garments 5 and 6, their answers were only included in the evaluation for male garments 1, 2, 3 and 4, and eliminated from the evaluation of male garments 5 and 6.

### **Male Subject Summary**

There were 123 total male subjects surveyed, accounting for 26.97% of the total subjects surveyed, regardless of gender. Over 65% of the total male survey population fell into the age group of 18-25 (Table 1), and over 88% were located in the South Atlantic region (Table 2).

### **Research Statement Findings: Male Subjects**

The three research statements made in the Introduction of this research were again assessed after the statistical analysis of the male subject data was complete. The following are findings based on these statements.

**Research Statement 1.** *What demographic or other related factors are influential in a typical U.S male consumer's choices concerning digitally printed repeat patterns for textile apparel products?*

The following is an analysis of the selection of each of the eight patterns by the male subjects, and any statistically significant demographic factors associated with their selection throughout the survey.

- Pattern 1: Selection by male subjects was influenced by the subjects' *marital status* and the *garment* for which it was selected.
  - 76.19% of all male subjects who chose pattern 1 on any occasion were single.
  - In the cases where pattern 1 was chosen, it was most often matched with garment 3, accounting for 20.75% of all pattern 1 choices made by male subjects.
- Pattern 2: Selection by male subjects was influenced by the *garment* for which the pattern was chosen.
  - In the cases where pattern 2 was chosen, it was most often matched with garments 4 and 5, each accounting for 21.74% of all pattern 2 choices made by male subjects.
- Pattern 3: Selection by male subjects was influenced by the subjects' *age* and the *garment* for which it was chosen.
  - Pattern 3 was most often chosen by male subjects in the 18-25 age group, accounting for 61.33% of the age groups that chose pattern 3 on any occasion. (Age groups not represented in this case were 77-95 and 95 or older.)

- In the cases where pattern 3 was chosen, it was most often matched with garment 5, accounting for 25.0% of all pattern 3 choices made by male subjects.
- Pattern 4: Selection by male subjects was influenced by the subjects' *age*.
  - Pattern 4 was most often chosen by male subjects in the 18-25 age group, accounting for 70.0% of the age groups that chose pattern 4 on any occasion. (Age groups not represented in this case were *40-48*, *77-95* and *95 or older*.)
- Pattern 5: Selection by male subjects was influenced by the subjects' *marital status* and the *garment* for which it was chosen.
  - 73.44% of all male subjects who chose pattern 5 on any occasion were single.
  - In the cases where pattern 5 was chosen, it was most often matched with garment 6, accounting for 21.90% of all pattern 5 choices made by male subjects.
- Pattern 6: Selection by male subjects was not influenced by any single known statistically significant factor.
- Pattern 7: Selection by male subjects was influenced by the *garment* for which it was chosen.
  - In the cases where pattern 7 was chosen, it was most often matched with garment 2, accounting for 23.42% of all pattern 7 choices made by male subjects.

- Pattern 8: Selection by male subjects was influenced by the *garment* for which it was chosen.
  - In the cases where pattern 8 was chosen, it was most often matched with garment 1, accounting for 26.58% of all pattern 8 choices made by male subjects.

**Research Statement 2.** *What are a typical U.S. male consumer's preferences concerning basic design elements within digitally printed repeat patterns for textile apparel products?*

The pattern choices made by male subjects were assessed on their frequency of choice by first evaluating the number of times each of the 8 patterns was chosen for each of the 6 garments and calculating that percentage of the total choices made for each garment. The pattern most often chosen overall was noted as the number one choice and the pattern in second place was noted as the number two choice. If there was a tie for either placement, those two tied patterns were noted together. Based on the number of marks acquired by each pattern, the patterns most often chosen by male subjects were:

1<sup>st</sup> choice: **pattern 3**

2<sup>nd</sup> choices: **patterns 6 and 7**

Pattern 3, accounting for 16.74% of all patterns chosen by males (regardless of garment) exhibited a strong use of *texture*, as it was chosen most frequently by the design professionals as the foremost represented design element. This choice of texture accounted for 50.0% of the design professionals' choices to represent

pattern 3. *Line* and *value* were the second most frequently chosen elements for Pattern 3, each accounting for 18.75% of the design professionals' choices for pattern 3.

Patterns 6 and 7 both accounted for 16.02% of all patterns chosen by males (regardless of garment). Pattern 6 was defined as highly representative of *texture*, which accounted for 43.75% of the design professionals' choice for the most evident design element. *Line* and *value* were the second most often chosen design elements represented in pattern 6 by the design professionals at 25.0% each. Pattern 7 exhibited a strong use of *line*, accounting for 43.75% of the design professionals' choices. *Value* was the second most chosen element at 37.5%.

**Research Statement 3.** *What demographic factors are influential in a typical U.S. male consumer's choices concerning the combination of a specific garment style and a digitally printed textile repeat pattern?*

There were some demographic factors that may have had an impact on which patterns were chosen for each garment by the male subjects surveyed. In many cases, there were factors that only had an impact when combined with one or more other factors. These instances were referred to as *intercepts* in the statistical analysis. The weight of each factor included in an intercept was not known.

*Age* and *geographic region* were the most evident demographic factors which may have affected the pattern and garment choice combinations made by male subjects. Additionally, a combination of multiple factors may have influenced these choices made by male subjects.

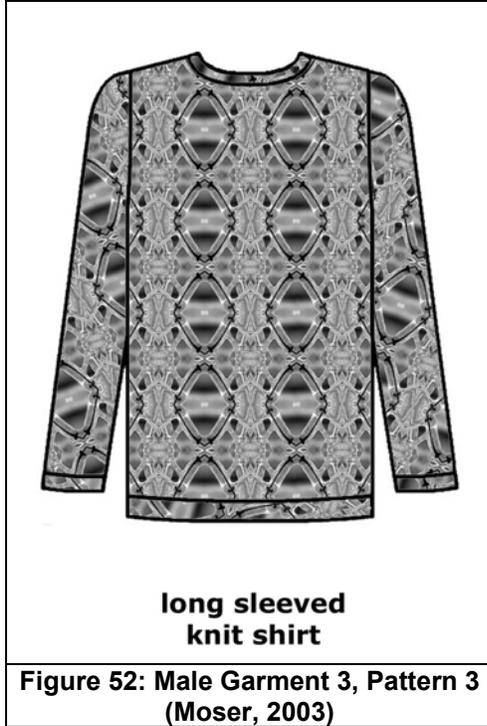
The following is an account of which demographic factors, if any, had a statistically significant impact on the patterns that were chosen for each of the six male garments.

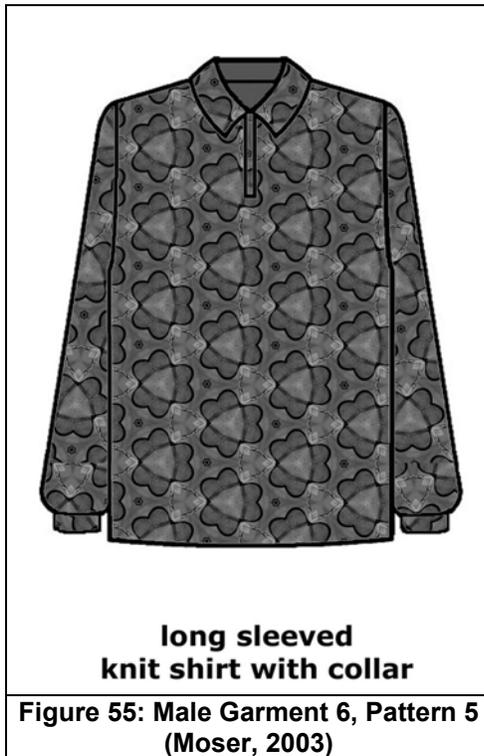
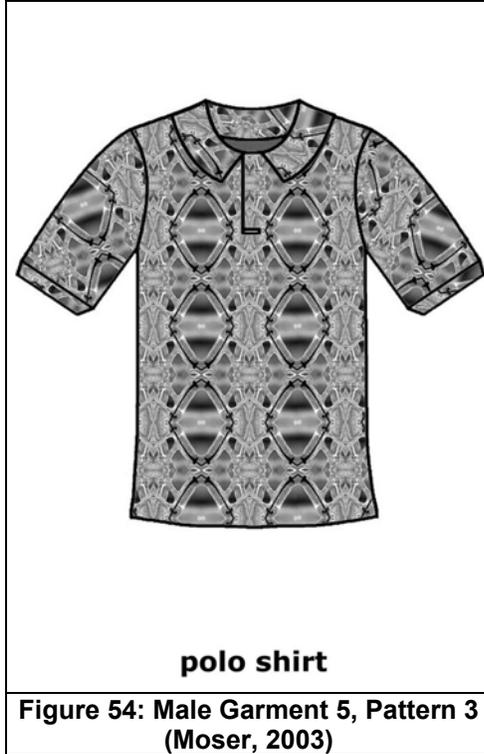
- Garment 1: Pattern selection by male subjects was influenced by the *age* of the subjects.
  - *Pattern 8* was most often chosen for this garment at 18.64% (Figure 50).
  - The combination choice of garment 1 and pattern 8 was most often made by male subjects in the 18-25 age group, accounting for 59.10% of the age groups that made this choice combination on any occasion. (Age groups not represented in this case were *12-17*, *77-95* and *95 or older*.)
- Garment 2: Pattern selection by male subjects was influenced by the *geographic region* of the subjects.
  - *Pattern 7* was most often chosen for this garment at 22.22% (Figure 51).
  - The combination choice of garment 2 and pattern 7 was most often made by male subjects living in the South Atlantic region, accounting for 96.15% of all males that made this choice combination on any occasion. (Regions represented in this case were *South Atlantic* and *Pacific*.)

- Garment 3: Pattern selection by male subjects was influenced by the subjects' *age*, *geographic region*, and monthly *expenditure* on clothing and accessories.
  - *Pattern 3* was most often chosen for this garment at 18.26% (Figure 52).
  - The combination choice of garment 3 and pattern 3 was most often made by male subjects in the 18-25 age group, accounting for 66.67% of the age groups that made this choice combination on any occasion. (Age groups not represented in this case were *12-17*, *26-32*, *77-95* and *95 or older*.)
  - The combination choice of garment 3 and pattern 3 was most often made by male subjects living in the South Atlantic region, accounting for 90.48% of all males that made this choice combination on any occasion. (Regions represented in this case were *South Atlantic*, *Pacific* and *West North Central*.)
  - The combination choice of garment 3 and pattern 3 was most often made by male subjects who spend less than \$50 per month on clothing and accessories, accounting for 71.43% of all males that made this choice combination on any occasion. (Categories represented in this case were *less than \$50*, *\$51-\$100*, *\$101-\$150*, *\$151-\$200*, *\$301-\$400* and *\$601-\$800*.)

- Garment 4: Pattern selection by male subjects was not affected by any specific parameters.
  - *Pattern 5* was most often chosen for this garment at 16.52% (Figure 53).
- Garment 5: Pattern selection by male subjects was not influenced by any single known statistically significant factor.
  - *Pattern 3* was most often chosen for this garment at 18.26% (Figure 54).
- Garment 6: Pattern selection by male subjects was influenced by the *age* of the subjects.
  - Pattern 5 was most often chosen for this garment at 21.24% (Figure 55).
  - The combination choice of garment 6 and pattern 5 was most often made by male subjects in the 18-25 age group, accounting for 66.67% of the age groups that made this choice combination on any occasion. (Age groups not represented in this case were 77-95 and 95 or older.)







## Female Subject Summary

There were 333 total female subjects surveyed, accounting for 73.03% of the total subjects surveyed, regardless of gender. More than 45% of the total female survey population fell into the age group of 18-25 (Table 1), and over 72% were located in the South Atlantic region (Table 2).

### **Research Statement Findings: Female Subjects**

The three research statements made in the Introduction of this research were again assessed after the statistical analysis of the female subject data was complete. The following are findings based on these statements.

**Research Statement 1.** *What demographic or other related factors are influential in a typical U.S. female consumer's choices concerning digitally printed repeat patterns for textile apparel products?*

The following is an analysis of the selection of each of the eight patterns by the female subjects, and any significant demographic factors associated with their selection throughout the survey.

- Pattern 1: Selection by female subjects was not influenced by any single known statistically significant factor.
- Pattern 2: Selection by female subjects was not influenced by any single known statistically significant factor.
- Pattern 3: Selection by female subjects was not influenced by any single known statistically significant factor.

- Pattern 4: Selection by female subjects was not influenced by any single known statistically significant factor.
- Pattern 5: Selection by female subjects was not influenced by any single known statistically significant factor.
- Pattern 6: Selection by female subjects was not influenced by any single known statistically significant factor.
- Pattern 7: Selection by female subjects was not influenced by any single known statistically significant factor.
- Pattern 8: Selection by female subjects was not influenced by any single known statistically significant factor.

**Research Statement 2.** *What are a typical U.S. female consumer's preferences concerning basic design elements within digitally printed repeat patterns for textile apparel products?*

The pattern choices made by female subjects were assessed on their frequency of choice in the same manner of evaluating the male choices (see p. 98). Based on the number of marks acquired by each pattern, the patterns most often chosen by female subjects were:

1<sup>st</sup> choice: **pattern 5**

2<sup>nd</sup> choice: **pattern 6**

Pattern 5, accounting for 16.84% of all choices made by female subjects, exhibited a strong use of *shape*, as it was the most frequently chosen design element represented at 43.75% according to the design professionals. *Texture* was

the second most often chosen design element represented in pattern 5, accounting for 25.0% of the design professionals' choices.

Pattern 6 was the second most often chosen pattern by female subjects at 16.02%. The design professionals' choice for the most represented design element within pattern 6 was *texture*, accounting for 43.75%. The two secondary elements chosen by the professionals for pattern 6 were *line* and *value* at 25.0% each

**Research Statement 3.** *What demographic factors are influential in a typical U.S. female consumer's choices concerning the combination of a specific garment style and a digitally printed textile repeat pattern?*

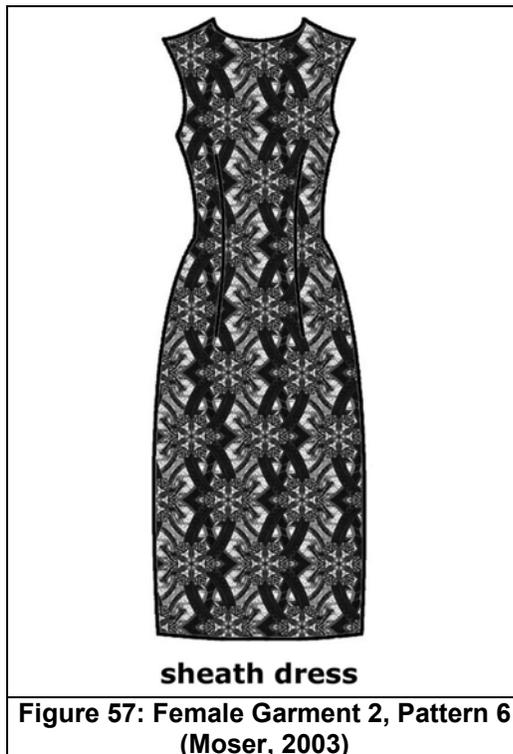
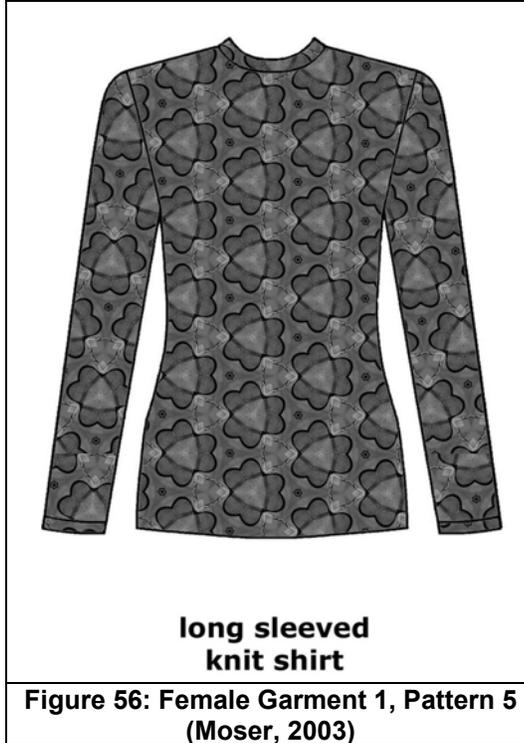
There were some demographic factors that may have had an impact on which patterns were chosen for each garment by the female subjects surveyed. In many cases, there were factors that only had an impact when combined with one or more other factors. These instances were referred to as *intercepts* in the statistical analysis. The weight of each factor included in an intercept was not known.

In the cases of each of the six garments, there was not a single known demographic factor which influenced the pattern and garment choice combinations made by female subjects. These choices were, however, defined by a combination of multiple factors which are unknown.

The following is an account of which demographic factors, if any, had an impact on the patterns that were chosen for each of the six female garments.

- Garment 1: Selection by female subjects was not influenced by any single statistically significant factor.

- *Pattern 5* was most often chosen for this garment at 26.97% (Figure 56).
- Garment 2: Selection by female subjects was not influenced by any single statistically significant factor.
  - *Pattern 6* was most often chosen for this garment at 19.70% (Figure 57).
- Garment 3: Selection by female subjects was not influenced by any single statistically significant factor.
  - *Pattern 3* was most often chosen for this garment at 19.76% (Figure 58).
- Garment 4: Selection by female subjects was not influenced by any single statistically significant factor.
  - *Pattern 8* was most often chosen for this garment at 17.02% (Figure 59).
- Garment 5: Selection by female subjects was not influenced by any single statistically significant factor.
  - *Pattern 3* was most often chosen for this garment at 21.65% (Figure 60).
- Garment 6: Selection by female subjects was not influenced by any single statistically significant factor.
  - *Pattern 6* was most often chosen for this garment at 18.40% (Figure 61).





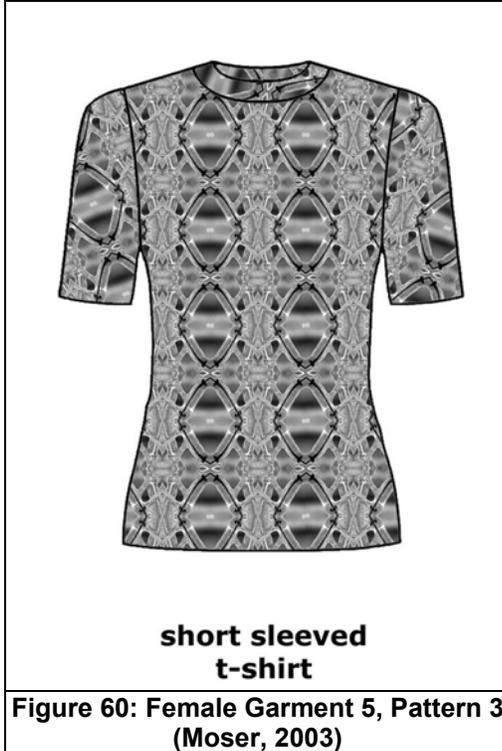
**tank top**

**Figure 58: Female Garment 3, Pattern 3  
(Moser, 2003)**



**A-line skirt**

**Figure 59: Female Garment 4, Pattern 8  
(Moser, 2003)**



## **CHAPTER FIVE: DISCUSSION**

This research was conducted with intentions of providing insight into factors which may or may not affect a consumer's decision when concerning digitally printed patterns for use in textile apparel products. Through statistical evaluation and assessment of the test subjects' comments on the internet survey tool, the following areas emerged as topics of interest:

1. scale of patterns
2. pattern placement on garments
3. survey choice options
4. demographics
5. data collection

These topics are covered in depth after being confirmed by the subject comments in Figure 62.

### **Survey Subject Comments**

The photographic patterns created for use in this research were constructed solely of black and white photographs. Each of the 8 patterns utilized various basic design elements in a very dynamic fashion. Despite the previously stated reasons for choosing the 8 patterns that were used, many of the subjects commented negatively on the actual patterns. For example, some subjects did not prefer patterns with dramatic shapes or lines, and some did not like the limited choices

(inability to choose “no pattern”). However, there were also subjects that responded positively and were interested to know more about the pattern origins.

The following is a sample of some subject comments from the internet survey tool who directly addressed their feelings or suggestions. Please note that any personal information left by a subject has been censored for their privacy.

There were some items that I did not like any of the patterns for, I just picked one because I have to.

Adding colors so that the choices were in color would have been better...unless of course, gray, black, and white are the colors.

I really loved the patterns that I had to choose from! Where did you get your patterns from, because I would really like to use them as inspiration for some fashion pieces! I can be reached at: xxxxx@xxx.com Thanks!

I think the designs are very unique. However, some designs don't appeal to me as much because of the combination of the clothes' design and the pattern design. In a way it gives me a feeling of clothes for older women. I like my clothes in a simple design pattern and probably, that is why some designs here didn't appeal to me. But I like how the pattern applied to the clothes design. Good luck on your project!

The patterns were hard to choose from.

It would have been easier to compare if each page contained the garment in all eight patterns, rather than having to try each pattern on the garment. Also, on one of them I thought all of the options were bad and was unable to choose "solid color" as a choice.

I didn't like the scale of the patterns - too large!

Need an option to not like any of them.

It was a great choice to allow the fabric designs to be displayed on the garments, the scale was much different in relation to the garments than I would have envisioned from the swatches shown.

I would have liked to be able to go back and change my choices... after I saw a better fit of design on another garment...

For my taste I would prefer more subdued design options. However, this looks like a good way to select a design that best fits the individual garment.

I made selections from the requested patterns only because there was no way to not choose one. However, I don't know that I would purchase any of those patterns on any item.

These patterns are interesting but the scale of most of them was too large to be flattering to most women's figures. Also once or twice the pattern produced ended up not being centered on the dress or shirt. I wasn't sure I'd wear any of them as they are now though I thought some of the dress and shirt styles were fine.

The sheath dress matched with the patterns seemed to put big designs right where a woman's breasts would be and this bothered me, because I thought it would draw attention inappropriately. The shirts seemed to keep the patterns smaller, so any of the designs would

have appealed to me.

The fabric choice I liked the best unfortunately had diamond shapes with a dot in the center located where breasts are located which took away from the choice.

Personally, I don't think anything with the pattern running horizontally is complimentary -just my opinion.

#### TOO MANY BUSY PATTERNS

Will be interesting to know of the results. With such small samples it is difficult to tell what might look good on a particular garment. Good luck in your research.

I work with about 160 prints a year for nurses uniforms, so I look at many prints throughout the year. Very interesting survey, good luck to you.

I didn't really like any of the patterns for any of the pieces. Sorry!

Horrible patterns for clothing in my opinion.

Interesting survey. I had a hard time deciding on some of the clothing because the patterns really did not fit for that type of attire.

All of the patterns are a little "busy" for my taste, so I selected the one that looked the best out of the choices for each item, but I didn't really care much for any of them.

surprising to realize how different the graphic design preferences are for different garment designs!

I think the scale was too large for men's apparel (in general). Also, with traditional printing the Strike-offs would probably not have the desired tonal look of these images. Perhaps transfer/paper printing on synthetic swim shorts would be more appropriate. xxxxx@xxx.com

Scale of the pattern influenced my choices. Would have liked to have seen a choice of smaller scale patterns.

Out of the 8 patterns, only 3 or 4 emerged that I would have even potentially considered. On any shirt, repetition in design may be a good thing, but not if the design is too large so that only 4 or 5 repetitions occur.

Although I selected the pattern I liked best on each piece of clothing, the boldness of the pattern and colors would determine whether or not I would purchase such an item.

None of the designs that were used as options represent any clothing that I presently own or would buy in the future. The income question was not answered correctly because this question is considered to be too personal.

I picked patterns for each section, however I did not find any of the given patterns appealing.

I think it would be more effective for research if you included 'Some college' since many of those finding this survey (such as me) will be graduating soon.

It was very helpful to have the pattern appear on the garment. None of the patterns appealed to my taste or design interest.

Interesting survey. If you were to ask, however, would I wear any of those garments with the patterns on them, I would say no, I would not wear any of them. However, the choice was a forced choice, only asking which pattern did you like better.

Actually I wouldn't wear any of the patterns. They were all too busy.

Good job. I enjoyed the experience.

I thought this survey was neat! thanks!

No comments

It was difficult to determine what scale the design would be when applied to the garment. They all appeared much larger than I had imagined them to be.

The size scales of the motifs are too large for the garment sketches. It doesn't look good as I thought.

I really wouldn't put any of those patterns on any of my clothes. You should have a "none of the above" choice. It was interesting to see the different patterns on the different clothing types. Thanks.

was not crazy about the pattern selection. probably would only buy the skirt with one of those patterns.

The background of the screen appeared gray on my machine. The limited contrast between the background and text made for difficult reading. In regards to the question about \$ spent monthly on clothes, I included credit card payments as part of my monthly expenditure for clothing.

patterns were too big in scale for me. when you are only 5'1" you don't wear big prints.

Scaling of prints on flats is an important factor to sense of satisfaction with choice. Good luck with this survey.

I really didn't like any of the patterns on any of the garments. They were all too busy so my selections were really ambiguous.

You may add "no pattern" option in your choice. Also, how about color choices? Should be another chapter of survey but just my thought.

The patterns were too busy/ optical for my personal preference.

Color in the designs may have helped me make better decisions, but it would have also probably made me make different decisions. The design patterns were too big on the shirts. The difference in size between the patterns on the left side and how they were represented when placed on the shirt changed my opinion about which patterns I liked on which shirts.

the patterns were pretty busy, but still worked. I think for skirts, diagonal lines work well-- and with dresses, something that draws the line up and down the body. personally, I'm into more solid colors, and stripes. but I'm working on breaking out of my shell. :) so that's why I didn't much like the patterns. perhaps if they didn't enlarge once you put them on the garments, it would've been better...? anyhow--hope your research goes well!

It would be better if we could see some colors...would have made my choices easier.

I would have liked it if some of the prints were smaller. All the prints were VERY LARGE.

Even though all the prints were very geometric, there was a variety of choices ranging from harsh lines/stripes to smooth curves to overall balance. All of the designs had a very strong presence on their own. I think the range of gray scale helped out with the degree/level of presence.

I prefer a "not so busy pattern" for tops

honestly, I thought they were all pretty ugly. also, I wouldn't wear the majority of the articles offered (I wear more boyish clothes)

I found it very interesting that depending on the article of clothing I either liked or disliked the same pattern.

**Figure 62: Sample Selection of Subject Comments**

## **Topics Frequently Addressed by Subjects**

There were some comments and suggestions made by the survey subjects which appeared repeatedly throughout the data. The following areas were heavily critiqued by the subjects.

### **Scale of Patterns**

Some subjects, especially females, suggested that the scale of the patterns should be smaller. Many commented that patterns with large repeats are not flattering to women who are petite and/or full figured. It was suggested that the scale of each pattern as seen in the sample square beside each radio button was more preferable than how they were ultimately modeled on the garment flats.

### **Pattern Placement on Garments**

The position of specific patterns when modeled on some garments appeared unflattering to many subjects, especially females. Pattern 3 seemed to highlight the female breast area when placed on many of the garment flats. This gave some female subjects a negative opinion about this particular pattern.

### **Survey Choice Options**

Some subjects suggested that the survey should have an option to choose none of the patterns, but rather a garment with no pattern or a solid color. Although this suggestion was valid from a consumer standpoint, it would have defeated the purpose of the research which was specifically based on consumer preferences of photorealistic patterns and the design elements within those patterns.

## **Demographics**

Some of the subjects exhibited a negative reaction to the demographics question about annual income. There were even cases in which subjects refused to complete the survey due to this question. They felt it was a personal matter and did not wish to disclose that information. Additionally, some subjects admitted to choosing an incorrect value or simply choosing the highest given income on purpose since they did not feel comfortable disclosing their financial details.

As described in the Methodology, the request for subjects' annual income was deemed necessary when designing the survey since a consumer's financial situation is a major impact on their decisions when spending money (Kaiser & Garner, 2003). However, for the above stated reasons, annual income was not a focal point in the final statistical analysis of the data.

## **Data Collection**

The manner in which the data was compiled into a spreadsheet was helpful in sorting values and creating separated lists. However, there were some strategies that would have made the final evaluation easier, such as creating a separate column in the spread sheet for the pattern chosen for each of the six garments.

For the purposes of statistical analysis, it would have been easier to create two different spreadsheets for the separation of male and female subject data. Also, since the U.S. state chosen by each subject was ultimately condensed into one of 9 geographical categories, it would have saved time to assign those 9 values while

building the survey so that the chosen state would automatically list the region in the data spreadsheet.

### **Basic Design Element Evaluation by Design Professionals**

Based on the response by some of the design professionals that validated the basic design element representation, the evaluation method may have needed a different approach. Some of the professionals felt very restricted in the way that the evaluation tool was constructed. The limited ability to assign whatever design elements they wanted was frustrating in some cases, as there were a specific number of times and places in which an element could be assigned (see *Appendix A*).

### **Summary of Data**

The results of this research were successful in that the original purpose and research statements were answered according to the data compiled from the internet survey tool. In some cases, there are specific demographics or other related points that affect the patterns and design elements within patterns chosen by male and female subjects. However, in other cases there may be no definite demographics or related points that suggest why some subjects prefer specific patterns or design elements.

Concerning the subjects surveyed in this research, U.S. male consumers' choices of patterns for digitally printed apparel products is significantly influenced by the *garment* on which the pattern is to be used. These males' pattern preferences

most often represent the design elements *texture*, and *line/value*, respectively. *Age* is the most influential demographic factor in the male choices concerning the combination of a specific garment style and a pattern for digitally printed apparel products.

Concerning the subjects surveyed in this research, there is *no definite demographic* or other related point that significantly influences U.S. female consumers' preferences of digitally printed apparel products. These females' pattern preferences most often represent the design elements *shape* and *texture*, respectively. Additionally, there is *no definite demographic* or other related point that significantly influences U.S. female consumers' choices concerning the combination of a specific garment style and a pattern for digitally printed apparel products.

## CHAPTER SIX: RECOMMENDATIONS

The research performed in this study identified several specific points that can have an effect on consumer preferences of digitally printed textile apparel products. Although there were many sections of the research which were successful, such as the statistical results of the data, there are also some areas in which future research may be beneficial. The following are suggestions for future research or expansion upon this research.

Only four basic design elements (*line, shape, value, texture*) were used in the evaluation of the 8 photographic patterns, when in actuality, there are many more elements of design documented and used by experts on this topic (Malcolm, 1972; Wong, 1993). Incorporating more elements might have lead to more in-depth conclusions. For example, Malcolm (1972) also notes *space* and *form* as two elements of design. Wong (1993) even goes so far as to divide his in-depth list of design elements into four categories: *conceptual elements* (point, line, plane, volume), *visual elements* (shape, size, color, texture), *relational elements* (direction, position, space, gravity) and *practical elements* (representation, meaning, function) (Wong, 1993). These alternative elements provide many more ways to define patterns in addition to the four that were chosen for this research.

There is also the consideration of not only design elements, but also design principles. The use of *design principles* is described by Malcolm (1972, p. 75) as the act of “thoughtfully balancing, moving, repeating, emphasizing and contrasting the

design elements” in order to “arrive at a thoroughly satisfying and unified art form”. Some principles include *balance*, *movement*, *repetition* (see p. 21), *emphasis*, *contrast* and *unity* (Malcolm, 1972).

Although this study was focused specifically on the consumer preferences of patterns, a *no pattern* option may have provided insight into consumers who really do not prefer patterns overall. However, this also brings into account the actual patterns used in this research, and how subjective they can be in the eyes of each individual subject. If a subject does not prefer one pattern with a strong use of *line*, it cannot be concluded that the subject will never prefer a pattern that is representative of *line*.

Along with the consideration of the patterns used, the scale of the patterns could be another point of interest in future research. An investigation of the pattern size preferred would be insightful for determining whether most people prefer larger or smaller repeats.

Although the reasons for the elimination of color from this research were described earlier, the incorporation of color would be beneficial and virtually necessary in future studies. Color is a pivotal point in the design, manufacture and sale of apparel products (Fiore & Kimle, 1997). Subjects may be more impressed by digitally printed images with color or even prefer them over the black and white images used in this study. Because color forecasting is such a lucrative sector of the textile and apparel industries, a study on the combination of color and pattern could provide even more valuable insight into consumer preferences (Fiore & Kimle,

1997). Color is typically the first feature that draws a consumer to a product and it can also have the greatest influence over whether a consumer likes or dislikes an item, especially when considering apparel products (Fiore & Kimle, 1997).

Digital printing technology is still a virtually unexplored area of the textile industry concerning mass production of and actual consumer responses to these types of apparel products. A similar study using actual garments constructed of digitally printed fabric may be a better way for subjects to visualize these products and make a more concrete decision concerning their preferences. Also, changing the type of garment or apparel item may have an effect on how the patterns are perceived by consumers. For example, there may have been a completely different response if the pattern scale was reduced and used on an item such as a men's tie.

Another newly developed technology that this type of study could benefit from is 3-D virtual modeling or draping. If the subject cannot hold a tangible product in order to make their decision, perhaps a 3-dimensional image of the garment would give them a better idea of how the product would look on a human form.

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## **APPENDICES**

**APPENDIX A: DESIGN ELEMENT EVALUATION SHEET**

## Design Element Evaluation Sheet

Graduate Research conducted by Carrie A. Moser  
Fall 2003 – Spring 2004, NCSU College of Textiles

Evaluator's Name (*please print*): \_\_\_\_\_

**Instructions:** You will be viewing eight (8) repeat patterns created from photographic modules. You will also be provided with four (4) basic design elements. For each of the repeat patterns, you must assign the **two (2) elements that are best represented in that pattern** (in no particular order). You must assign these elements in such a way that each element is used **only four times**. Place a mark for the corresponding elements next to each image in the table below.

The four (4) basic design elements from which you may choose are:

**a. LINE      b. SHAPE      c. VALUE      d. TEXTURE**

	<b>a.</b>	<b>b.</b>	<b>c.</b>	<b>d.</b>
<b>Image 1</b>				
<b>Image 2</b>				
<b>Image 3</b>				
<b>Image 4</b>				
<b>Image 5</b>				
<b>Image 6</b>				
<b>Image 7</b>				
<b>Image 8</b>				

Thank you very much for your assistance and expertise!

**Note to the Evaluator:** In my Graduate Research writing, your name, position, and educational background will be identified exactly as you are on the NCSU College of Textiles online faculty listing. If I should wish to use your evaluation information in any other way in my future educational endeavors, I will contact you to request permission. Please sign your name below to verify that you understand these statements, and to allow your identity and any information on this sheet to be used in the completion and submission of my research and thesis to The Graduate School at North Carolina State University.

Thank you,  
Carrie A. Moser

Evaluator's Signature: \_\_\_\_\_

Date of Evaluation Completion: \_\_\_\_\_

**Figure 63: Design Element Evaluation Sheet  
(Moser, 2003)**

## **APPENDIX B: DESIGN ELEMENT EVALUATION RESULTS**

	<b>line</b>	<b>shape</b>	<b>value</b>	<b>texture</b>
<b>Image 1</b>	6**	7*	2	1
<b>Image 2</b>	1	8*	6**	1
<b>Image 3</b>	3**	2	3**	8*
<b>Image 4</b>	6*	3	5**	2
<b>Image 5</b>	2	7*	3	4**
<b>Image 6</b>	4**	1	4**	7*
<b>Image 7</b>	7*	0	6**	3
<b>Image 8</b>	3	4**	4**	5*

**Table 3: Design Professionals' Evaluation Choice Totals**  
 (\* = Primary Choice, \*\* = Secondary Choice(s))

<b>Image</b>	<b>primary</b>	<b>primary %</b>	<b>secondary</b>	<b>secondary %</b>
<b>1</b>	shape	43.75	line	37.5
<b>2</b>	shape	50.0	value	37.5
<b>3</b>	texture	50.0	line, value	18.75 each
<b>4</b>	line	37.5	value	31.25
<b>5</b>	shape	43.75	texture	25.0
<b>6</b>	texture	43.75	line, value	25.0 each
<b>7</b>	line	43.75	value	37.5
<b>8</b>	texture	31.25	shape, value	25.0 each

**Table 4: Primary and Secondary Choices, Percent of All Design Professionals' Choices for Each Individual Image**

**APPENDIX C: LIST OF FIELD SELECTIONS FOR INTERNET SURVEY TOOL**

1. Gender

- Male
- Female

2. Age group

- 18-25
- 26-32
- 33-39
- 40-48
- 49-58
- 59-76
- 77-95
- 95 or older

3. Marital status

- Single
- Married

4. Number of dependent children living in your household

- 0
- 1
- 2
- 3
- 4 or more

5. State in which you have spent the majority of the previous year

*States were translated into the 9 regions shown below:*

- New England
- Middle Atlantic
- East North Central
- West North Central
- South Atlantic
- East South Central
- West South Central
- Mountain
- Pacific

6. Occupation

- Management
- Business/Financial Operations
- Computer/Math Sciences
- Architecture/Engineering
- Life/Physical/Social Sciences
- Community/Social Services
- Legal
- Education/Training
- Creative Arts/Design
- Entertainment/Media
- Sports
- Healthcare
- Culinary/Food Preparation

- Sales
- Office/Administrative
- Farming/Forestry
- Construction
- Maintenance/Repair
- Production
- Transportation
- Home Caretaker
- Student
- Unemployed
- Retired
- Other (please explain)

7. Highest education level completed

- Currently in Middle or High School
- High School Diploma
- Associate's Degree
- Bachelor's Degree
- Master's Degree
- Doctoral Degree

8. Which best describes your annual household income?

- I am a minor with no income
- Under \$15,000
- \$15,000 - \$19,999
- \$20,000 - \$24,999
- \$25,000 - \$29,999
- \$30,000 - \$34,999
- \$35,000 - \$39,999
- \$40,000 - \$44,999
- \$45,000 - \$49,999
- \$50,000 - \$59,999
- \$60,000 - \$74,999
- \$75,000 - \$99,999
- \$100,000 - \$124,999
- \$125,000 - \$149,000
- \$150,000 or more

9. Approximately how much you spend on clothing and accessories each month?

- Less than \$50
- \$51-\$100
- \$101-\$150
- \$151-\$200
- \$201-\$250
- \$251-\$300
- \$301-\$400
- \$401-\$500
- \$501-\$600
- \$601-\$800
- \$801-\$1000
- \$1000 or more

**APPENDIX D: SAMPLE PAGES FROM INTERNET SURVEY TOOL**

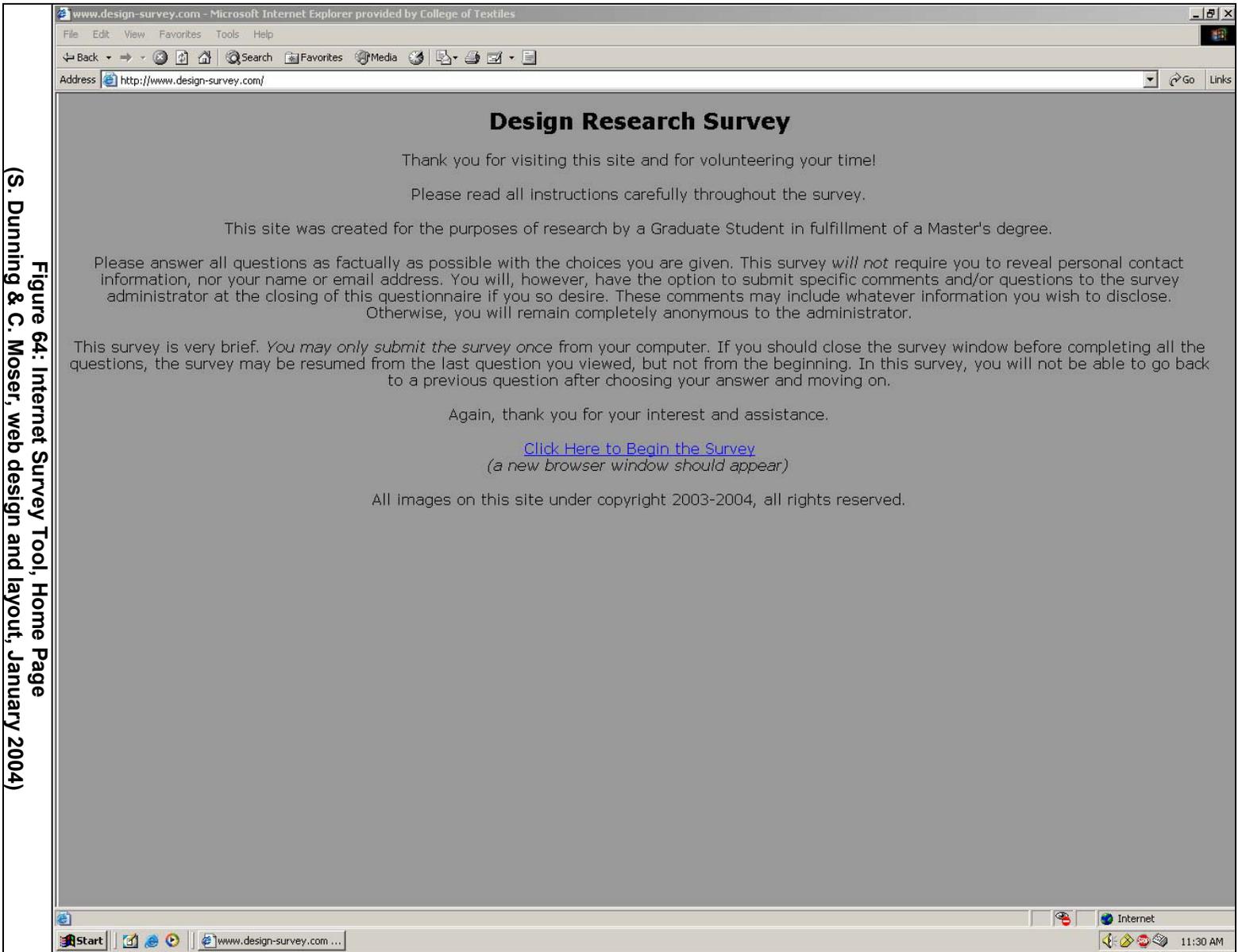


Figure 64: Internet Survey Tool, Home Page  
(S. Dunning & C. Moser, web design and layout, January 2004)

Figure 65: Internet Survey Tool, Demographics Page  
(S. Dunning & C. Moser, web design and layout, January 2004)

Web Survey - Microsoft Internet Explorer provided by College of Textiles

Please answer all questions about yourself as factually as possible.

- What is your gender?
- What is your age group?
- What is your marital status?
- How many dependent minors live in your household?
- In what U.S. state have you spent the *majority* of the last year?
- What is your occupation? (*Check all that apply.*)
  - Management
  - Business/Financial Operations
  - Computer/Math Sciences
  - Architecture/Engineering
  - Life/Physical/Social Sciences
  - Community/Social Services
  - Legal
  - Education/Training
  - Creative Arts/Design
  - Entertainment/Media
  - Sports
  - Healthcare
  - Other (please explain)
  - Culinary/Food Preparation
  - Sales
  - Office/Administrative
  - Farming/Forestry
  - Construction
  - Maintenance/Repair
  - Production
  - Transportation
  - Home Caretaker
  - Student
  - Unemployed
  - Retired
- What is the highest level of education you have completed?
- Indicate your approximate annual household income.
- Approximately how much do you spend on clothing and accessories per month?

Click to Continue

Start | www.design-survey.com ... | KeyAccess | Web Survey - Microsof... | 11:36 AM

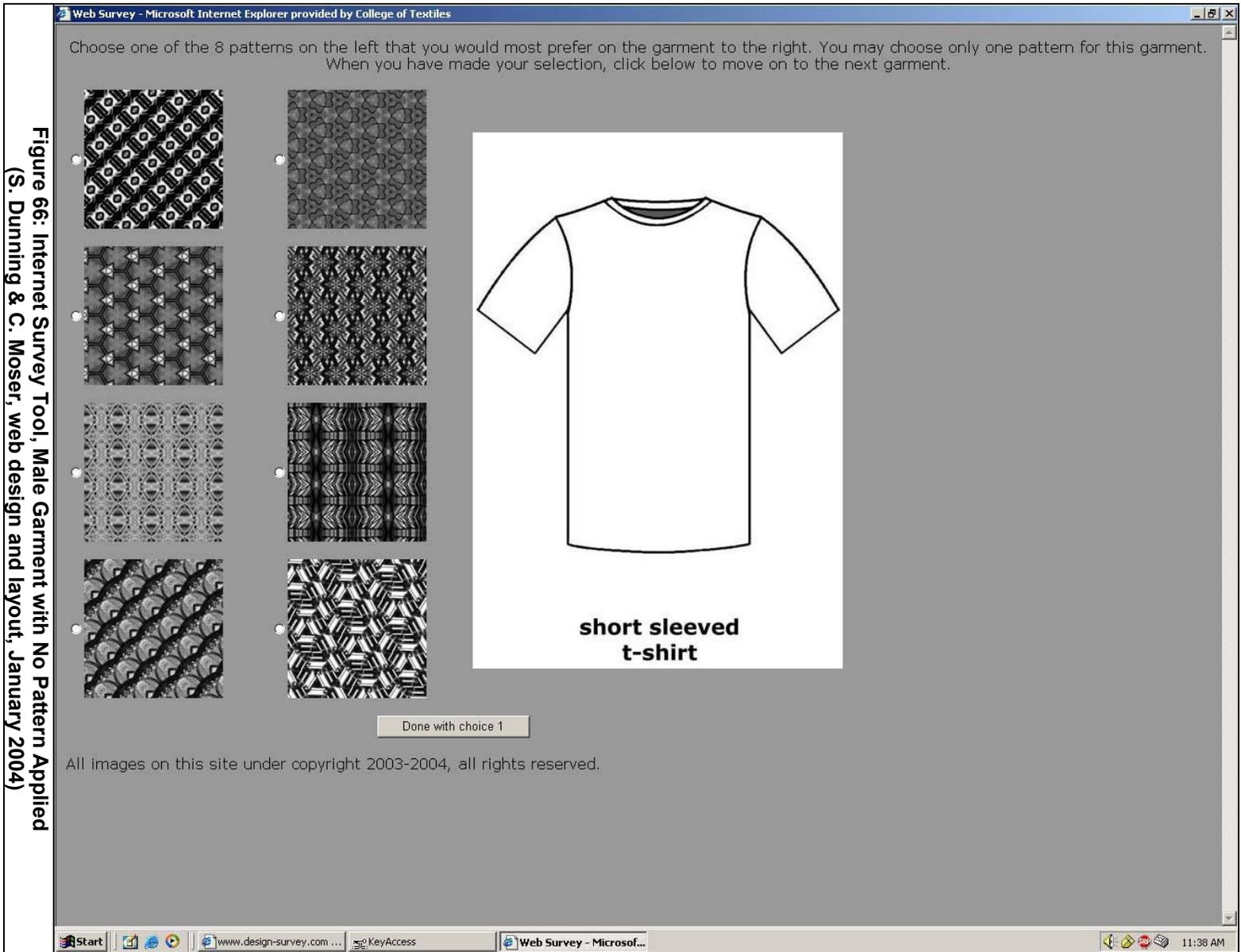
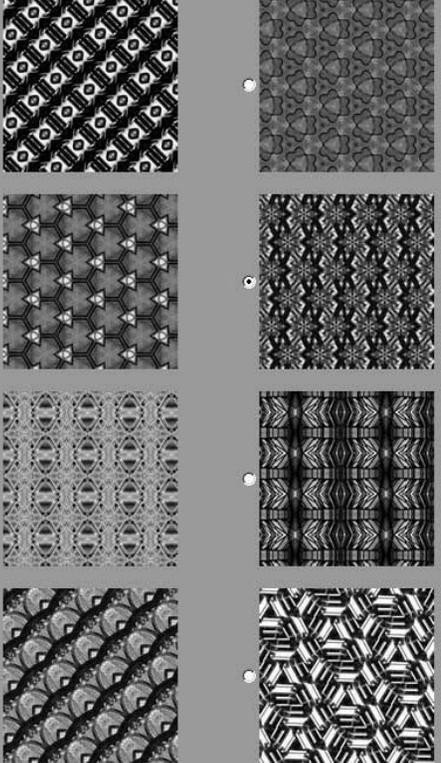


Figure 66: Internet Survey Tool, Male Garment with No Pattern Applied  
(S. Dunning & C. Moser, web design and layout, January 2004)

Web Survey - Microsoft Internet Explorer provided by College of Textiles

Choose one of the 8 patterns on the left that you would most prefer on the garment to the right. You may choose only one pattern for this garment.  
When you have made your selection, click below to move on to the next garment.



**short sleeved  
t-shirt**

Done with choice 1

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Start | www.design-survey.com ... | KeyAccess | Web Survey - Microsof... | 11:40 AM

Figure 67: Internet Survey Tool, Male Garment with Pattern Applied  
(S. Dunning & C. Moser, web design and layout, January 2004)

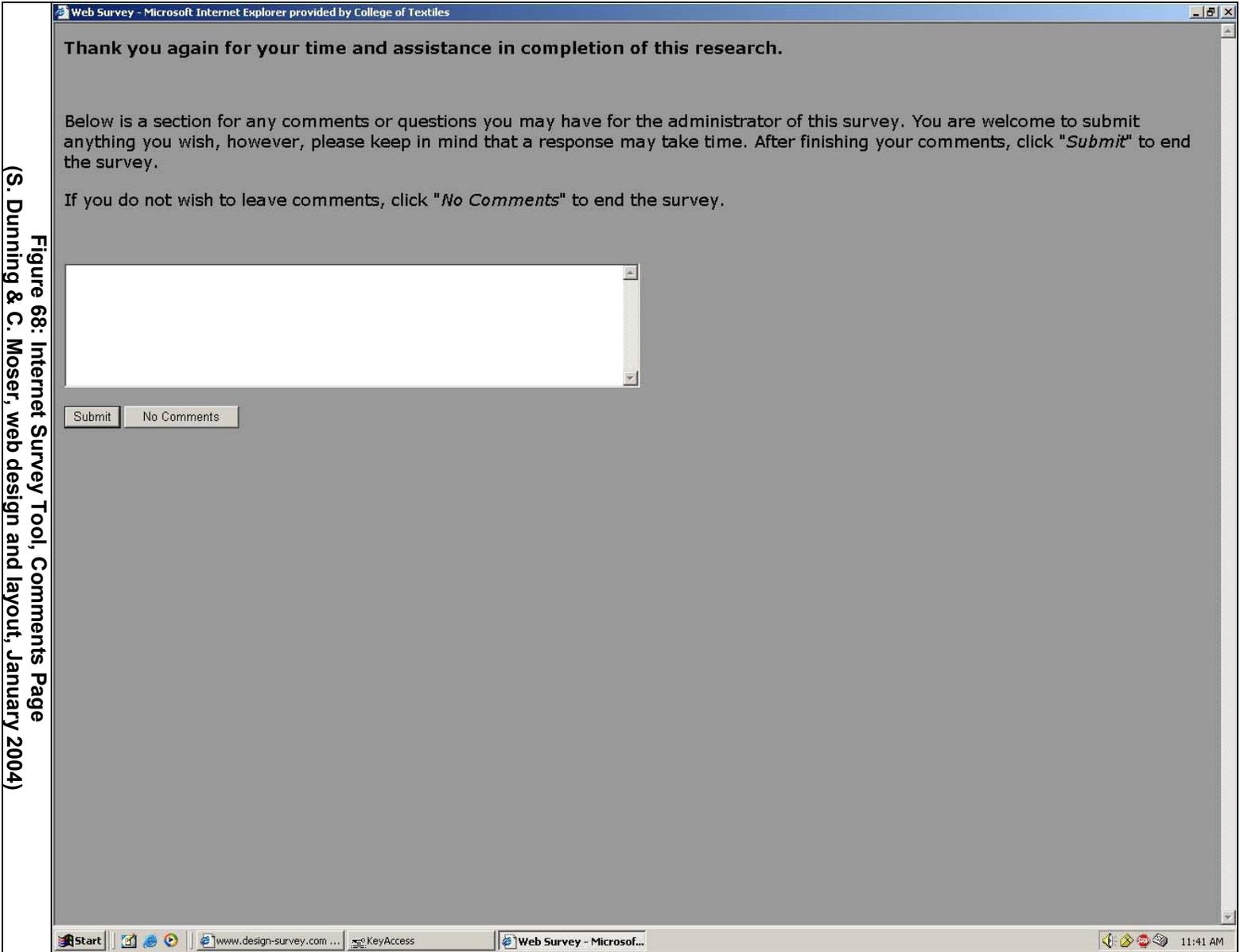


Figure 68: Internet Survey Tool, Comments Page  
(S. Dunning & C. Moser, web design and layout, January 2004)

## **APPENDIX E: SAS STATISTICAL MODEL EXAMPLES**

1. The first statistical model example specifically addresses the analysis of female garment 1 and its relationship to the subjects' age groups, i.e., whether the subjects' ages were statistically significant in their choices of a specific pattern for garment 1.

SAS Output: LOGISTIC regression for FEMALE GARMENT 1

Analysis of Maximum Likelihood Estimates

Parameter	y	DF	Estimate	Standard Error	Wald Chi-Square	Pr>ChiSq
Intercept	1	1	0.2022	1.0499	0.0371	0.8473
Intercept	2	1	-4.0683	0.9511	18.2954	<.0001
Intercept	3	1	-1.7592	0.5963	8.7033	0.0032
Intercept	4	1	-0.2212	0.5403	0.1677	0.6822
Intercept	5	1	-0.1522	0.4484	0.1151	0.7344
Intercept	6	1	-1.4158	0.5158	7.5342	0.0061
Intercept	7	1	-0.3920	0.4906	0.6382	0.4244
age	1	1	-0.0642	0.0444	2.0880	0.1485
age	2	1	0.0693	0.0226	9.3564	0.0022
age	3	1	0.0367	0.0178	4.2713	0.0388
age	4	1	0.000840	0.0183	0.0021	0.9635
age	5	1	0.0240	0.0146	2.7126	0.0996
age	6	1	0.0427	0.0156	7.4530	0.0063
age	7	1	0.0172	0.0160	1.1583	0.2818

The model appeared as:

$$\log\left(\frac{P(Y=i)}{P(Y=8)}\right) = \alpha_i + \beta_i * AGE \quad (\text{where } i = 1, \dots, 7)$$

This was a base-line model for *multinomial response*. Since there were 8 pattern choices, they were referred to as multinomial responses. The 8<sup>th</sup> pattern was used as the reference pattern. The number used for *age* was the mean of each age group.

The model was then combined with the condition:

$$\sum_{i=1}^8 P(Y=i) = 1$$

The probability of choosing each pattern was given as:

$$P(Y=i) = \frac{\exp(\alpha_i + \beta_i * AGE)}{1 + \sum_{j=1}^7 \exp(\alpha_j + \beta_j * AGE)} \quad (\text{where } i = 1, \dots, 7)$$

$$P(Y = 8) = \frac{1}{1 + \sum_{j=1}^7 \exp(\alpha_j + \beta_j * AGE)} \quad (\text{where } i = 8)$$

**Figure 69: Statistical Model Example, Female Garment 1**  
(M. Xiong, statistical advisor, personal communication, April 2004)

2. The second statistical model shows an analysis of females who chose pattern  $i$  (where  $i = 1 \dots 8$ ) in equation (1). The corresponding coefficients in each model are given in Table 5.

$$\log it[P(Y = i)] = \log \left[ \frac{P(Y = i)}{1 - P(Y = i)} \right] = \beta_0 + \beta_G^i + \beta_M^j + \beta_{Age} * AGE + \beta_{Inc} * INCOME \quad (1)$$

where  $\beta_G^i$  is the coefficient for *garment i*,  $\beta_M^j$  is the coefficient for *marital status*, and  $\beta_{Age}$  and  $\beta_{Inc}$  are the coefficients for *age* and *income*, respectively. Here, *age* and *income* are treated as continuous variables even though in the collected data they are ordinal variables (categorical variables with natural order).

Pattern	$\beta_0$	$\beta_G^1$	$\beta_G^2$	$\beta_G^3$	$\beta_G^4$	$\beta_G^5$	$\beta_G^6$	$\beta_M^m$	$\beta_M^s$	$\beta_{Age}$	$\beta_{Inc}$
1	-1.7287	-1.3268	-0.1387	-0.8205	-0.1683	-0.5898	0	-0.4400	0	0	0
2	-3.1634	-0.7802	-1.1954	0	0.2505	0.6001	0	0	0	0	0.0119
3	-2.8354	-0.1940	-0.4778	0.8323	-0.2813	0.9847	0	0	0	0.0142	0.0023
4	-1.2542	0	0	0	0	0	0	0	0	-0.0233	0
5	-1.6601	0.7841	0.1449	0.0499	-0.3790	0.3185	0	0.5162	0	-0.0110	0
6	-1.6655	0	0	0	0	0	0	0	0	0	0
7	-2.4079	0.8095	0.9150	0.3490	0.7194	0.1154	0	0	0	0	0
8	-1.7600	0.0480	-0.2106	-0.0246	0.1832	-0.5698	0	0	0	0	0

**Table 5: Corresponding Coefficients for Equation (1)**

If equation 1 is rewritten for the probability of choosing pattern  $i$ :

$$P(Y = i) = \frac{1}{1 + \exp\left[-\left(\beta_0 + \beta_G^i + \beta_M^j + \beta_{Age} * AGE + \beta_{Inc} * INCOME\right)\right]}$$

For example, if a single female aged 18-25 is given garment 3, the probability of that subject choosing pattern 5 is:

$$P(Y = i) = \frac{1}{1 + \exp\left[-\left(-1.6601 + 0.0499 + 0 - 0.011 * 21.5\right)\right]} = 0.1363$$

For a married female aged 18-25 who is given garment 3, the odds of choosing pattern 5 are  $e^{0.5162} = 1.6756$  times that for a single female aged 18-25, i.e., the probability of choosing pattern 5 for a married female are larger than that for a single female.

The coefficients in Table 5 show that beyond *garment shape*, only *marital status*, *age*, and *income* may have had an impact on consumer preference. *Education level*, *geographical region*, *number of dependent children* and *monthly expenditure* on clothing and accessories do not have a significant impact on the results.

#### Additional Points:

In the cases of patterns 4 and 6, the *garment shape* did have a significant effect on female consumers' preferences. For patterns 1 and 5, the consumers' *marital status* also had a significant impact on their preferences. The choices of patterns 3, 4, and 5 were dependent upon consumers' *age*. The probability of choosing patterns 4 and 5 decreases as the consumers' *age* increases. The probability of choosing patterns 2 and 3 increases as the consumers' *income* increases.