COMPARISON OF SUBJECTIVE EVALUATION AND OBJECTIVE LABORATORY MEASUREMENT OF THE PROPERTY OF HAND IN TEXTILE FABRICS

by

Audrey Lee Jarrelle

A Thesis Submitted to
the Faculty of the Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Greensboro
1973

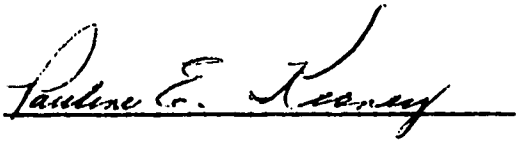
Approved by

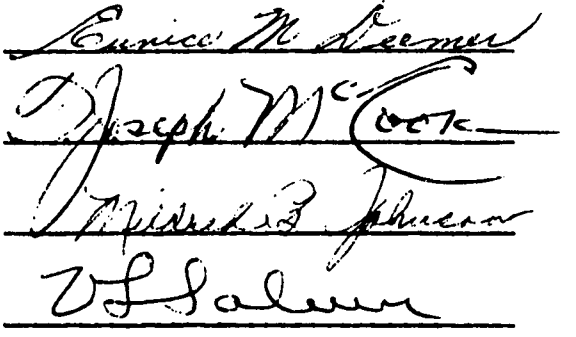
Pauline E. Keeney

Thesis Adviser

APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of the Graduate School at The University of North Carolina at Greensboro.

Dissertation Adviser 

Oral Examination Committee Members 

February 2, 1973
Date of Examination

JARRELLE, AUDREY LEE. Comparison of Subjective Evaluation and Objective Laboratory Measurement of the Property of Hand in Textile Fabrics. (1973) Directed by: Dr. Pauline E. Keeney. Pp. 110

This research was undertaken to determine the importance of the aesthetic property of hand to consumers and to relate the subjective evaluation of fabric hand to objective laboratory measurement of the same property. Data for this study were obtained by subjective evaluation and by objective laboratory measurement of fifteen white fabrics including felt, Pellon®, tricot, doubleknit, broadcloth, georgette, organza, casement cloth, satin, flannelette, chintz, melton, corduroy, velvet, and terrycloth. Properties of hand evaluated subjectively and objectively included flexibility, compressibility, extensibility, resilience, weight, thickness, surface contour, surface friction, and thermal character.

Fifty consumers evaluated subjectively the hand of the selected fabrics. Subjective data were obtained from a consumer opinion questionnaire and from ratings of terminology used by consumers in describing the hand of the fabrics. A series of standard laboratory procedures were used to measure objectively the hand of the fifteen fabrics including (1) ASTM D-1388-64, Stiffness of Fabrics, (2) ASTM D-1682-64, Breaking Load and Elongation of Textiles, (3) ASTM D-1295-67, Wrinkle Recovery of Woven Textile Fabrics Using the Vertical Strip Apparatus, (4) ASTM D-1910-64, Construction Characteristics of Woven Fabrics, (5) ASTM D-1777-64, Measuring Thickness of Textile Materials, (6) Instruction Manual, Thwing-Albert Handle-O-Meter.

An analysis of variance was used to determine statistically significant differences in hand of fabrics as subjectively evaluated by

visual, tactile, and visual/tactile examination and to determine significant differences in hand of fabrics as measured by laboratory tests. Correlation coefficients between the subjective evaluation and laboratory measurement of fabric hand were obtained using Spearman's Rank Correlation Coefficient. Findings were considered significant at the .05 level.

The results of this study indicated that the property of hand was an important consideration to consumers of textile products, including textiles for apparel and for decorative purposes. Those properties of hand which were considered important by consumers of this study, as expressed by terminology used, included flexibility, compressibility, extensibility, resilience, weight, thickness, surface contour, surface friction, and thermal character. Results also indicated that consumers were able to identify, differentiate, and evaluate properties of hand by using a combination of visual and tactile means. There were significant differences in the hand of the fifteen fabrics as evaluated subjectively by visual, tactile and a combination of visual and tactile means. Differences were also significant in the hand of the selected fabrics as measured by laboratory procedures. There was a significant relationship between subjective evaluation of the hand of each of the fabrics and the objective laboratory measurement of the same property.

ACKNOWLEDGMENT

The author wishes to express her appreciation to those who have given so graciously of their time in helping her with the preparation of this study.

Sincere gratitude is expressed to Dr. Pauline E. Keeney, advisor in this dissertation, for her continuing interest and assistance; to Dr. Eunice Deemer, Dr. Mildred Johnson, Dr. Victor Salvin, and Dr. Thomas McCook, members of the thesis committee for their pertinent suggestions, and to Dr. Larry Nelson and Mrs. Mary Carsky for their assistance in research procedures. Appreciation is also given to the industries who furnished materials for this study.

For their encouragement in this undertaking, the author expresses special thanks to her family and to the faculty of the Department of Clothing, Textiles and Interior Design, University of Connecticut.

TABLE OF CONTENTS

LIST OF TABLES

Table | Page

LIST OF FIGURES

Figure Page

CHAPTER I

INTRODUCTION

Man's response to his surroundings revolves around his aesthetic sensibility. It is through the use of textiles in his near environment that he is able, in part, to satisfy his aesthetic needs. The importance of aesthetics in textiles is well recognized by many segments of the textile industry, the apparel industry, and the home furnishing industry, as well as by the consumer. Yet little research has been done on those properties which are integrated into the aesthetics of textiles. There are a number of reasons for this. Aesthetics in textiles is not a single entity, but a combination of many factors including color, design, texture, and hand. Secondly, aesthetic determination is to a large extent a subjective matter. Lastly, explicit definitions are lacking and vary among individuals.

Of the many factors involved in the aesthetics of textiles, the property of hand is one which is particularly significant to many consumers of textile products. Therefore, there must be a constant effort by textile producers to maintain high aesthetic qualities of hand. Maintenance by industry of these qualities of hand requires a two-fold solution. First, objective test procedures need to be available that can be used to assess this property. Secondly, the results obtained from these procedures should reflect improvement in fabrics produced and correlate closely with subjective consumer evaluations of fabric hand. Thus research is needed to confirm those objective tests which

can be used to measure the property of hand and to determine whether such results correlate with subjective consumer evaluation of the property of hand. This research was designed to meet this need.

THE PROBLEM

Statement of the Problem

This research was undertaken to determine the importance of the aesthetic property of fabric hand to consumers and to relate the subjective evaluation of hand by consumers to selected objective laboratory measurement of the same property. The premise of this study was based on the assumptions that hand is one factor relating to aesthetics of textiles and that the aesthetic property of hand is a measurable quality. The specific objectives of this study were:

1. To determine the degree of importance of hand to consumers of textiles.
    a. To determine those properties of hand which are most important to consumers of textiles.
    b. To determine those descriptive terms used by consumers of textiles to evaluate the hand of fabric.
    c. To determine the degree to which the property of hand is evaluated by consumers through visual, tactile, or a combination of visual and tactile means.
2. To determine those objective tests which can be used to measure the property of hand in textile fabrics.
3. To determine whether a correlation exists between subjective evaluation and objective laboratory measurement of the property of hand in textile fabrics.

The data for this study were obtained by subjective and by objective means. All experimentation was limited to fifteen fabrics selected by the researcher and considered typical of fabrics often used by

consumers either for apparel or for decorative purposes. Fifty consumers evaluated subjectively the hand of the selected fabrics. Subjective data were obtained from two sources: (1) an opinion questionnaire, and (2) the ratings of subjective terminology used by the consumers in describing the hand of the selected fabrics. A series of objective tests were used to measure this same property of hand.

The statistical treatment of the data included:

1. Analysis of variance to determine significant differences in hand of fabrics as subjectively evaluated by (a) visual examination only, (b) tactile examination only, and (c) a combination of visual and tactile examination.

2. Analysis of variance to determine significant differences in hand of fabrics as measured by objective laboratory tests.

3. Correlation coefficients to determine the degree of correlation between the subjective rankings for each fabric and the rankings of the fabrics as measured objectively by laboratory tests.

DEFINITION OF TERMS

Hand. The characteristics of a fabric determined by a mental correlation of all the stimuli induced by those physical properties of a fabric appreciated by the sense of touch.

Visual. An examination by sight only.

Tactile. An examination by touch only.

Visual/Tactile. An examination using a combination of sight and touch.

Flexibility. Ease of bending; that property of a material by virtue of which it may be flexed or bowed repeatedly without undergoing rupture.

Compressibility. Ease of squeezing; resistance to compression of a handful of fabric.

Extensibility. Ease of stretching; that property by virtue of which a material can undergo extension or elongation following the application of sufficient force.

Resilience. Ability to recover from deformation; that property of a material by virtue of which it is able to work against restraining forces during return from a deformed state.

Thickness. In a material having well defined and essentially parallel surfaces, the distance between one surface and its opposite. Thickness in textile materials is usually determined under a specific pressure.

Fabric Weight. Mass per unit area expressed in ounces per square yard (grams per square meter).

Surface Contour. Divergence of the surface of a material from planeness.

Surface Friction. Resistance to slipping offered by the surface of a material.

Thermal Character. Apparent difference in the temperature of the fabric and the skin of the observer touching it.

CHAPTER II

REVIEW OF LITERATURE

One function of the textile industry is to produce textiles with properties which will satisfy consumer wants. Included among these properties is the property of hand. Yet because of the multiplicity of factors involved in the subjective and objective determination of hand, a review of literature reveals that little research has been conducted to aid the industry in producing textiles with hand desired by consumers.

HAND - NOMENCLATURE

One of the inherent problems in research concerning hand has been in defining nomenclature. A review of literature revealed a variety of concepts and definitions used by researchers.

The term hand or handle is usually related to the textural quality of fabric. Brand incorporated this idea in describing hand as "the visual and tactile perception of the fabric surface."[1] Schwarz defined handle as "the feel of the material,"[2] while Hoffman and Beste designated hand as "the impressions which arise when fabrics are touched,

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[1]R. H. Brand, "Measurement of Fabric Aesthetics," Textile Research Journal, XXXIV (September, 1964), 796.

[2]E. R. Schwarz, "Technical Evaluation of Textile Finishing Treatment," Textile Research Journal, IX (1939), 216.

squeezed, rubbed, or otherwise handled."[3] Lundgren used the term to "describe tactile and muscular (kinesthetic) sensations produced by a fabric."[4]

The problem involved in research of hand, however, has not been in the definition of the term alone, but as Kaswell described it, "the inability of the human mind to separate the many interacting effects involved."[5] Thus from researcher to researcher long lists of terms describing the different types of hand have evolved. In some of the earliest research concerning hand, Pierce stated:

> In judging the feel or handle of a material, use is made of such sensations as stiffness or limpness, hardness or softness, and roughness or smoothness.[6]

Nine years later Schwarz listed numerous terms used by judges in evaluation of hand:

> Visual: smart, level, clear, well-covered, even, smooth, bright, homogeneous, compact, well-rounded, balanced, rawky, rough, irregular, streaky, "grins," knoppy, crepey, rubbed up, clumsy, cockly, thin, flannelly, solid, sharp, stripy, evenly-balanced, lustrous.
>
> Tactile: silky, soft, full, kind, firm, pliable, tight, solid, well-bedded, mellow, velvety, rich, elastic, sticky, loose, springy, lofty, boardy, weighty, foody, warm, tapery, drapes well, cottony, lumpy, dead, leathery.[7]

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[3]R. M. Hoffman and L. F. Beste, "Some Relation of Fiber Properties to Fabric Hand," Textile Research Journal, XXI (February, 1951), 66.

[4]H. P. Lundgren, "New Concepts in Evaluating Fabric Hand," Textile Chemist and Colorist, I (January 1, 1969), 35.

[5]Ernest Kaswell, Textile Fibers, Yarns, and Fabrics (New York: Reinhold Publishing Company, 1953), p. 421.

[6]F. T. Pierce, "The Handle of Cloth as a Measurable Quantity," Journal of the Textile Institute, XXI (1930), T377.

[7]Schwarz, p. 216.

Much current research has integrated the concept of polar words into the evaluation of hand. In his study relating to "Measurement of Fabric Aesthetics," Brand used polar pairs such as "dry-clammy, warm-cool, cottony-waxy, slick-greasy, soft-hard" to describe the concept of surface texture.[8]

The concept of polar pairs has also been accepted by The American Society for Testing and Materials. Table 1 describes the list of terms accepted by the organization.

HAND - PSYCHOLOGICAL, SOCIOLOGICAL, AND ECONOMIC IMPLICATIONS

Psychological Implications

It is recognized that determination of hand in textile fabrics involves human reaction; consequently, there is an obvious psychological implication.

> Textile hand implies human judgment. Human judgment of quality in general brings into the picture more than just physical characteristics of the products. It brings into consideration the individual's response to stimuli. . . .[9]

> Because human preferences influence judgments of textile hand, there is need for a broader consideration of hand than the expression of intrinsic structure and properties of a material. Preferences take into account, consciously or unconsciously, the appropriateness of the product for an intended or possible end use, as well as its intrinsic structure and properties.[10]

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[8]Brand, p. 796.

[9]Lundgren, p. 35.

[10]Lundgren, p. 36.

Table 1

List of Terms Relating to the Hand of Fabrics*

Physical Property	Explanatory Phrase	Terms to be Used in Describing Range of Corresponding Component of Hand
Flexibility	Ease of bending	Pliable (high) to Stiff (low)
Compressibility	Ease of squeezing	Soft (high) to Hard (low)
Extensibility	Ease of stretching	Stretchy (high) to Nonstretchy (low)
Resilience	Ability to recover from deformation	Springy (high) to Limp (low) Resilience may be flexural, compressional, extensional, or torsional.
Density	Weight per unit volume (based on measurement of thickness and fabric weight)	Compact (high) to Open (low)
Surface Contour	Divergence of the surface from planeness	Rough (high) to Smooth (low)
Surface Friction	Resistance to slipping offered by the surface	Harsh (high) to Slippery (low)
Thermal Character	Apparent difference in temperature of the fabric and the skin of the observer touching it	Cool (high) to Warm (low)

*1965 ASTM Book of Standards, Part 24 (Philadelphia: The American Society for Testing and Materials, 1965), p. 50.

Studies have been done to determine consumer preference for textile materials and in most cases aesthetic preferences for hand were reported in the results. Ryan described research designed to study consumer motivation and satisfaction as measured by preference for fabric characteristics:

> Women were asked to rank a list of fabric characteristics in order of their importance. The most important fabric characteristic for the women in this sample was the ability to hold shape, wrinkle resistance was next in importance, and color-fastness third. When the women were asked to name the characteristics which influenced the choice of last dress bought, the most frequent answers were attributes of garments. . . such as weave, color, feel on skin; and the characteristics which they had ranked previously as most important were seldom mentioned.[11]

Meanings attached to fabric texture by college students were studied by Torreta and reported by Compton:

> . . .two principle factors or components were found - an affective factor and a physical factor. Variables contributing heavily to the affective factor included pleasant-unpleasant, harsh-soft, demanding-relaxing, pleasurable-painful, beautiful-ugly, lively-dead. These words seemed to indicate affective (feeling) qualities and, therefore, the researcher named the factor "affective." The physical factor was so named because it was loaded with weight and density characteristics such as dense-sheer, bulky-sleazy, light-heavy.[12]

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[11]Mary Shaw Ryan, Clothing: A Study in Human Behavior (New York: Holt, Rinehart & Winston, Inc., 1966), p. 156.

[12]Norma Compton and Olive Hall, Foundations of Home Economics Research, A Human Ecology Approach (Minneapolis: Burgess Publishing Company, 1972), p. 281, citing D. M. Torreta, "Somesthetic Perception of Clothing Fabrics in Relation to Body Image and Psychological Security" (unpublished Doctor's dissertation, Utah State University, 1968).

Students indicated physical characteristics of texture in research by Dennis[13] while Maw studied the effect of color on visual judgments of texture.[14]

Sociological Implications

The sociological implications of hand have not been as widely discussed as its psychological counterpart. With increasing awareness of environmental influences, however, suggestions have been forwarded to relate man's aesthetic needs to his near environment. National Goals and Guidelines for Research in Home Economics has encouraged research relating to the role that textile fabrics in the form of clothing and furnishings play in fulfilling aesthetic needs and expression.[15]

Historically, many textile fabrics were used because of their aesthetic characteristics including hand. In this sense costume historians have associated fashion and aesthetics in fabric textures with the social climate of the era in which it was created. Boucher described such a relationship in sixteenth century Italy:

> The use of silks and other costly stuffs gave clothing more variety than it had had while wool and linen had been in favor. . . . Silk's softness, brilliance, and smooth texture were better fitted to stress the lines of the body which lost their medieval verticality.[16]

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[13]Thelma Dennis, "Physical Characteristics of Texture as Indicated by Student Responses" (unpublished Master's thesis, The Pennsylvania State University, 1962).

[14]Doris Maw, "The Effect of Color on the Visual Judgment of Selected Textures in Textile Fabrics by a Group of Homemakers" (unpublished Master's thesis, The Pennsylvania State University, 1963).

[15]Jean D. Schlater (director), National Goals and Guidelines for Research in Home Economics (Lansing, Michigan: Michigan State University Press, 1970), 37.

[16]Francois Boucher, 20,000 Years of Fashion (New York: Harry N. Abrams, Inc., 1966), p. 213.

Current work also is being done relating aesthetic characteristics to the present emphasis on environmental awareness. In a paper presented at a Symposium on Sensory Evaluation of Appearance of Materials, Abend discussed the relationship of aesthetics to the present social climate. Believing that textures can be conceptualized through experience and sensation, Abend stated:

> . . .correlations [that] exist between psychological and social factors as they are aesthetically expressed and visually perceived. It appears likely that all products, as a result of their total aesthetic properties, conditioned by visual association and appearance of materials influence subjective responses in favorable or unfavorable ways.[17]

Economic Implications

The economic implications of textile aesthetic properties including hand is obvious. Without aesthetics, fabrics would not sell and profit for all segments of the textile industry would be nonexistent.

There have been vast changes within the textile industry in the past decade and many of these changes have been oriented toward the improvement of textile aesthetics. The industry has said, "We know it works, now let's make it beautiful."[18] Much of the current drive for fiber sophistication has an aesthetic basis. The "look" demands

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[17]C. J. Abend, "Product Appearance as Communication" (paper read at American Society for Testing and Materials Symposium, Philadelphia, Pennsylvania, October 24, 1972).

[18]"The Third Generation of Man-made Fibers," American Fabrics, LXXXII (Spring, 1969), 48.

a much more sophisticated aesthetic fabric that has a richer surface and a more compelling hand.[19]

Many industries continually carry out research designed to maintain product acceptability. Jenkins described this type of research carried out by E. I. DuPont de Nemours & Company:

> Subjective impressions must frequently be recorded and summarized to evaluate and compare products. . . . Even with objectively measurable properties, subjective thresholds of acuity, acceptability, or preference must be obtained. This insures that the product is desirable and that research money is not allocated to product development or to the tightening of quality control limits which represent marginal appeal or improvements that are not noticeable.[20]

HAND - INFLUENCE OF FIBER, YARN, FABRIC AND FINISH

A textile product is not a single entity but a combination of factors which make an integrated product. Among these factors which form the final textile product are fiber, yarn, fabric, and finish.

> The hand of a textile depends not only on the finish but also on details of the fabric's structure. Structure, of course, includes: fabric weave-the type and compactness; yarn structure-the type and degree and tightness of twist; and the fiber structure-including supermolecular, macromolecular and molecular structures.
>
> The contributions of all components of structure to texture depend on their distribution and amounts, as well as their sizes, shapes, compactness, cohesiveness and mobilities.[21]

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[19] American Fabrics, p. 49.

[20] M. W. Jenkins, "Obtaining and Summarizing Subjective Impressions for Correlations With Analytical Measurements" (paper read at American Society for Testing and Materials Symposium, Philadelphia, Pennsylvania, October 24, 1972).

[21] Lundgren, p. 36.

Influence of Fiber Structure on Hand

Of the many factors involved in fabric hand, fiber properties have been the subject of some research. Kaswell suggests that "in order to compare the relative ability of fibers to produce specific fabrics, the cataloging of fabric properties would be required."[22]

Research which was undertaken by Hoffman and Beste to study the relationship of fibers to fabric hand followed this direction:

> The three basic fiber properties that have the most to do with fabric stiffness are the elastic modulus, the lateral dimensions, and the cross-sectional shape. . . .[23]

> The varying liveliness felt when one handles various fabrics may depend somewhat upon stiffness, but probably is even more dependent. . .upon interfiber friction.[24]

> . . .density is primarily due to low twist and intense crimp in the filaments, to the fiber elastic properties, and to a lesser degree, to low polymer density.[25]

Summarizing their research, the authors concluded:

> The hand, liveliness, and shape retention of fabrics are controlled in large measure by three fiber properties: the initial stiffness; the change in stiffness as the deformation of the load is increased; and the recovery when the load is removed.[26]

Harshness, as viewed by Bogarty and others, was also directly related to hand and was a function of fiber diameter and the length of the surface fiber:

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[22]Kaswell, p. 447.

[23]Hoffman and Beste, p. 67.

[24]Hoffman and Beste, p. 71.

[25]Hoffman and Beste, p. 71.

[26]Hoffman and Beste, p. 76.

> The relationship of fiber fineness to cloth softness is well known. . . . The prickle sensation given by short surface fibers acting as columns and resisting collapse by the fingers is also characteristic of some types of harshness.[27]

Current research, particularly in the area of man-made fibers, has suggested other fiber properties which relate to hand in fabrics. Highly oriented fibers sometimes have a rather unattractive harsh handle, while those which are less oriented have a warm, soft hand. Cross-sectional shape, crimp, and fiber character also affect the hand of fabrics. Modification in cross-section, bulking the fiber and roughening the fiber surface all tend to improve the tactility.[28]

Influence of Yarn Structure on Hand

Hand in fabrics bears a direct relationship to the type of yarn used in the fabric. Spun yarns are characterized by protruding fiber ends which contribute to a rather dull, fuzzy surface appearance in fabrics. Filament yarns which have not been textured are smooth and silklike which gives them more luster than spun yarns and produces a smooth fabric. Maximum smoothness is obtained by use of filaments laid together with little or no twist. Novelty yarns change the hand of textile fabrics by increasing surface interest through the use of slubs, flakes of color, or unevenly twisted yarns.

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[27]H. Bogarty, N. R. S. Hollies, and M. Harris, "The Judgment of Harshness of Fabrics," Textile Research Journal, XXVI (May, 1965), p. 359.

[28]"Design a Fiber to Order," Encyclopedia of Textiles (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1972), p. 68.

> Complex or novelty yarns are valued primarily for their appearance. They add texture and design to a fabric. . . . Some complex yarns are rough and harsh. . . . On the other hand, loopy yarns, such as mohair, are soft and pleasant to touch.[29]

Yarn size is also a factor which relates to fabric hand. Density in yarns has been thought to have some bearing upon leanness and bulk in fabric:

> Low yarn density is primarily due to low twist and intense crimp in the filaments. . . .
> When yarn diameter is equal to the distance between yarn centers. . .the fabric has minimum leanness. . . . In addition, a fabric which is not lean may be either lofty or hard, depending upon apparent yarn density.
> The advantage of cutting up continuous yarn into staple may be partly the retention of crimp in order to obtain bulkiness.[30]

Influence of Fabric Structure on Hand

The various properties of fabrics which relate directly to hand are numerous. Methods of fabrication can increase or decrease properties of hand. Woven fabrics have received most attention by researchers. Hoffman and Beste described aspects of hand as a function of fabrication:

> . . .the type of weave affects the stiffness. A satin weave is softer than a plain weave, for example, because the warp threads are not locked in by alternate picks, but only by every fifth pick or every ninth pick.[31]
>
> Another factor that can affect the hand and the apparent stiffness of a fabric is the weight per square yard.[32]

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[29]Marjory Joseph, Textile Science (New York: Holt, Rinehart & Winston, Inc., 1972), 205.

[30]Hoffman and Beste, pp. 71-72.

[31]Hoffman and Beste, p. 68.

[32]Hoffman and Beste, p. 71.

Smoothness is a well recognized aspect of hand and is due primarily to fabric structure:

> There are many ways of avoiding smoothness - exemplified in crepes, seersuckers, tweeds, corded and ribbed fabrics, piques, bouclés, slubbed fabrics and many other fabrics. On the other hand, the super-smooth effect of a mirror-like surface is sometimes sought. . . . These are all mainly effects of fabric architecture. . . .[33]

Influence of Finishes on Hand

It is assumed by many segments of the textile industry that without the application of finishes, textile fabrics would be unacceptable to consumers.

> It is the consumer who has the final say. But it is the finisher's task to impart the last word into the fabric. The finisher's job is fashioning into fabrics "the equivalent of the complex state of the consumer's desires."
>
> Finishing is considered an art because art is concerned with the uniqueness of a thing as distinct from science which is concerned with the generalities. With refinement of ways to determine the uniqueness of a particular fabric, finishers will be able more systematically to impart into the fabric the "final word."[34]

Thus, it is not surprising that one of the factors influenced by finishing treatments is that of fabric hand.

Research has indicated relationships between levels of fabric softeners and appreciation of hand. In a study carried out by a committee of The American Association of Textile Chemists and Colorists, a comparison was made of preferences of fabrics processed with various amounts of softeners:

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[33]Hoffman and Beste, p. 75.

[34]Lundgren, p. 44.

> The test subjects were required to indicate their preferences of paired samples and to denote their preference through the use of six common textile terms for hand. The terms were softness, smoothness, firmness, coarseness, thickness, and heaviness.
>
> A definite preference for fabrics containing a varying amount of softener as compared to no-softener was noted by all groups. An overwhelming number of the sampling used the terms softness and smoothness to denote preferences.[35]

Mechanical finishing treatments as well as chemical additives affect fabric hand:

> The effects on handle caused by length of surface fibers are seen in fabrics which are made softer by a napping or brushing operation, or conversely by shearing or close cropping.[36]

EVALUATION OF FABRIC HAND

Research which has been undertaken to evaluate hand in fabric has incorporated subjective evaluation, objective measurement and a combination of the two methods.

Research Incorporating Subjective Evaluation of Hand

There have been a few studies which have dealt strictly with subjective evaluation of fabric properties including hand. "Our society is gradually realizing that an evaluation of technological problems

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[35]"An Assessment of the Relationship Between Softener Level and People's Appreciation of Fabric Hand," American Dyestuff Reporter, LV (January 3, 1966), 30.

[36]Bogarty, Hollies and Harris, p. 359.

involves human factors just as much as the distribution of physical systems."[37]

Psychometric research involves the measurement of opinion using a combination of techniques including psychology, mathematics, computers and ingenuity. The United States Testing Company used psychometric techniques to test the acceptability of various fabrics before they were manufactured for the market. A selected group of individuals was brought into the laboratory where all extraneous influences were removed. By method of paired comparisons or rankings, subjects indicated preferences for various fabrics on a number of variables including hand.[38]

Members of the textile industry also have engaged in psychometric research to develop subjective measures for hand. In an article entitled "Measuring the Aesthetic Appeal of Textiles," Hoffman debated whether laboratory instruments can measure the physical properties responsible for good aesthetics. Believing it is possible to do this only after determining preferences, Hoffman concluded:

> In the future, the textile industry will probably encounter a growing number of problems in product evaluation for which the techniques of psychometrics may be uniquely effective.[39]

One of the most conclusive pieces of research regarding textile aesthetics was undertaken by Brand. Agreeing that effective research of

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[37]J. F. Halldane, "Physical Measurement Related to Human Perception and Cognition," Materials Research Standards, X, 12 (December, 1970), 8.

[38]Ryan, p. 157.

[39]R. M. Hoffman, "Measuring the Aesthetic Appeal of Textiles," Textile Research Journal, XXV (May, 1965), 428-434.

aesthetic characteristics was difficult because of a lack of definitions, Brand believed that the most reliable tool in measuring aesthetics tended to be subjective evaluation. Words, therefore, served as an important tool if arranged according to textile frames of reference.[40]

Sensory evaluation of fabric has been the subject of research by Lundgren:

> Textile hand is considered as the summation of the "weighted" contribution of stimuli evoked by a fabric on the major sensory centers presumably present in the human hand. Such centers can be uniquely sensitive to roughness, stiffness, bulk, and thermal properties.[41]

Research Incorporating Objective Measurement of Fabric Hand

Little research has been conducted using objective techniques alone to measure hand. It is significant that though several instruments have been developed to measure hand, neither have been accepted for standard test procedures nor have been used extensively for research.

Two instruments have been developed which are purported to measure hand. Thwing-Albert Instrument Company described the Handle-O-Meter as "designed to measure that elusive quality called handle in tissues, towels, nonwoven textiles, gauzes and thin plastic films."[42] Similarly the Fabricometer was "designed to measure the hand and

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[40]Brand, pp. 791-804.

[41]Lundgren, p. 35.

[42]E. J. Albert, "Facts on Testing - No. 6508," Thwing-Albert Instrument Company, p. 4.

drape quality of sheet materials such as. . .nonwoven and woven textiles."[43]

Research Incorporating Subjective Evaluation and Objective Measurement of Fabric Hand

With the increasing awareness of the importance of subjective evaluation in determination of fabric hand, most research dealing with this topic has combined techniques of subjective evaluation and objective laboratory measurement.

Some of the earliest research combining the two techniques was conducted by Howorth and Oliver. They concluded that:

> Unskilled observers describe the feel of these fabrics mostly in terms of smoothness, softness, coarseness, thickness, weight, warmth, and stiffness. The relationship between these qualities and objective measurements of stiffness, weight, thickness, hardness, and cover factors has been examined.
>
> . . .the relationship between the tests implies that there exist physical tests that will give a description of the handling quality of a fabric. These can be identified as smoothness, stiffness and thickness. Satisfactory measurements of stiffness and thickness can be made, but no measurement of smoothness has yet been found which correlates well with the subjective impression of smoothness.[44]

Similar research done later by Howorth confirmed that "smoothness, stiffness and thickness account for most of the differences in

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[43]"Thwing-Albert Fabricometer" (unpublished leaflet, No. 1091), Thwing-Albert Instrument Company, Philadelphia, Pennsylvania.

[44]W. S. Howorth and P. H. Oliver, "The Application of Multiple Factor Analysis to the Assessment of Fabric Handle," Journal of the Textile Institute, XLIX (November, 1958), T540.

handle."[45] From his research he deduced preferred terms for description of handle:

Smoothness - Smooth-Rough
Stiffness - Stiff-Limp
Thickness - Thick-Thin
Weight - Heavy-Light
Softness - Soft-Firm[46]

Other researchers have added several factors to be considered in evaluation of hand by subjective and objective means. Significant correlations between subjective evaluation and objective measurements of fabric stiffness and liveliness were found by Dawes and Owen.[47] Studies by Kobayashi and Suda have added other factors:

> Physical properties relating to the handling of cotton shirting are weight, thickness, flexibility, surface friction and yarn diameter.[48]

SUMMARY

A review of the literature reveals that little current research has been conducted concerning the relationship of the subjective evaluation of hand to objective laboratory measurement. The literature did

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[45]W. S. Howorth, "The Handle of Suiting, Lingerie, and Dress Fabrics," Journal of the Textile Institute, LV (April, 1964), T251.

[46]W. S. Howorth, "Fabric Handle," Journal of the Textile Institute, LVI (February, 1965), T95.

[47]V. Dawes and J. D. Owen, "The Assessment of Fabric Handle: Stiffness and Liveliness," Journal of the Textile Institute, LXII, 5 (May, 1971), 233.

[48]S. Kobayashi and N. Suda, "On Sensation of the Handling of Cotton Shirting," Journal of the Textile Machinery Society of Japan (English Edition), XII, 5 (1966), 208.

reveal, however, the implication of psychological, sociological, and economic factors on fabric hand, and the importance of such components as fibers, yarns, fabrics, and finishes upon hand of textile products.

CHAPTER III

PROCEDURE

This research was undertaken to determine the importance of the aesthetic property of fabric hand to consumers and to compare the subjective evaluation of hand by consumers to the objective laboratory measurement of the same property.

Selection of Fabrics for the Evaluation of Hand

Fifteen fabrics, purchased as over-the-counter goods, were chosen to be tested in this study. Fabrics selected were typical of those used by consumers either as apparel fabrics or fabrics for decorative purposes. The fabrics chosen were white or off-white in color to eliminate color and design variables. The fifteen fabrics evaluated by both subjective and objective procedures were:

1. Felt - 50% Wool, 50% Rayon
2. Nonwoven Pellon® - 100% Polyester
3. Tricot - 100% Triacetate
4. Double knit - 100% Polyester
5. Broadcloth, Durable Press finish - 65% Polyester, 35% Cotton
6. Georgette - 100% Rayon
7. Organza - 65% Rayon, 35% Silk
8. Casement cloth - 100% Glass
9. Satin - 100% Acetate

10. Flannelette - 100% Cotton
11. Chintz - 100% Cotton
12. Melton - 100% Wool
13. Corduroy - 100% Cotton
14. Velvet - 100% Rayon
15. Terrycloth - 100% Cotton

Preparation of Samples for the Subjective Evaluation of Hand

A 15 x 12 inch sample of each of the fabrics was mounted on white cardboard. Five sets of fifteen samples were used in this study with one set used for every ten subjects.

SUBJECTIVE EVALUATION OF THE HAND OF FABRICS

A group of fifty consumers was chosen to evaluate subjectively the hand of the selected fabrics. All of the consumers were interviewed by the researcher who completed questionnaires and evaluation sheets which had been pretested by twenty-five graduate students in a research class at the University of North Carolina at Greensboro.

Each subject was asked a series of questions prior to the actual examination of the fabric to obtain information concerning opinions on fabric hand. The purpose of the preliminary questionnaire was twofold:

1. To request demographic information of the consumer involved in the subjective evaluation of hand.
2. To obtain information concerning consumer familiarity with fabrics and with terms related to the hand of textiles.

Descriptive words related to hand as used in this questionnaire were drawn from terminology used by consumers and by the textile industry. The

questionnaire administered in this part of the study is included in Appendix A.

The subjective evaluation of hand consisted of four parts: (I) a visual examination only, (II) a tactile examination only, (III) a visual/tactile examination, and (IV) a rank ordering of the fabrics. In all parts the consumers were presented with the 15 x 12 inch fabric sample mounted on white cardboard, and were asked to evaluate the hand of fabrics using standard terms designated by The American Society for Testing and Materials. The properties evaluated included:

flexibility - pliable-medium-stiff

compressibility - soft-medium-hard

extensibility - stretchy-medium-nonstretchy

resilience - springy-medium-limp

weight - light-medium-heavy

thickness - thin-medium-thick

surface contour - smooth-medium-rough

surface friction - slippery-medium-harsh

thermal character - cool-medium-warm

The evaluation sheets used for the visual, tactile, and visual/tactile examinations appear in Appendix B.

Visual Examination of Fabric Hand

Part I of the subjective evaluation of fabric hand consisted of a visual examination of each fabric by the subjects with no tactile examination. The subjects designated the hand of each fabric by using the terms prescribed for this study.

Tactile Examination of Fabric Hand

Part II of the subjective evaluation consisted of a tactile examination of the fabrics. Subjects were placed behind an opaque screen having an opening through which they could place one or both hands to touch the fabrics. Again subjects were asked to describe the hand using the designated terms. Responses were recorded by the researcher.

Visual/Tactile Examination of Fabric Hand

Part III of the subjective evaluation consisted of a visual/tactile examination of the fabrics by the subjects. The subjects were allowed to see and touch the fabrics and were asked to describe the hand using the designated terms.

The time required for the subjects to complete the preliminary questionnaire and the visual, tactile, and visual/tactile examinations varied from forty-five minutes to one hour.

Rank Ordering of the Fabrics

In the final part of the subjective evaluation, the consumers were asked to rank each of the fifteen fabrics from one (1) to fifteen (15) on each of the nine properties relating to hand:

1. Flexibility - pliable (1) to stiff (15)
2. Compressibility - soft (1) to hard (15)
3. Extensibility - stretchy (1) to nonstretchy (15)
4. Resilience - springy (1) to limp (15)
5. Weight - light (1) to heavy (15)

6. Thickness - thin (1) to thick (15)

7. Surface Contour - smooth (1) to rough (15)

8. Surface Friction - slippery (1) to harsh (15)

9. Thermal Character - cool (1) to warm (15)

The evaluation sheet used for the rank ordering appears in Appendix C. In order to facilitate ranking, the subjects were directed to separate the fifteen fabrics into three groupings for each property to be evaluated. As soon as the subject was satisfied with the rankings for a specific property, the rank order of the fabrics was recorded. The average time taken for completion of Part IV of the subjective evaluation was forty-five minutes to one hour.

OBJECTIVE LABORATORY MEASUREMENT OF THE HAND OF FABRICS

A combination of laboratory tests was used to measure objectively the hand of the fifteen selected fabrics. All laboratory tests were carried out under controlled conditions of $70^{\circ}F.\pm2^{\circ}F.$ and 65%±2% relative humidity. The American Society for Testing and Materials denotes nine standard properties relating to the hand of fabric. Standard test methods have been developed to measure these properties and are as follows:

Flexibility Compressibility	ASTM D-1388-64 (Reapproved 1970) Stiffness of Fabrics
Extensibility	ASTM D-1682-64 (Reapproved 1970) Breaking Load and Elongation of Textiles
Resilience	ASTM D-1295-67 Wrinkle Recovery of Woven Textile Fabrics Using the Vertical Strip Apparatus

Weight	ASTM D-1910-64 Construction Characteristics of Woven Fabrics
Thickness	ASTM D-1777-64 (Reapproved 1970) Measuring Thickness of Textile Materials
Surface Contour Surface Friction	Instruction Manual Thwing-Albert Handle-O-Meter
Thermal Character	No test method available

Sampling Plan

The samples tested for flexibility-compressibility, extensibility, resilience, weight, thickness, and surface contour-surface friction were taken from a portion of each fabric used in this study. Figure 1 shows the placement of the samples tested. Fabric samples were cut for each of the six tests from each of the fifteen fabrics. Sample size, the number of samples cut, and the number of tests per sample depended upon the specific test procedures and are shown in Table 2.

Determination of Flexibility and Compressibility

Standard Methods of Test for Stiffness of Fabrics, ASTM D-1388-64 (Reapproved 1970) was used to determine the flexibility and compressibility of fabrics. The Cantilever test is the preferred method for measuring stiffness and is applicable to all types of fabrics. The method employs the principle of cantilever bending of cloth under its own weight.[1] Twenty samples to be tested were cut with ten test samples, 6 x 1 inches, cut with the long direction parallel to the warp, and ten

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[1]"Test Specifications-Drape-Flex Tester" (Brooklyn: Fabric Development Tests), p. 1.

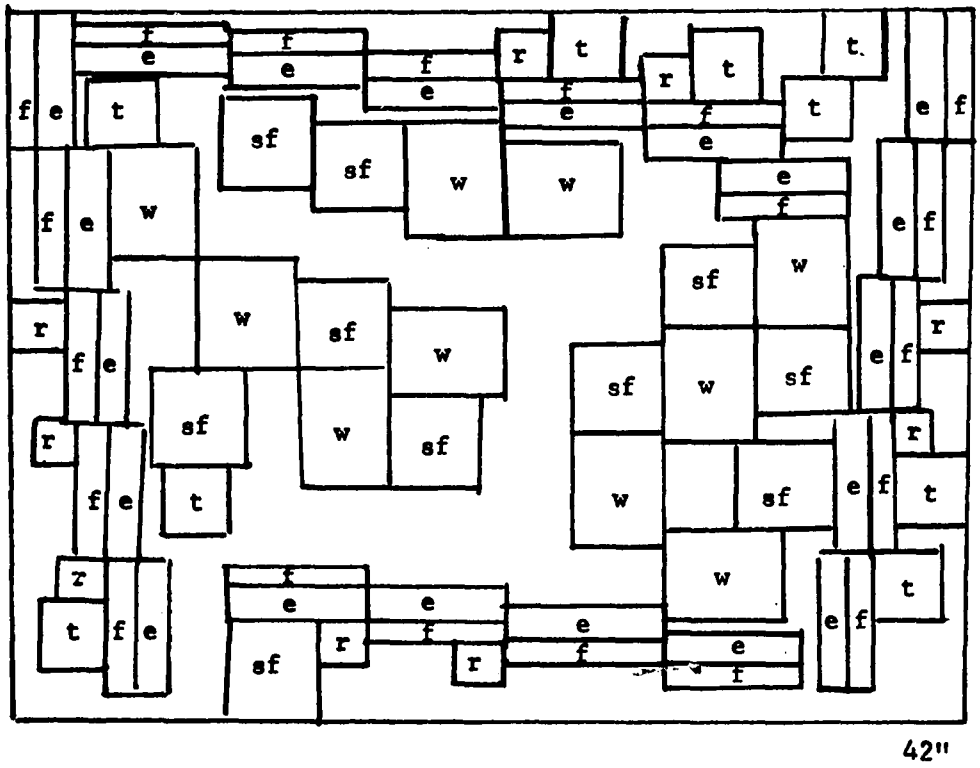

Figure 1

Placement of Samples Tested
Objective Tests

Key

e - extensibility

f - flexibility

r - resilience

sf - surface friction

t - thickness

w - weight

Table 2

Sampling Plan for Objective Tests of Evaluation of Hand

Property Tested	Sample Size	Samples Tested Per Fabric	Test Per Sample	Total Tests Per Fabric
Flexibility-Compressibility	6.0 x 1.0 in.	10 Warp	4	40
	1.0 x 6.0 in.	10 Filling	4	40
Extensibility	6.0 x 1.5 in.	10 Warp	1	10
	1.5 x 6.0 in.	10 Filling	1	10
Resilience	4.0 x 1.5 cm.	10 Warp	1	10
	1.5 x 4.0 cm.	10 Filling	1	10
Weight	4.0 x 5.0 in.	10	1	10
Thickness	3.0 x 3.0 in.	10	1	10
Surface Friction-Surface Contour	4.0 x 4.0 in.	10	4	40
			Total	180

$$\frac{\text{Total Tests Per Fabric}}{180} \times \frac{\text{Fabrics}}{15} = \frac{\text{Total Objective Tests}}{2700}$$

test samples, 1 x 6 inches, cut with the long direction parallel to the filling.

The Drape-Flex Stiffness Tester was the instrument used to measure the flexibility-compressibility of the fifteen selected fabrics. The instrument consists of a smooth flat surfaced horizontal platform of polished metal with a leveling bubble incorporated into the platform and an indicator inclined at an angle of 41.5 degrees below the plane of the platform surface. A metal bar, 1 x 6 x 1/8 inches, serves as a weight.[2] A six inch ruler with 1/10 inch graduation is fastened to the top of the platform.[3]

The instrument was placed on a table so that it was horizontal as indicated by the leveling bubble. Each sample was tested by placing it on the instrument platform with the weight on top. The sample and weight were then slid steadily forward until the leading edges projected beyond the edge of the platform. As soon as the sample tip fell to the level of the inclined plane when viewed parallel to the surface of the slope, a reading was taken from the ruler to the nearest 0.05 inches.[4] Four readings were taken for each sample. Two readings were taken on the face and two on the back of fabrics, first at one end and then the other.[5] The flexibility and compressibility were recorded in centimeters

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[2]1970 Annual Book of ASTM Standards, Part 24 (Philadelphia: American Society for Testing and Materials, 1970), p. 304.

[3]"Test Specifications - Drape-Flex Tester," p. 1.

[4]"Test Specifications - Drape-Flex Tester," p. 2.

[5]1970 Annual Book of ASTM Standards, p. 305.

as one-half the length of the overhang of the sample when it reached the 41.5 degree slope.

Determination of Extensibility

To determine the extensibility of the fifteen selected fabrics, Standard Methods of Test for Breaking Load and Elongation of Textile Fabrics, ASTM D-1682-64 (Reapproved 1970), was used. This method is suitable for testing the elongation of most types of textile fabrics. Several test procedure options are available depending upon samples to be tested and the instrument to be used. For this study the raveled strip option was used for all woven fabrics and the cut strip option was used for nonwoven and knitted fabrics. For those fabrics which were appropriate to testing by the raveled strip option, ten samples were cut from each fabric, 6 x 1½ inches, with the long direction parallel to the warp. Threads were raveled from each side resulting in a 6 x 1 inch sample. Ten similar samples were cut with the long direction parallel to the filling and were raveled as directed by the procedure. For fabrics which could not be easily raveled, twenty samples were cut, 6 x 1 inches, with ten test samples cut with the long direction parallel to the filling. The nonwoven Pellon® was cut 1 x 7 inches as directed by ASTM D-117, Testing of Nonwoven Fabrics.

The instrument used in this study to test the extensibility of the fabrics was a Scott Model J Tensile and Elongation Tester. This testing instrument is classified as a constant rate-of-traverse (pendulum type) machine. The principle of operation involves a pulling clamp moving at a uniform rate with the load applied through a second clamp.

The constant load used in this study was 300 pounds. The rate of increase of elongation is dependent upon the extension characteristics of the samples being tested.[6]

Each of the samples was secured in the clamps of the testing machine under uniform tension, so that the long dimension was parallel to the application of the load. The vertical starting lever was pulled forward to move the clamps apart and to exert pull on the fabric. The elongation of the fabric was recorded by an autographic recording device and the maximum elongation was measured at the point at which the fabric broke under the load. The extensibility was expressed for each sample as the percentage increase in length.

Determination of Resilience

Standard Method of Test for Wrinkle Recovery of Woven Textile Fabrics Using the Vertical Strip Apparatus, ASTM D-1295-67, was used to determine the resilience of the fifteen selected fabrics. Twenty samples, 1.5 x 4 centimeters, were cut from both the warp and filling directions of each fabric. Because of variability of factors determining wrinkle recovery, conditions such as applied pressure, time under pressure, and recovery time were carefully controlled.[7]

The Monsanto Wrinkle Recovery Tester was the instrument used to estimate the resilience of the fifteen selected fabrics. The instrument consists of a disk and protractor on which the fabric sample is mounted

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[6]1970 Annual Book of ASTM Standards, p. 2.

[7]1970 Annual Book of ASTM Standards, p. 268.

by means of a clamp for the specimen holder. Accessories include the specimen holder, a transparent plastic press, and a 500 gram weight.[8]

The samples tested were placed between the leaves of the specimen holder with one end directly under the 1.8 centimeter mark. The exposed end of the sample was lifted over the mark on the short metal leaf and held in place with the left thumbnail. The holder and sample were placed in the plastic press, with the jaw having the small raised platform outside of and parallel to the longer metal strip of the holder. The edge of the flat and thicker jaw was brought into contact with the specimen, with only sufficient pressure to hold the sample in place. The press-holder combination was inverted on a table top with the small platform upward and a 500 gram load was applied to the platform. After exactly five minutes, the load was removed and the sample in its specimen holder was inserted into the clamp of the tester. The press was removed and the specimen holder was adjusted by aligning the crease in the sample with the vertical guide line in the center of the tester. For the next five minutes, the specimen was kept aligned with the vertical guide line. Precisely five minutes later, final adjustment was made and the degree of wrinkle recovery was recorded.[9]

Determination of Weight

Standard Methods of Test for Construction Characteristics of Woven Fabrics, ASTM D-1910-64 (Reapproved 1970), was used to measure

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[8] 1970 Annual Book of ASTM Standards, p. 269.

[9] 1970 Annual Book of ASTM Standards, p. 271.

weight in ounces per square yard of the fabrics. Using the method applicable for weighing small samples, ten samples, 4 x 5 inches, were cut from all fabrics with the exception of the felt. The weight in ounces per square yard of felt was determined according to Standard Methods of Testing Felt, ASTM D-461-67. Ten 5 x 8 inch samples were cut.

Each sample was weighed on a standard analytical balance made by Eimer and Amend and the weight in grams to the nearest .0001 gram was recorded for each sample. Conversion of the weight in grams to the weight in ounces per square yard was calculated using the following formula:

$$\frac{\text{Weight of specimen in grams X 45.72}}{\text{Length of specimen in inches X Width of specimen in inches}}$$ [10]

Determination of Thickness

Standard Method for Measuring Thickness of Textile Materials, ASTM D-1777-64 (Reapproved 1970), was used to determine the thickness of the selected textile fabrics. This method is applicable for measuring the thickness in all types of textile fabrics, including wovens, nonwovens and knits.[11] Thickness of textiles is determined by observing the linear distance that a movable plane is displaced from a parallel surface by the textile material while under a specified pressure.[12] Ten

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[10] 1970 Annual Book of ASTM Standards, p. 425.

[11] 1970 Annual Book of ASTM Standards, p. 382.

[12] 1970 Annual Book of ASTM Standards, p. 382.

3 x 3 inch samples were cut from each of the fourteen fabrics to be used for thickness measurement. Ten 4 x 5 inch samples were cut from the felt, as directed in ASTM D-461-67, Standard Method of Testing Felt.

The instrument used to determine thickness was the C & R Thickness Tester, CS 55 070, supplied by Custom Scientific Instruments. All testing was done using a presser foot 0.375 inch in diameter and under pressure of 0.50 psi.

Each test sample was placed under the anvil of the testing instrument and the presser foot was then brought into contact with the fabric. The thickness reading was made after a five second loading time interval and recorded to the nearest 0.001 inch. One reading for thickness was taken from each of the ten samples for fourteen of the fabrics. Five readings for thickness were taken from each of ten samples for felt as directed by the test procedures.

Determination of Surface Friction-
Surface Contour

The Thwing-Albert Handle-O-Meter is an instrument which has been developed to measure the resistance due to the surface friction of a textile material. The factor of surface friction is measured by using a Linear Variable Differential Transformer to detect the resistance encountered by a blade forcing a sample of material into a slot of parallel edges. A microammeter indicates the resistance in grams. The surface friction of any given material is considered to be the sum of four readings taken on both sides and in both directions of

the sample and is recorded in grams per standard width of sample.[13] Ten 4 x 4 inch samples were cut from each of the fifteen fabrics to be tested on the Handle-O-Meter, and four measurements were taken for each sample.

Each sample was placed under the blade on the platform so that the direction to be tested was perpendicular to the slot. The start switch was pressed and the surface friction was recorded as the maximum reading indicated in grams on the Microammeter. The blade of the Handle-O-Meter was automatically reset for the succeeding test after a fifteen second cycle was recorded.

ANALYSIS OF DATA

Analysis of variance was used to test significant differences in subjective evaluation of the fifteen selected fabrics by visual, tactile, and visual/tactile examinations. Analysis of variance was also used to test significant differences in hand of fabric as measured by objective tests. Findings were considered significant at the .05 level and highly significant at the .01 level.

The Spearman Rank Correlation Coefficient was used to determine the relationship between the subjective ranking of each fabric on each of the properties and the ranking of the results of the objective laboratory measurements.

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[13]"Instructions for the Thwing-Albert Handle-O-Meter" (Philadelphia: Thwing-Albert Instrument Company), p. 2.

CHAPTER IV

PRESENTATION OF DATA

The major objective of this study was to determine the relationship between subjective evaluation and objective laboratory measurement of the property of hand in textile fabrics. Data were obtained from subjective evaluation and laboratory testing of fifteen selected fabrics.

Fifty consumer subjects evaluated the hand of the fifteen fabrics under three different subjective testing conditions - visual examination only, tactile examination only, and visual/tactile examination. Using terms relating to the property of hand, consumers were asked to describe the fabrics and then to rank order them. The properties evaluated included flexibility, compressibility, extensibility, resilience, weight, thickness, surface friction, surface contour, and thermal character.

Objective data were obtained by laboratory testing of the fifteen selected fabrics. Standard test procedures were used to measure flexibility-compressibility, extensibility, resilience, weight, thickness, and surface contour-surface friction. An analysis of variance was used to determine whether significant differences existed between fabrics as evaluated subjectively under the three different subjective test conditions. The same statistical procedure was used to determine significant differences between fabrics as measured by laboratory tests. Correlation coefficients were calculated to determine whether relationships exist between subjective evaluation and objective laboratory measurement of the property of hand of the fifteen selected fabrics.

DISCUSSION OF FINDINGS RELATED TO THE SUBJECTIVE EVALUATION OF HAND

Data for the subjective evaluation of hand were obtained from several sources. A preliminary questionnaire was given to each consumer subject to gather demographic information and to determine consumer familiarity with terms relating to hand in fabrics. Evaluation sheets were used to record consumer evaluation of fabric hand under the three testing conditions and to record the rank ordering of the fifteen selected fabrics.

Description of Subjects

Fifty consumers participated in the study. These consumers consisted of forty-six women and four men. Forty-eight percent of the population ranged in age between twenty-six and thirty-five. Thirty-two percent of the subjects had completed high school and 68 percent had completed one or more years of college. Fifty-four percent of the subjects listed their occupational status as housewife, 14 percent as students, and 32 percent in other occupations or retired. Seventy-two percent of the subjects had some sewing experience, while 28 percent listed no sewing experience. Experience with textile products, other than sewing, included the purchase of clothing and hobbies such as knitting and crocheting. Table 3 presents complete demographic information concerning the consumers participating in this study.

Consumer Usage of Terms to Describe Hand of Textile Fabrics

A list of words was presented to each subject in order to determine those terms consumers would use to describe the hand of fabrics and the association each term would have for the consumer,

Table 3

Demographic Information Concerning Consumers* Evaluating Property of Hand in Textiles

Demographic Information	Number	Percent
SEX		
Female	46	92
Male	4	8
AGE		
15 - 25	8	16
26 - 35	24	48
36 - 45	7	14
46 - 55	4	8
56 - 65	5	10
Over 65	2	4
EDUCATIONAL LEVEL		
High School	16	32
College		
One	1	2
Two	6	12
Three	1	2
Four	14	28
Five	12	24
OCCUPATION		
Housewife	27	54
Student	7	14
Other	16	32
SEWING EXPERIENCE		
None	14	28
Little	8	16
Some	11	22
Much	17	34

*N = 50

Pleasant associative words. Many of the terms listed were used by consumers to denote a pleasant association. Such terms as clean, comfortable, smooth, and soft were associated pleasantly by 70 percent or more of the subjects. Other terms associated pleasantly by more than one half of the subjects included bouncy, cool, crisp, cottony, downy, furry, light, pliable, resilient, sheer and warm. Several words were never associated pleasantly by the subjects including beefy, bitey, bristly, clammy, dead, greasy, hard, harsh, hungry, lean, mushy, mussy, rubbery, sandy, scroopy, thready, wrinkled, and wiry. Table 4 presents the distribution of terms having a pleasant association as used by subjects to describe hand of fabric.

Unpleasant associative words. A number of terms describing hand were listed by consumers as having unpleasant associations. Terms including bristly, harsh, limp, rough, scratchy, sleazy, stiff, and wrinkled were associated unpleasantly by at least 60 percent of the subjects. Only one other term, clammy, was considered unpleasant by more than one-half of the subjects. The words clean, compliant, cool, cottony, full, light, lively, resilient, smooth, soft, supple, and white were never associated unpleasantly. Table 5 presents the distribution of terms having an unpleasant association as used by subjects to describe hand of fabrics.

Pleasant or unpleasant associative words. Many terms were listed by consumers as having both a pleasant and unpleasant association depending upon use. The terms heavy and thin were seen as most variable depending upon use. At least 40 percent of the subjects listed the terms bulky, elastic, sheer, shiny, stretchy, and thick as also

Table 4

Distribution of Terms Used by Subjects to Describe Hand of Fabrics - Pleasant Associative Words*

Words	Number	Percent	Words	Number	Percent
Beefy	0	0	Lofty	4	8
Bitey	0	0	Luster	17	34
Boardy	1	2	Mushy	0	0
Bouncy	29	58	Mussy	0	0
Bulky	10	20	Nonstretchy	9	18
Bristly	0	0	Papery	6	12
Clammy	0	0	Pliable	27	54
Clean	35	70	Resilient	34	68
Clinging	11	22	Rough	1	2
Comfortable	46	92	Rubbery	0	0
Compliant	10	20	Scratchy	1	2
Cool	34	68	Sandy	0	0
Crinkly	12	24	Scroopy	0	0
Crisp	34	68	Sheer	25	50
Cottony	26	52	Shiny	12	24
Dead	0	0	Sleazy	3	6
Downy	29	58	Slick	3	6
Dry	7	14	Slippery	3	6
Elastic	17	34	Smooth	36	72
Extendable	6	12	Snappy	16	32
Firm	12	24	Soft	42	84
Full	9	18	Springy	21	42
Furry	31	62	Stiff	3	6
Fuzzy	20	40	Stretchy	16	32
Greasy	0	0	Supple	24	48
Hard	0	0	Thick	9	18
Harsh	0	0	Thin	11	22
Heavy	6	12	Thready	0	0
Hungry	0	0	White	16	32
Lean	0	0	Warm	25	50
Leathery	18	36	Waxy	0	0
Light	31	62	Wet	5	10
Limp	4	8	Wrinkled	0	0
Lively	20	40	Wiry	0	0

*Words which were never associated pleasantly are shown as zero (0) in Number and Percent columns.

Table 5

Distribution of Terms Used by Subjects to Describe Hand of Fabrics - Unpleasant Associative Words*

Words	Number	Percent	Words	Number	Percent
Beefy	1	2	Lofty	1	2
Bitey	6	12	Luster	5	10
Boardy	10	20	Mushy	9	18
Bouncy	3	6	Mussy	15	30
Bulky	14	28	Nonstretchy	88	16
Bristly	32	64	Papery	14	28
Clammy	26	52	Pliable	1	2
Clean	0	0	Resilient	0	0
Clinging	21	42	Rough	33	66
Comfortable	1	2	Rubbery	17	34
Compliant	0	0	Scratchy	45	90
Cool	0	0	Sandy	15	30
Crinkly	11	22	Scroopy	2	4
Crisp	3	6	Sheer	1	2
Cottony	0	0	Shiny	14	28
Dead	10	20	Sleazy	30	60
Downy	1	2	Slick	15	30
Dry	8	16	Slippery	24	48
Elastic	5	10	Smooth	0	0
Extendable	1	2	Snappy	1	2
Firm	5	10	Soft	0	0
Full	0	0	Springy	1	2
Furry	6	12	Stiff	30	60
Fuzzy	15	30	Stretchy	6	12
Greasy	13	26	Supple	0	0
Hard	24	48	Thick	10	20
Harsh	33	66	Thin	2	4
Heavy	11	22	Thready	16	32
Hungry	3	6	White	0	0
Lean	5	10	Warm	2	4
Leathery	4	8	Waxy	11	22
Light	0	0	Wet	16	32
Limp	34	68	Wrinkled	30	60
Lively	0	0	Wiry	18	36

*Words which were never associated unpleasantly are shown as zero (0) in Number and Percent columns.

being either pleasant or unpleasant depending upon use. Table 6 presents the distribution of terms having a pleasant/unpleasant association as used by consumers to describe hand of fabrics.

Other terms used to describe hand of fabrics. Other words were listed by consumers to describe the hand of fabric. Nubby, silky, flimsy, textured, coarse, airy, and slinky were listed at least twice, whereas filmy, good, cuddly, spongy, grainy, luxurious, sturdy, bumpy, absorbent, ribbed, and starchy were added by at least one subject.

Consumer description of fabrics. In order to determine familiarity with the hand of the fifteen selected fabrics, the subjects were asked to describe how the fabrics would feel. Of the fifteen fabrics, consumers used the most words to describe broadcloth, chintz, velvet, and terrycloth and the least words to describe georgette, casement cloth, and melton. With each of the fifteen fabrics, there were several words which were used repeatedly by the consumers. Table 7 presents the most frequently used words to describe the hand of each of the fabrics.

Importance of Hand to Consumers

A majority of consumer subjects felt that hand was an important characteristic in many types of apparel including underwear and lingerie, dresses, blouses, sweaters, shirts, pants, scarves and gloves. The hand of fabrics was considered important in such home furnishing items as carpeting, draperies, upholstery, sheets and towels.

Visual Examination of Fifteen Fabrics

Each of the fifteen fabrics was examined visually by the fifty subjects and was evaluated on a numerical scale from one to three for

Table 6

Distribution of Terms Used by Subjects to Describe Hand of Fabrics - Pleasant/Unpleasant Associative Words*

Words	Number	Percent	Words	Number	Percent
Beefy	1	2	Lofty	1	2
Bitey	3	6	Luster	10	20
Boardy	3	6	Mushy	0	0
Bouncy	5	10	Mussy	0	0
Bulky	23	46	Nonstretchy	19	38
Bristly	2	4	Papery	6	12
Clammy	1	2	Pliable	9	18
Clean	2	4	Resilient	7	14
Clinging	16	32	Rough	13	26
Comfortable	0	0	Rubbery	5	10
Compliant	4	8	Scratchy	1	2
Cool	15	30	Sandy	0	0
Crinkly	19	38	Scroopy	0	0
Crisp	11	22	Sheer	21	42
Cottony	14	28	Shiny	22	44
Dead	1	2	Sleazy	6	12
Downy	0	0	Slick	16	32
Dry	4	8	Slippery	14	28
Elastic	20	40	Smooth	13	26
Extendable	4	8	Snappy	2	4
Firm	13	26	Soft	8	16
Full	7	14	Springy	6	12
Furry	8	16	Stiff	13	26
Fuzzy	13	26	Stretchy	24	48
Greasy	2	4	Supple	5	10
Hard	6	12	Thick	22	44
Harsh	1	2	Thin	31	62
Heavy	32	64	Thready	8	16
Hungry	1	2	White	15	30
Lean	1	2	Warm	20	40
Leathery	17	34	Waxy	0	0
Light	16	32	Wet	5	10
Limp	7	14	Wrinkled	4	8
Lively	4	8	Wiry	2	4

*Words which were never associated as pleasant/unpleasant are shown as zero (0) in Number and Percent columns.

Table 7

Words Most Frequently Used by Consumers to Describe Hand of Fifteen Selected Fabrics

Fabrics	Descriptive Words	Percent of Consumers
Felt	Soft	48
	Thick	18
	Smooth	14
	Stiff	10
Pellon®	Stiff	36
	Soft	12
Tricot	Soft	20
	Slippery	16
	Smooth	12
	Clinging	10
Broadcloth	Smooth	12
	Stiff	12
Double Knit	Soft	26
	Stretchy	20
	Pliable	14
Georgette	Sheer	8
Organza	Stiff	18
	Sheer	16
Casement Cloth	Scratchy	4
	Rough	4
Chintz	Smooth	18
	Shiny	14
Satin	Smooth	40
	Shiny	24
	Slippery	10
Flannelette	Soft	54
	Warm	22
Corduroy	Heavy	20
	Soft	18
	Warm	12
	Rough	10
Velvet	Soft	48
	Smooth	20
Melton	Heavy	12
Terrycloth	Rough	30
	Soft	20
	Absorbent	18

the nine properties of hand. Means of the fifteen fabrics for the properties of hand as evaluated by visual examination are presented in Table 8.

Fabrics were evaluated for flexibility on a numerical scale of pliable (1), medium (2), and stiff (3). Seventy-four percent of the fabrics were rated from pliable to medium with tricot, georgette, flannelette, velvet, and terrycloth evaluated as most pliable. Fabrics including casement cloth, chintz, melton, and corduroy were evaluated as the softest fabrics, while casement cloth was rated as the hardest.

Extensibility of the fabrics was evaluated as stretchy (1), medium (2), and nonstretchy (3). Only three fabrics, tricot, double knit, and georgette were evaluated as stretchy to medium, while the remainder of the fabrics were judged as nonstretchy. The least stretchy fabrics were satin and chintz. Mean evaluations varied from 1.28 to 2.90.

The fifteen fabrics were evaluated for resilience on a numerical scale of springy (1), medium (2), and limp (3). With the exception of double knit and melton, the fabrics were generally evaluated as medium. The most springy fabric was double knit with a mean of 1.32, and the limpest fabric was flannelette with a mean of 2.30.

For the property of weight, fabrics were evaluated as light (1), medium (2) and heavy (3). Organza, georgette, and tricot were rated as lightest in weight, while melton was evaluated as the heaviest fabric. Fabrics judged as medium to heavy included casement cloth, corduroy, velvet, felt, and terrycloth, whereas the remaining fabrics were evaluated as light to medium.

Table 8

Means of Fifteen Fabrics for Properties of Hand as Evaluated by Visual Examination

Fabrics	Means of Properties of Hand*								
	Flexibility	Compressibility	Extensibility	Resilience	Weight	Thickness	Surface Contour	Surface Friction	Thermal Character
Felt	1.86	1.76	2.74	1.90	2.12	2.34	1.86	2.34	2.66
Pellon®	1.82	1.62	2.70	1.86	1.26	1.30	1.62	2.04	1.84
Tricot	1.08	1.12	1.34	2.12	1.16	1.12	1.12	1.14	1.36
Double Knit	1.50	1.62	1.28	1.32	1.90	2.04	2.54	2.16	2.04
Broadcloth	1.62	1.64	2.66	2.12	1.26	1.18	1.28	1.94	1.40
Georgette	1.12	1.08	1.60	1.88	1.06	1.12	1.30	1.38	1.30
Organza	1.38	1.42	2.50	1.94	1.04	1.02	1.06	1.34	1.14
Casement Cloth	2.22	2.36	2.42	1.80	2.02	2.04	2.80	2.50	2.24
Satin	1.94	1.60	2.80	1.98	1.60	1.62	1.08	1.20	1.60
Flannelette	1.40	1.20	2.36	2.30	1.92	1.94	1.64	2.06	2.68
Chintz	2.14	1.94	2.90	1.92	1.52	1.50	1.22	1.72	1.64
Melton	2.10	1.70	2.40	1.46	2.88	2.88	2.38	2.48	3.00
Corduroy	2.02	1.74	2.60	1.82	2.08	2.08	2.16	2.28	2.62
Velvet	1.44	1.14	2.06	1.76	2.10	2.16	1.30	1.68	2.48
Terrycloth	1.48	1.68	2.10	2.02	2.42	2.46	2.88	2.52	2.38

*N = 50

The thickness of the fifteen fabrics was evaluated as thin (1), medium (2), and thick (3). Mean evaluations ranged from 1.02 to 2.88. Organza, georgette, and tricot were considered the thinnest fabrics, while melton was rated as the thickest.

Fabrics were evaluated for surface contour on a numerical scale of smooth (1), medium (2), and rough (3). Organza, satin, and chintz were judged as the smoothest fabrics, with means of 1.06, 1.08, and 1.12 respectively. The roughest fabrics as viewed visually were casement cloth and terrycloth with means of 2.80 and 2.88.

Surface friction for the fabrics was evaluated as slippery (1), medium (2), and harsh (3). Tricot and satin were judged as the most slippery of the fabrics, while casement cloth and terrycloth were considered harshest. Mean evaluations ranged from 1.14 to 2.52.

For the property of thermal character, fabrics were rated as cool (1), medium (2), and warm (3). Organza was rated as the coolest fabric with a mean of 1.14 while melton was considered to be warmest with a mean of 3.00.

Tactile Examination of Fifteen Fabrics

Each of the fifteen fabrics was evaluated by a tactile examination and was judged on a numerical scale from one to three for the nine properties of hand. Means of the fifteen fabrics for the properties of hand as evaluated by tactile examination only are presented in Table 9.

Flexibility of the fabrics was evaluated as pliable (1), medium (2), and stiff (3). All fifty of the consumers evaluated tricot as the most pliable fabric with a mean of 1.00, while flannelette and georgette

Table 9

Means of Fifteen Fabrics of Properties of Hand as Evaluated by Tactile Examination

Fabrics	Means of Properties of Hand*								
	Flexibility	Compressibility	Extensibility	Resilience	Weight	Thickness	Surface Contour	Surface Friction	Thermal Character
Felt	1.82	1.64	2.92	1.74	2.26	2.24	1.64	2.24	2.82
Pellon®	2.82	2.60	2.96	1.56	1.80	1.70	2.10	2.04	1.92
Tricot	1.00	1.00	1.26	2.30	1.04	1.16	1.08	1.08	1.30
Double Knit	1.74	2.02	1.58	1.54	1.98	2.16	2.64	2.36	2.06
Broadcloth	1.90	1.96	2.80	1.76	1.46	1.46	1.38	1.98	1.48
Georgette	1.04	1.64	2.10	2.32	1.02	1.06	2.16	1.96	1.18
Organza	1.80	1.88	2.72	1.70	1.10	1.04	1.22	1.54	1.18
Casement Cloth	1.68	1.86	2.56	1.88	2.12	2.18	2.70	2.36	2.18
Satin	2.76	2.42	2.96	1.66	2.14	1.98	1.02	1.14	1.90
Flannelette	1.02	1.00	2.46	2.42	1.64	1.70	1.34	2.04	2.64
Chintz	2.38	2.28	2.94	1.86	1.66	1.72	1.58	1.98	1.94
Melton	2.66	2.48	2.58	1.56	2.98	2.98	2.38	2.64	2.96
Corduroy	1.44	1.44	2.64	1.90	2.00	1.94	2.04	2.12	2.64
Velvet	1.20	1.06	2.58	2.06	2.00	2.12	1.30	1.72	2.78
Terrycloth	1.22	1.92	2.38	2.12	2.04	2.20	2.72	2.50	2.38

*N = 50

were also considered to be very pliable. Pellon® was judged to be the stiffest fabric with a mean of 2.82. Other fabrics evaluated from medium to stiff included chintz, satin, and melton.

For the property of compressibility, the fifteen fabrics were evaluated on a scale of soft (1), medium (2), and hard (3). Tricot and flannelette were judged as equally soft with means of 1.00. Double knit, chintz, satin, corduroy and Pellon® were evaluated from medium to hard, with means of 2.02 to 2.60.

The extensibility of the fabrics was rated as stretchy (1), medium (2), and nonstretchy (3). Only the two knit fabrics were considered stretchy to medium. The remaining thirteen fabrics were evaluated as medium to nonstretchy with satin and Pellon® judged as least stretchy.

Resilience of the fabrics was evaluated as springy (1), medium (2), and limp (3). All of the fabrics were judged as close to medium with means ranging from 1.54 for double knit to 2.42 for flannelette.

Fabric weight was evaluated as light (1), medium (2), and heavy (3). Mean evaluations for weight ranged from 1.02 for georgette to 2.98 for melton. Fabrics including tricot, and organza were rated as lightweight; corduroy, velvet and terrycloth were considered to be medium weight; felt and melton were evaluated as heavier fabrics.

Thickness of fabrics was evaluated as thin (1), medium (2), and thick (3). Organza and georgette were judged as the thinnest fabrics with means of 1.04 and 1.06. Melton was considered to be the thickest fabric with a mean of 2.98.

For the property of surface contour, fabrics were evaluated as smooth (1), medium (2), and rough (3). Mean evaluations for surface contour ranged from 1.02 for satin to 2.72 for terrycloth. In addition to satin, tricot was considered to be a very smooth fabric, while double knit and casement cloth were evaluated as rough.

Surface friction of the fifteen fabrics was rated as slippery (1), medium (2), and harsh (3). The most slippery fabrics were judged to be tricot and satin with means of 1.08 and 1.14 respectively. Melton was judged the harshest fabric with a mean of 2.64.

For the property of thermal character, fabrics were evaluated as cool (1), medium (2), and warm (3). Mean evaluations ranged from 1.18 for georgette and organza to 2.96 for melton. Fabrics including tricot, broadcloth, satin, chintz, and Pellon® were evaluated in the cool to medium range, while the remainder of the fabrics were rated as medium to warm.

Visual/Tactile Examination of Fifteen Fabrics

Each of the fifteen fabrics was evaluated by a visual/tactile examination and was rated on a numerical scale from one to three. Means of the fifteen fabrics for the properties of hand as evaluated by visual/tactile examination are presented in Table 10.

Fabric flexibility was evaluated as pliable (1), medium (2), and stiff (3). Mean values ranged from 1.00 for tricot to 2.78 for satin. In addition to tricot, georgette and broadcloth were rated as the most pliable fabrics. Pellon® and melton were rated among the stiffest fabrics.

Table 10

Means of Fifteen Fabrics for Properties of Hand as Evaluated by Visual/Tactile Examination

Fabrics	Means of Properties of Hand*								
	Flexibility	Compressibility	Extensibility	Resilience	Weight	Thickness	Surface Contour	Surface Friction	Thermal Character
Felt	2.20	1.72	2.74	1.54	2.54	2.40	1.80	2.32	2.82
Pellon®	2.74	2.70	2.96	1.46	1.52	1.44	2.02	2.34	1.76
Tricot	1.00	1.04	1.14	2.32	1.02	1.16	1.02	1.02	1.34
Double Knit	1.62	2.06	1.36	1.48	2.12	2.12	2.66	2.30	2.22
Broadcloth	1.92	1.98	2.84	1.84	1.30	1.22	1.32	1.94	1.42
Georgette	1.04	1.58	1.80	2.34	1.00	1.00	2.20	1.70	1.24
Organza	2.02	1.98	2.74	1.62	1.00	1.02	1.36	1.38	1.14
Casement Cloth	1.82	2.06	2.52	1.82	2.10	2.08	2.68	2.38	2.40
Satin	2.78	2.32	2.88	1.64	2.12	1.84	1.08	1.10	2.02
Flannelette	1.06	1.00	2.50	2.48	1.60	1.74	1.42	2.02	2.64
Chintz	2.26	2.22	2.98	1.88	1.52	1.46	1.36	1.74	1.56
Melton	2.62	2.32	2.44	1.44	2.96	2.96	2.34	2.64	3.00
Corduroy	1.64	1.56	2.72	1.96	2.00	1.92	1.92	2.22	2.70
Velvet	1.16	1.10	2.68	2.00	2.22	2.16	1.34	1.78	2.62
Terrycloth	1.32	1.66	2.32	2.24	2.10	2.16	2.78	2.54	2.36

*N = 50

For the property of compressibility, fabrics were evaluated as soft (1), medium (2), and hard (3). Flannelette and tricot, with means of 1.00 and 1.04 respectively, were considered the softest fabrics. Pellon®, with a mean of 2.70, was rated as the hardest fabric.

Extensibility of fabrics was rated as stretchy (1), medium (2), and nonstretchy (3). Three fabrics, tricot, double knit and georgette, were evaluated as stretchy to medium. The remaining twelve fabrics were judged as medium to nonstretchy, with chintz and Pellon® rated as least stretchy. Mean evaluations for extensibility ranged from 1.14 for tricot to 2.98 for chintz.

Fabric resilience was evaluated as springy (1), medium (2), and limp (3). Mean evaluations ranged from 1.44 for melton to 2.48 for flannelette. Five fabrics, velvet, terrycloth, tricot, georgette, and flannelette, were rated as medium to limp, while the remaining fabrics were rated as springy to medium.

For the property of weight, fabrics were rated as light (1), medium (2), and heavy (3). The fabrics lightest in weight included georgette and organza with means of 1.00. Melton was judged the heaviest fabric with a mean of 2.96. In addition to the two lightest fabrics, tricot, broadcloth, chintz and flannelette were rated as light to medium, while the remaining fabrics were judged as medium to heavy.

Fabric thickness was evaluated as thin (1), medium (2), and thick (3). Georgette was rated as the thinnest fabric with a mean of 1.00, while melton was judged as thickest with a mean of 2.96. Organza and tricot were rated among the thinnest fabrics. Felt was judged as the thickest fabric after melton.

Surface contour of fabrics was rated as smooth (1), medium (2), and rough (3). Mean evaluations ranged from 1.02 for tricot and 1.08 for satin to 2.68 for casement cloth and 2.78 for terrycloth. Other fabrics including Pellon®, georgette, melton, and double knit were evaluated as medium to rough, while the remaining fabrics were judged as smooth to medium.

For the property of surface friction, fabrics were rated as slippery (1), medium (2), and harsh (3). Tricot, with a mean of 1.02, was considered to be the most slippery fabric, while melton, with a mean of 2.64, was rated as the harshest fabric.

Thermal character of fabrics was rated as cool (1), medium (2), and warm (3). Mean evaluations ranged from 1.14 for organza to 3.00 for melton. Fabrics including tricot, georgette, broadcloth, flannelette, and Pellon® were judged as cool to medium while the remaining fabrics were rated as medium to warm.

Differences Between Fabrics as Evaluated Subjectively

Analysis of variance was the statistical procedure used to determine differences between the fifteen fabrics evaluated subjectively. Mean ratings for all fabrics on the nine properties of hand as evaluated subjectively are presented in Table 11. Differences significant at .0001 were found between the fifteen fabrics on all nine properties of hand as evaluated subjectively in visual, tactile, and visual/tactile examinations.

Differences Between Visual, Tactile and Visual/Tactile Examinations

Analysis of variance was the statistical procedure used to determine differences between visual, tactile, and visual/tactile examination

Table 11

Means of Fifteen Fabrics for Properties of Hand as Evaluated Subjectively

Fabrics	Means of Properties of Hand*								
	Flexibility	Compressibility	Extensibility	Resilience	Weight	Thickness	Surface Contour	Surface Friction	Thermal Character
Felt	1.96	1.71	2.80	1.73	2.31	2.33	1.77	2.30	2.77
Pellon®	2.46	2.31	2.87	1.63	1.53	1.48	1.91	2.14	1.84
Tricot	1.03	1.05	1.25	2.25	1.07	1.15	1.07	1.08	1.33
Double Knit	1.62	1.90	1.41	1.45	2.00	2.11	2.61	2.27	2.11
Broadcloth	1.81	1.86	2.77	1.91	1.34	1.29	1.33	1.95	1.43
Georgette	1.07	1.43	1.83	2.18	1.03	1.06	1.89	1.68	1.24
Organza	1.73	1.76	2.65	1.75	1.05	1.03	1.21	1.42	1.15
Casement Cloth	1.91	2.09	2.50	1.83	2.08	2.10	2.73	2.41	2.34
Satin	2.49	2.11	2.88	1.76	1.95	1.81	1.06	1.15	1.84
Flannelette	1.16	1.07	2.44	2.40	1.72	1.79	1.47	2.04	2.65
Chintz	2.26	2.15	2.94	1.89	1.57	1.56	1.39	1.81	1.71
Melton	2.46	2.17	2.47	1.49	2.94	2.94	2.37	2.59	2.99
Corduroy	1.70	1.58	2.65	1.89	2.03	1.98	2.04	2.21	2.65
Velvet	1.25	1.10	2.44	1.95	2.11	2.15	1.31	1.73	2.63
Terrycloth	1.34	1.75	2.27	2.13	2.19	2.27	2.79	2.52	2.37

*N = 150

of the nine properties of hand. Means of visual, tactile, and visual/tactile examinations of the fifteen fabrics for the nine properties of hand are presented in Table 12.

Differences significant at .0001 were found between tests for properties of compressibility and extensibility. Differences were significant at .0002 for the property of flexibility. For the properties of thickness and surface contour, differences were significant at .01, while differences for weight and thermal character were significant at .02. There were no significant differences between tests for the properties of surface friction and resilience.

DISCUSSION OF FINDINGS RELATED TO THE OBJECTIVE EVALUATION OF HAND

Data for the objective evaluation of hand were obtained from a series of laboratory tests used to measure the properties which are associated with the hand of fabrics. Fifteen selected fabrics were tested for flexibility-compressibility, extensibility, resilience, weight, thickness, and surface friction-surface contour.

Flexibility-Compressibility

Mean values and rank order of the fifteen fabrics for the property of flexibility-compressibility as measured in centimeters are presented in Table 13, and are shown graphically in Figure 2.

Fabric means varied from 1.67 centimeters for tricot to 10.46 centimeters for Pellon®. The mean values for tricot, terrycloth, and flannelette indicated that these were the softest and most pliable fabrics. The hardest and least pliable fabrics as indicated by mean values were Pellon®, felt and melton.

Table 12

Means of Visual, Tactile, and Visual/Tactile Examinations for Properties of Hand

Properties of Hand	Test Means*		
	Visual	Tactile	Visual/Tactile
Flexibility	1.67	1.76	1.81
Compressibility	1.58	1.81	1.82
Extensibility	2.30	2.50	2.44
Resilience	1.88	1.89	1.87
Weight	1.76	1.82	1.81
Thickness	1.79	1.84	1.78
Surface Contour	1.75	1.82	1.82
Surface Friction	1.92	1.98	1.96
Thermal Character	2.02	2.10	2.08

*N = 750

Table 13

Mean Values and Rank Order of Fifteen Selected Fabrics for Property of Flexibility-Compressibility

Fabrics	Mean Values*	Rank Order**
Felt	8.85	14
Pellon®	10.46	15
Tricot	1.67	1
Double Knit	4.23	6
Broadcloth	5.69	9
Georgette	3.08	4
Organza	6.84	12
Casement Cloth	6.15	10
Satin	6.68	11
Flannelette	3.04	3
Chintz	5.15	8
Melton	8.09	13
Corduroy	4.70	7
Velvet	4.16	5
Terrycloth	2.86	2

*Mean values expressed in centimeters as measured by Drape-Flex Stiffness Tester.

**Rank order for flexibility: pliable (1) - stiff (15).
Rank order for compressibility: soft (1) - hard (15).

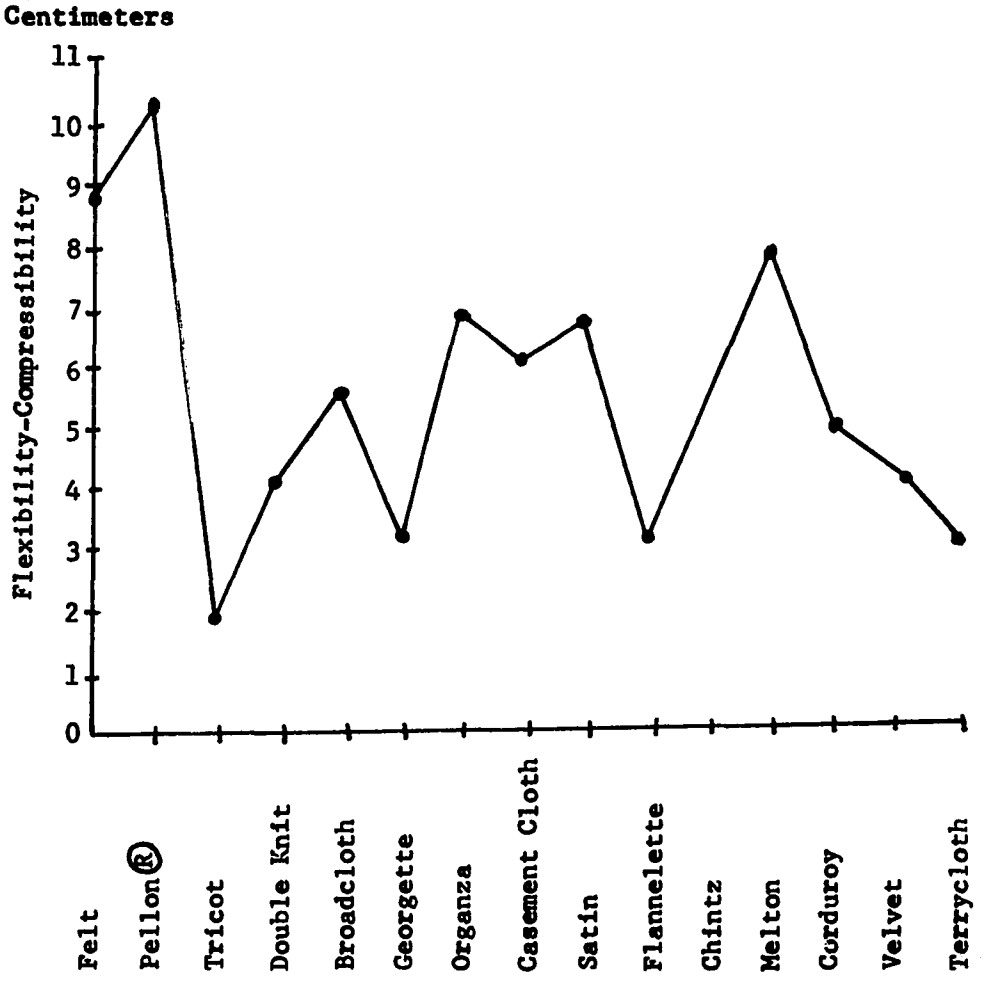

Figure 2

Mean Flexibility-Compressibility of
Fifteen Selected Fabrics

For purposes of evaluating flexibility-compressibility, fabrics were tested in both warp and filling directions. Analysis showed that there were highly significant differences between the warp and filling directions of all fabrics except broadcloth, in which there were no significant differences between the warp and filling.

The variance showed a highly significant difference between all fifteen fabrics for the property of flexibility-compressibility. An analysis of variance summary table for the property of flexibility-compressibility is presented in Table 14.

Table 14

Analysis of Variance Summary Table for Property of Flexibility-Compressibility

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F Value	Prob.>F
Fabric	14	6714.56	479.61	1099.74	.0001
Warp x Filling	1	338.35	338.35	775.84	.0001
Fabric x Warp x Filling	14	527.66	37.69	86.42	.0001
Error	270	117.75	0.44		

Extensibility

Mean values and rank order of the fifteen fabrics for the property of extensibility as measured in percentage increase in length are presented in Table 15, and are presented graphically in Figure 3.

Table 15

Mean Values and Rank Order of Fifteen Selected Fabrics for Property of Extensibility

Fabrics	Mean Values**	Rank Order**
Felt	41.8	3
Pellon®	31.6	5
Tricot	133.0	1
Double Knit	100.8	2
Broadcloth	21.3	9
Georgette	25.8	7
Organza	23.0	8
Casement Cloth	19.0	12
Satin	31.5	6
Flannelette	18.6	13
Chintz	16.6	15
Melton	37.7	4
Corduroy	18.4	14
Velvet	20.6	10
Terrycloth	20.4	11

*Mean values expressed in percentage increase in length at breaking point as measured by Scott Model J Tensile and Elongation Tester.

**Rank order for extensibility: stretchy (1) - nonstretchy (15).

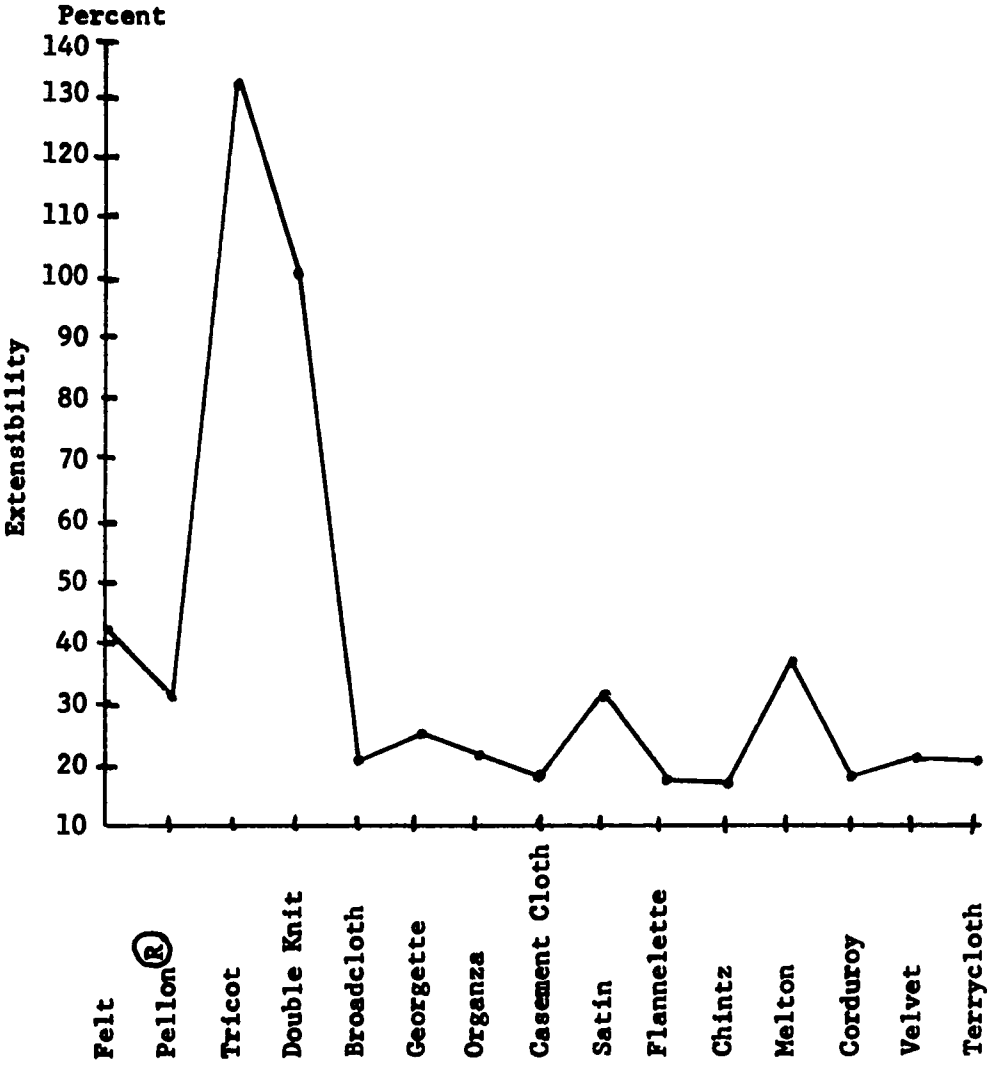

Figure 3

Mean Extensibility of Fifteen Selected Fabrics

The mean extensibility of the fifteen fabrics varied from 133 percent to 16 percent. The two knit fabrics, tricot and double knit, exhibited the greatest extensibility, while chintz and corduroy exhibited the least.

For purposes of evaluating extensibility, the fifteen fabrics were tested in both warp and filling direction. All fabrics except tricot, satin, and melton showed highly significant differences between the extensibility in the warp and filling directions.

The variance showed highly significant differences between all fifteen fabrics for the property of extensibility. The analysis of variance for the property of extensibility is summarized in Table 16.

Table 16

Analysis of Variance Summary Table for Property of Extensibility

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F Value	Prob.>F
Fabric	14	318245.32	22731.81	3286.66	.0001
Warp x Filling	1	8789.09	8789.09	1270.76	.0001
Fabric x Warp x Filling	14	10627.07	759.08	109.75	.0001
Error	270	1867.42	6.92		

Resilience

Mean values and rank order of the fifteen fabrics for the property of resilience as measured by degrees of wrinkle recovery are presented in Table 17. The means are shown graphically in Figure 4.

Table 17

Mean Values and Rank Order of Fifteen Selected Fabrics for Property of Resilience

Fabrics	Mean Values*	Rank Order**
Felt	139	7
Pellon®	155	2
Tricot	125	9
Double Knit	151	4
Broadcloth	133	8
Georgette	141	6
Organza	93	15
Casement Cloth	158	1
Satin	117	10
Flannelette	103	12
Chintz	101	13
Melton	151	3
Corduroy	97	14
Velvet	149	5
Terrycloth	110	11

*Mean values expressed in degrees recovery as measured by the Monsanto Wrinkle Recovery Tester.

**Rank order for resilience: springy (1) - limp (15).

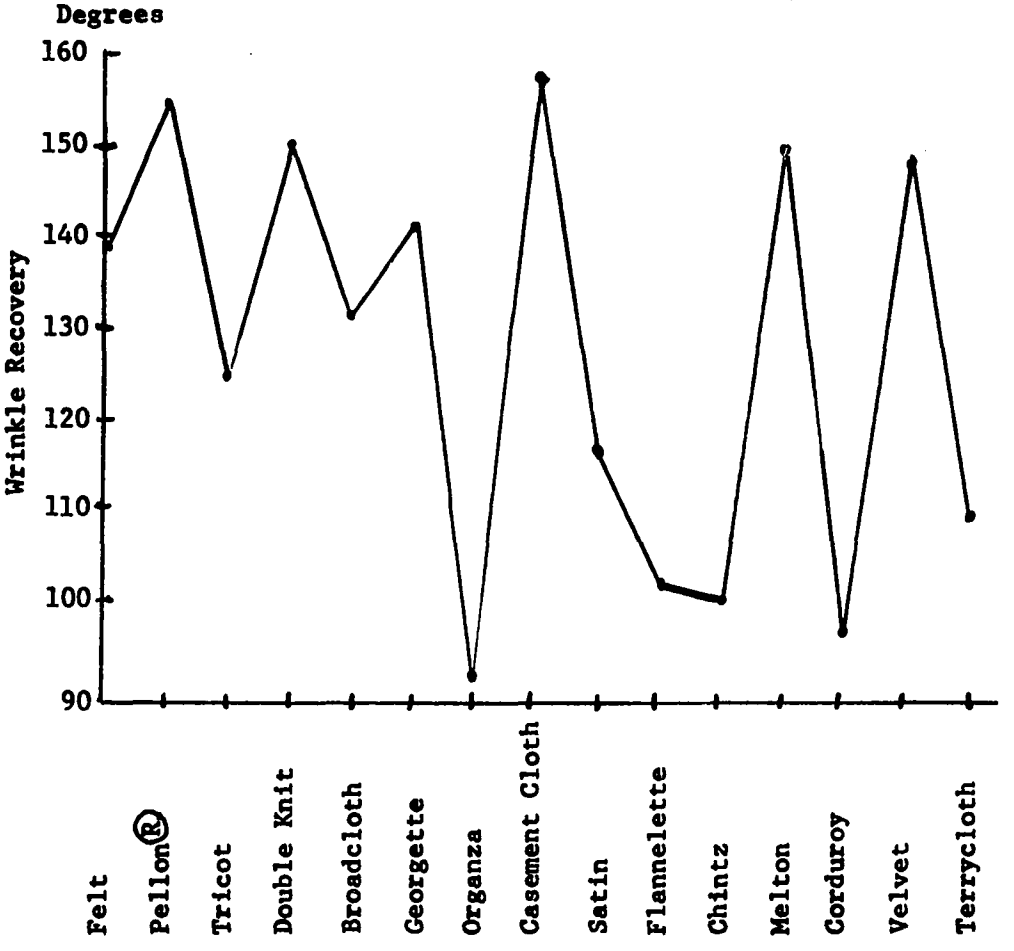

Figure 4

Mean Resilience of Fifteen Selected Fabrics

The mean wrinkle recovery of the fifteen fabrics varied from 158 to 93 degrees. The most resilient fabrics included casement cloth, Pellon® and melton. Organza, corduroy and chintz were the least resilient.

For purposes of evaluating resilience, the fifteen fabrics were tested in both warp and filling direction. There were highly significant differences between warp and filling in tricot, georgette, satin, flannelette and corduroy. The remainder of the fabrics showed no significant differences between warp and filling directions.

The variance showed a highly significant difference between all fifteen fabrics for the property resilience. This variance in resilience is presented in Table 18.

Table 18

Analysis of Variance Summary Table for Property of Resilience

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F Value	Prob.>F
Fabric	14	147628.19	10544.87	108.89	.0001
Warp x Filling	1	790.56	790.56	8.16	.0049
Fabric x Warp x Filling	14	20458.79	1461.34	15.09	.0001
Error	270	26146.50	96.84		

Weight

Mean values and rank order of the fifteen fabrics for the property of weight as measured in ounces per square yard are presented in Table 19. The means are shown graphically in Figure 5.

Table 19

Mean Values and Rank Order of Fifteen Selected Fabrics for Property of Weight

Fabrics	Mean Values*	Rank Order**
Felt	6.73	11
Pellon®	2.48	3
Tricot	2.73	4
Double Knit	6.98	13
Broadcloth	3.53	6
Georgette	1.33	2
Organza	0.78	1
Casement Cloth	5.34	8
Satin	5.57	9
Flannelette	3.55	7
Chintz	3.41	5
Melton	20.73	15
Corduroy	6.80	12
Velvet	6.05	10
Terrycloth	8.77	14

*Mean values expressed in ounces per square yard.

**Rank order for weight: light (1) - heavy (15).

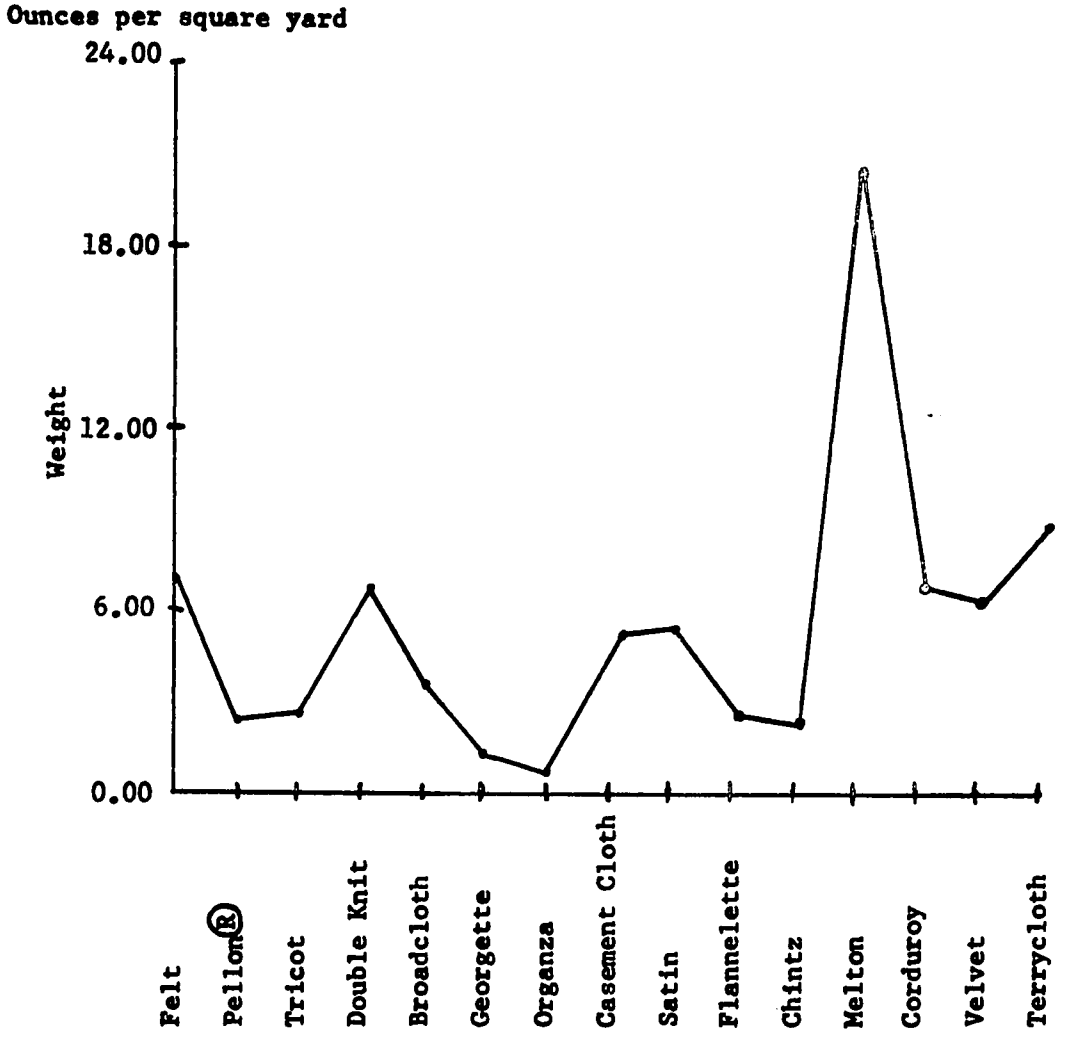

Figure 5

Mean Weight of Fifteen Selected Fabrics

The average weight of the fifteen fabrics varied from 0.78 ounces per square yard to 20.73 ounces per square yard. The fabrics which were lightest in weight were organza, georgette, and Pellon®. The heaviest fabrics included melton, terrycloth, and double knit.

The variance showed a highly significant difference between all fifteen fabrics for the property of weight. The analysis of variance summary table for the property of weight is presented in Table 20.

Table 20

Analysis of Variance Summary Table for Property of Weight

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F Value	Prob.>F
Fabric	14	3167.4696	226.2478	4981.09	.0001
Error	135	6.1319	.0454		

Thickness

Mean values and rank order of the fifteen fabrics for the property of thickness as measured in inches are presented in Table 21. The means are shown graphically in Figure 6.

The mean thickness of the fifteen fabrics varied from 0.004 inches to 0.116 inches. The thinnest fabrics included organza, chintz, and georgette, while the thickest fabrics included melton, terrycloth, and velvet.

Table 21

Mean Values and Rank Order of Fifteen Selected Fabrics for the Property of Thickness

Fabrics	Mean Values*	Rank Order**
Felt	0.0549	12
Pellon®	0.0142	7
Tricot	0.0100	5
Double Knit	0.0474	11
Broadcloth	0.0093	4
Georgette	0.0096	3
Organza	0.0040	1
Casement Cloth	0.0200	8
Satin	0.0110	6
Flannelette	0.0256	9
Chintz	0.0054	2
Melton	0.1162	15
Corduroy	0.0286	10
Velvet	0.0574	13
Terrycloth	0.0663	14

*Mean values expressed in inches as measured by the C & R Thickness Tester.

**Rank order for thickness: thin (1) - thick (15).

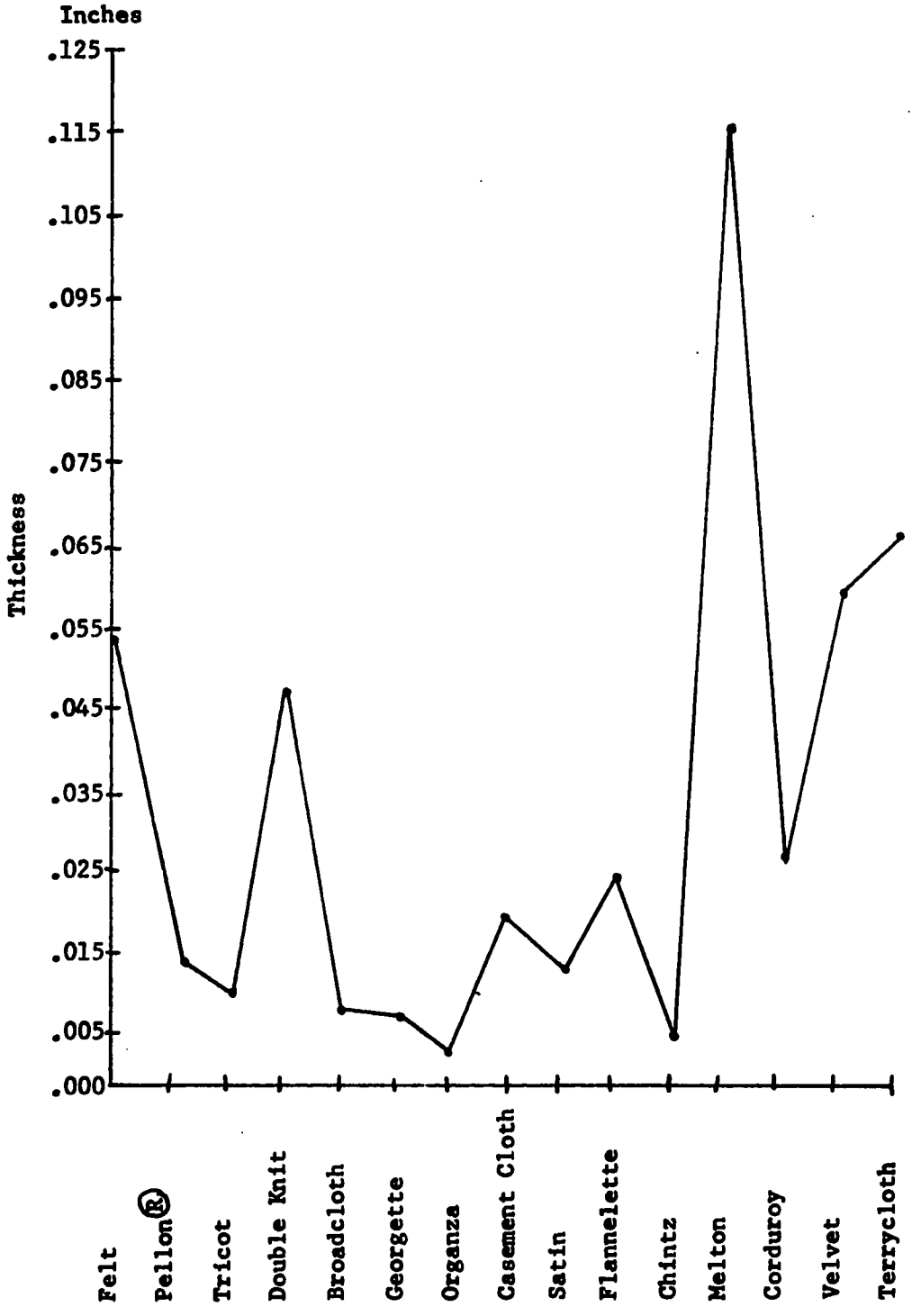

Figure 6

Mean Thickness of Fifteen Selected Fabrics

The variance showed a highly significant difference between all fifteen fabrics for the property of thickness. The analysis of variance summary table for the property of thickness is presented in Table 22.

Table 22

Analysis of Variance Summary Table for Property of Thickness

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F Value	Prob.>F
Fabric	14	.1364	.009740	3783.12	.0001
Error	135	.0003	.000003		

Surface Friction-Surface Contour

Mean values and rank order for the property of surface friction-surface contour are presented in Table 23. The means are shown graphically in Figure 7.

The mean surface friction-surface contour of the fifteen fabrics varied from 5.9 grams to 360 grams. Fabrics which offered least resistance to slipping included tricot and georgette, while melton and felt offered the most resistance to slipping.

The variance showed a highly significant difference between all fifteen fabrics for the property of surface friction-surface contour. The analysis of variance summary table for the property of surface friction-surface contour is presented in Table 24.

Table 23

Mean Values and Rank Order of Fifteen Selected Fabrics for Property of Surface Friction-Surface Contour

Fabrics	Mean Values*	Rank Order**
Felt	354.0	14
Pellon®	263.7	13
Tricot	5.9	1
Double Knit	167.9	10
Broadcloth	86.4	6
Georgette	8.6	2
Organza	45.0	4
Casement Cloth	182.1	11
Satin	200.4	12
Flannelette	31.1	3
Chintz	57.5	3
Melton	360.0	15
Corduroy	137.6	9
Velvet	90.7	7
Terrycloth	94.5	8

*Mean values expressed in grams per four inch width as measured by the Thwing-Albert Handle-O-Meter.

**Rank order for surface friction: slippery (1) - harsh (15). Rank order for surface contour: smooth (1) - rough (15).

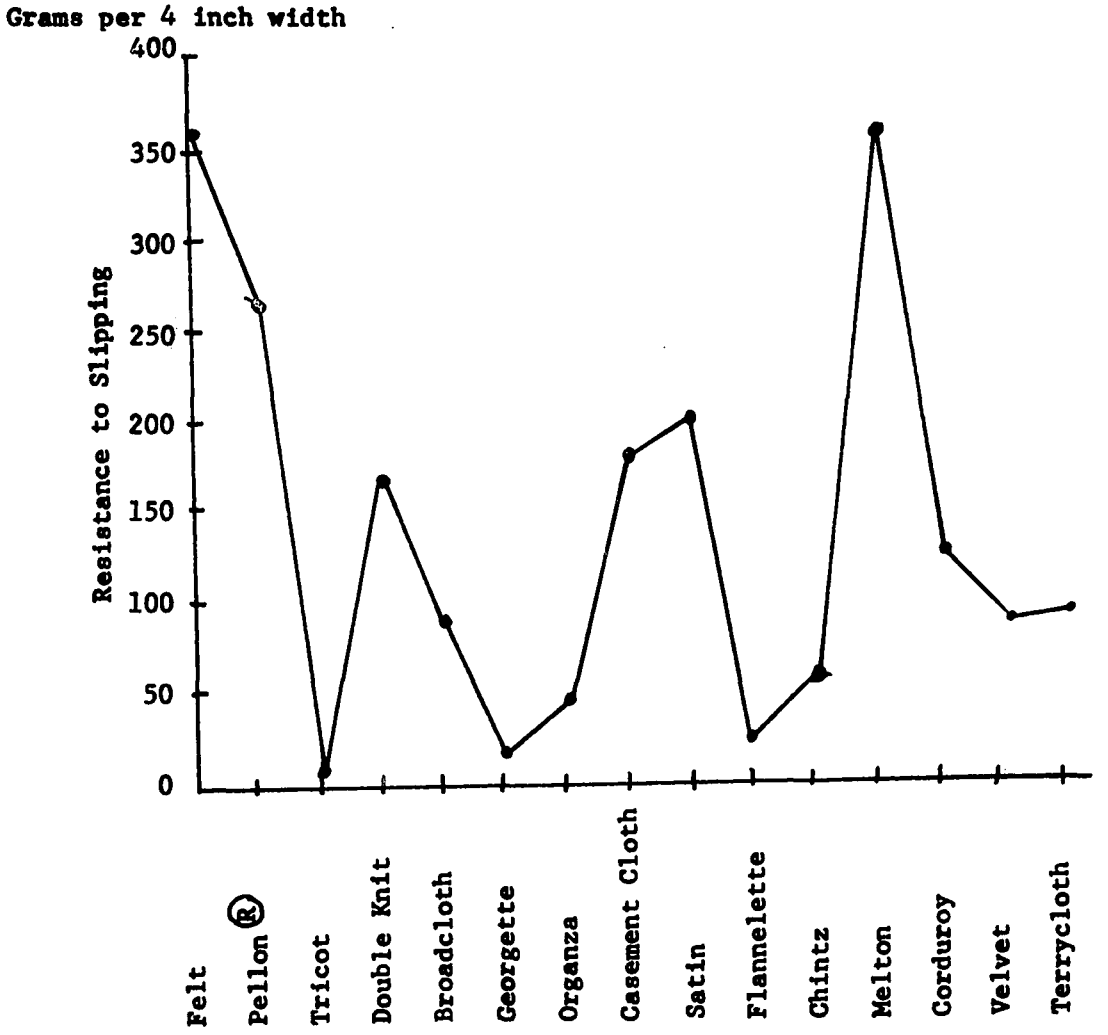

Figure 7

Mean Surface Friction-Surface Contour
of Fifteen Selected Fabrics

Table 24

Analysis of Variance Summary Table for Property of Surface Friction-Surface Contour

Source	Degrees of Freedom	Sum of Squares	Mean Squares	F Value	Prob.>F
Fabric	14	1886144.29	134724.592	956.23	.0001
Error	135	19020.40	140.892		

RELATION OF SUBJECTIVE EVALUATION TO OBJECTIVE LABORATORY MEASUREMENT OF FIFTEEN FABRICS FOR PROPERTIES OF HAND

Rank order of the fifteen fabrics was obtained from both subjective evaluation and objective laboratory measurement. For the subjective evaluation, consumers were asked to rank the fabrics from one to fifteen for each of the nine properties of hand. Rank order was based on sum total of the rankings of all subjects. Rank order for the objective tests was obtained from the means for each of the fifteen fabrics.

Correlation coefficients between subjective evaluation and objective laboratory measurement of the fifteen fabrics for properties of hand were computed using Spearman's Rank Correlation and are shown in Table 25. Correlation coefficients were considered significant at the .05 level of .456 and highly significant at the .01 level of .645.

Table 25

Correlation Coefficients Between Subjective Evaluation and Objective Laboratory Measurements for Properties of Hand

Properties of Hand	Spearman's Rank Correlation Coefficient
Flexibility	.85**
Compressibility	.87**
Extensibility	.25
Resilience	.54*
Weight	.94**
Thickness	.91**
Surface Contour	.453
Surface Friction	.54*
Thermal Character	No objective test available

*Significant at .05 .456
**Significant at .01 .645

Subjective and objective rank orders of the fifteen fabrics for the property of flexibility are presented in Figure 8. Three fabrics including Pellon®, tricot and melton were ranked the same on the two methods of evaluation. The greatest difference in ranking occurred with organza, as consumers considered the fabric to be more pliable than was measured by the objective test. For the property of flexibility, there was a highly significant positive correlation of .85 between subjective and objective evaluations.

Subjective and objective rank orders of the fifteen fabrics for the property of compressibility are presented in Figure 9. For the two methods of evaluation, Pellon®, tricot, georgette and melton were ranked the same. Greatest differences in ranking occurred with chintz, as

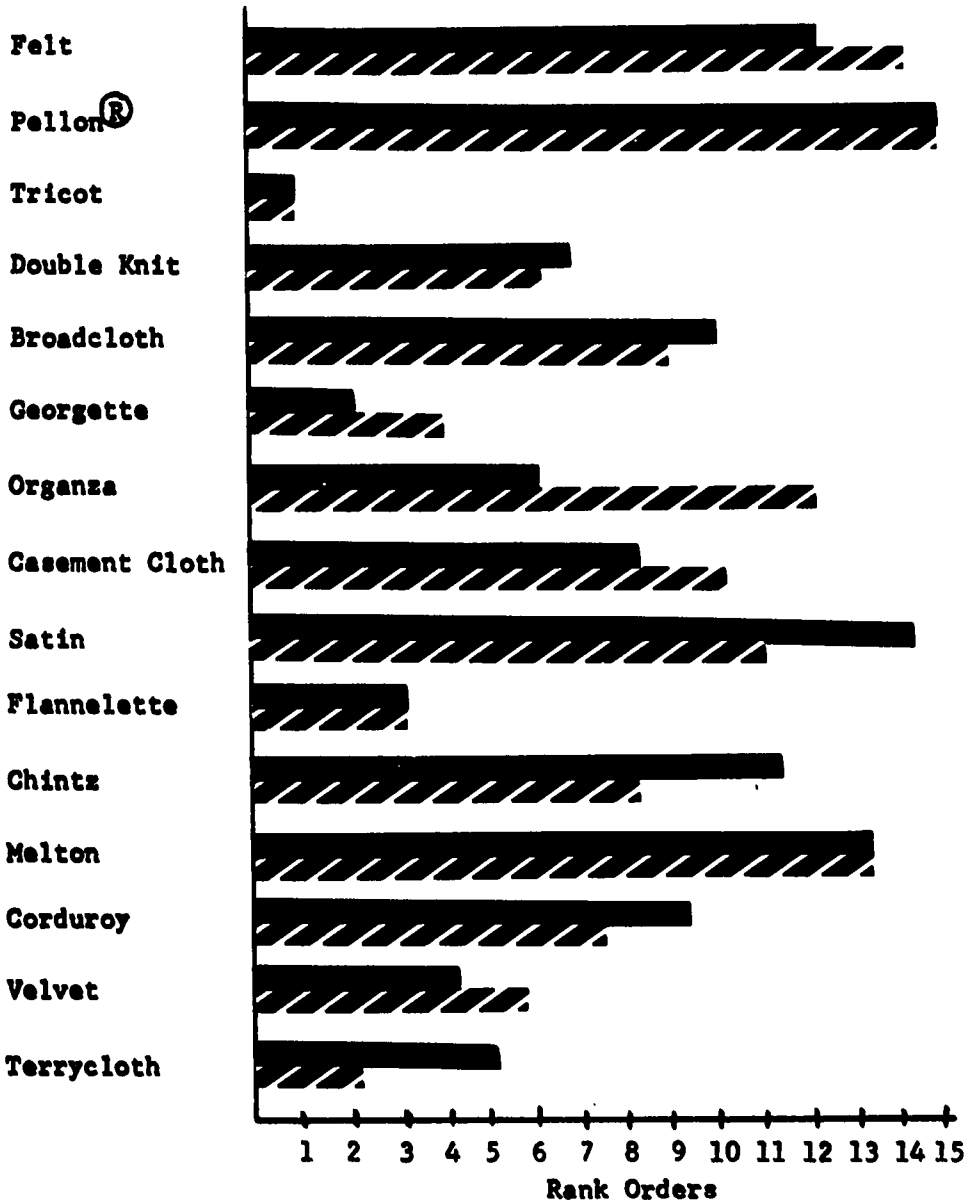

Figure 8

Subjective and Objective Rank Orders of Fifteen Fabrics for Property of Flexibility Pliable (1) - Stiff (15)

Key

Subjective Rank

Objective Rank

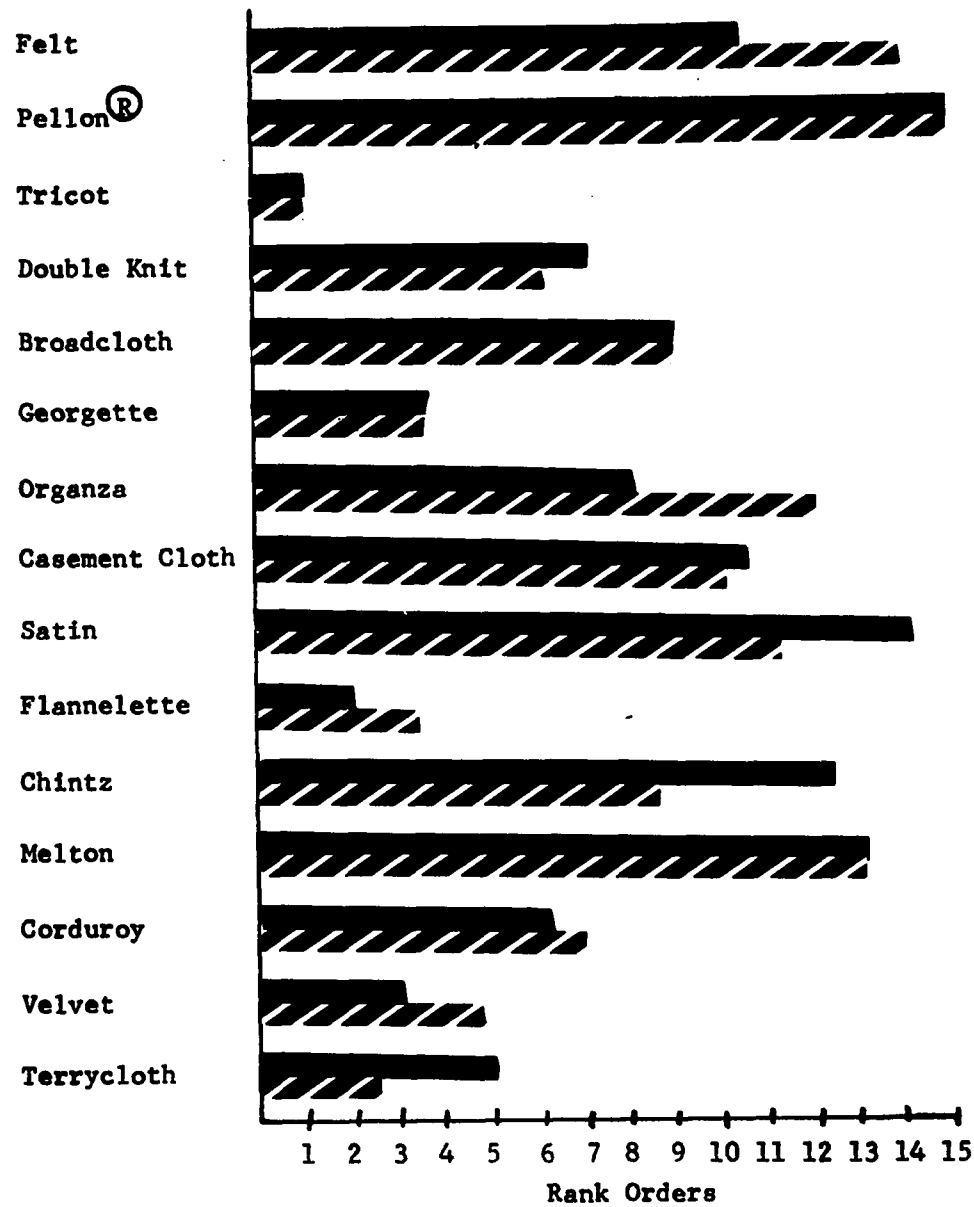

Figure 9

Subjective and Objective Rank Orders of Fifteen Fabrics
for Property of Compressibility
Soft (1) - Hard (15)

Key

Subjective Rank

Objective Rank

consumers considered the fabric to be harder than was measured objectively. There was a highly significant positive correlation for the property of compressibility of .87 between subjective evaluation and objective laboratory measurement.

Subjective and objective rank orders of fifteen fabrics for the property of extensibility are presented in Figure 10. The two knit fabrics, tricot and double knit, received equal rankings, while there were great differences in rankings of other fabrics including felt, Pellon®, satin, corduroy, and terrycloth. The positive correlation of .25 was not significant for the property of extensibility.

Subjective and objective rank orders of the fifteen fabrics for the property of resilience are presented in Figure 11. No two fabrics were ranked exactly the same for the property of resilience. Fabrics which were ranked closest included melton, velvet, and terrycloth, while greatest differences in ranking occurred in georgette, casement cloth, and tricot. There was a significant positive correlation of .54 between subjective evaluation and objective laboratory tests.

Subjective and objective rank orders of the fifteen fabrics for the property of weight are presented in Figure 12. Chintz and melton received the same rank for the two methods of evaluation. Eight fabrics were ordered within one rank of each other for both methods of evaluation, leading to a highly significant positive correlation of .94.

Subjective and objective rank orders of the fifteen fabrics for the property of thickness are presented in Figure 13. Four fabrics, double knit, broadcloth, organza, and corduroy, received the same rank

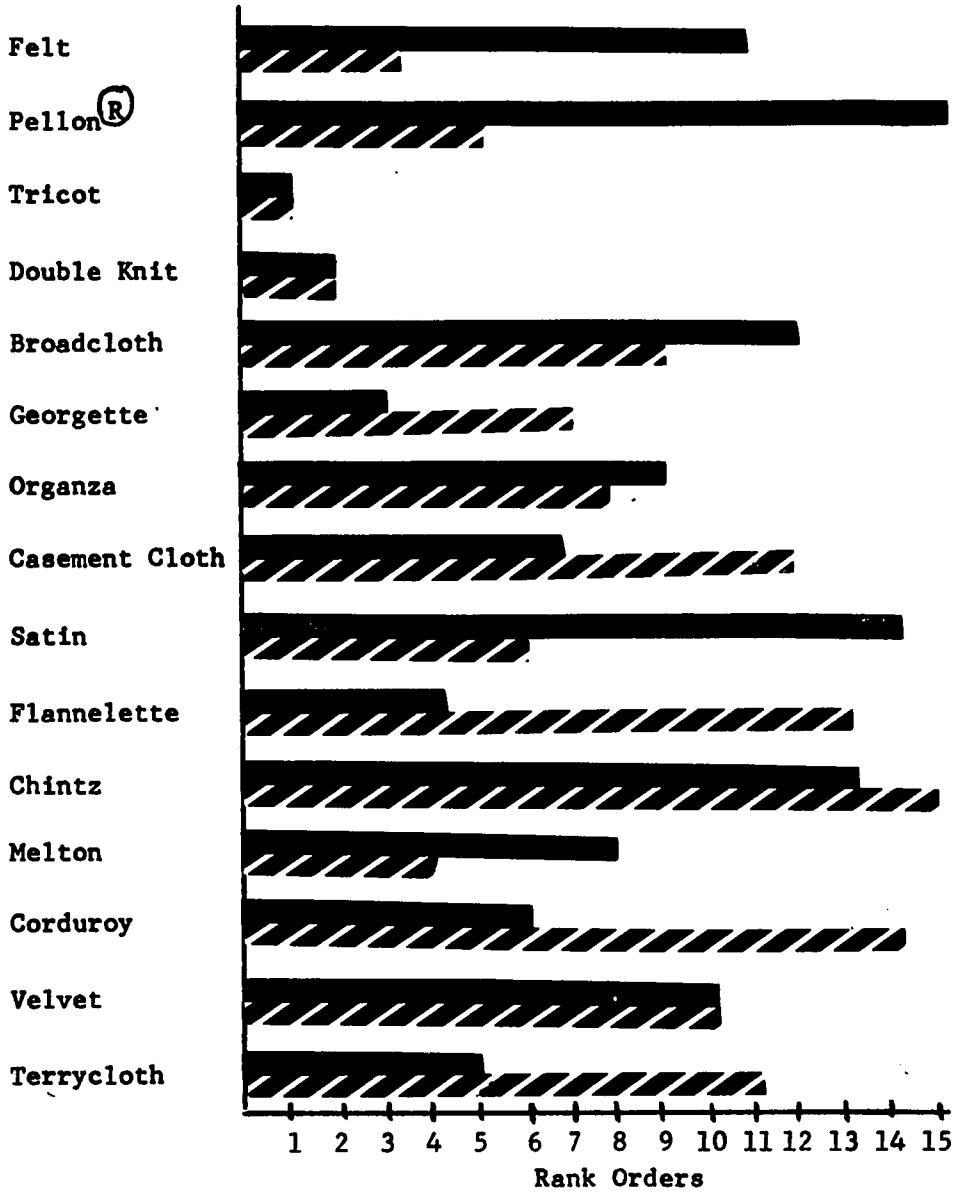

Figure 10

Subjective and Objective Rank Orders of Fifteen Fabrics for Property of Extensibility Stretchy (1) - Nonstretchy (15)

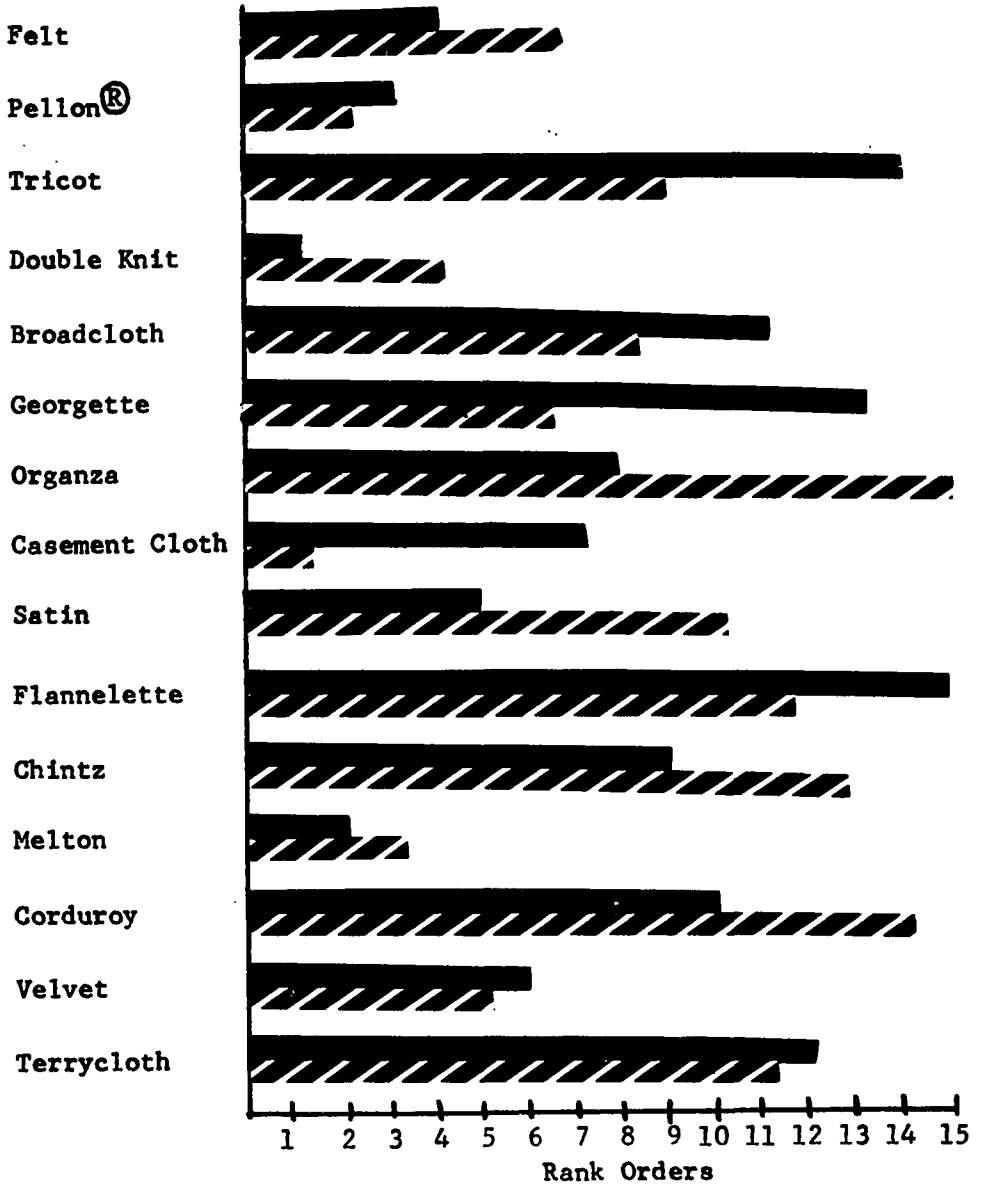

Figure 11

Subjective and Objective Rank Orders of Fifteen Fabrics for Property of Resilience
Springy (1) - Limp (15)

Key

Subjective Rank

Objective Rank

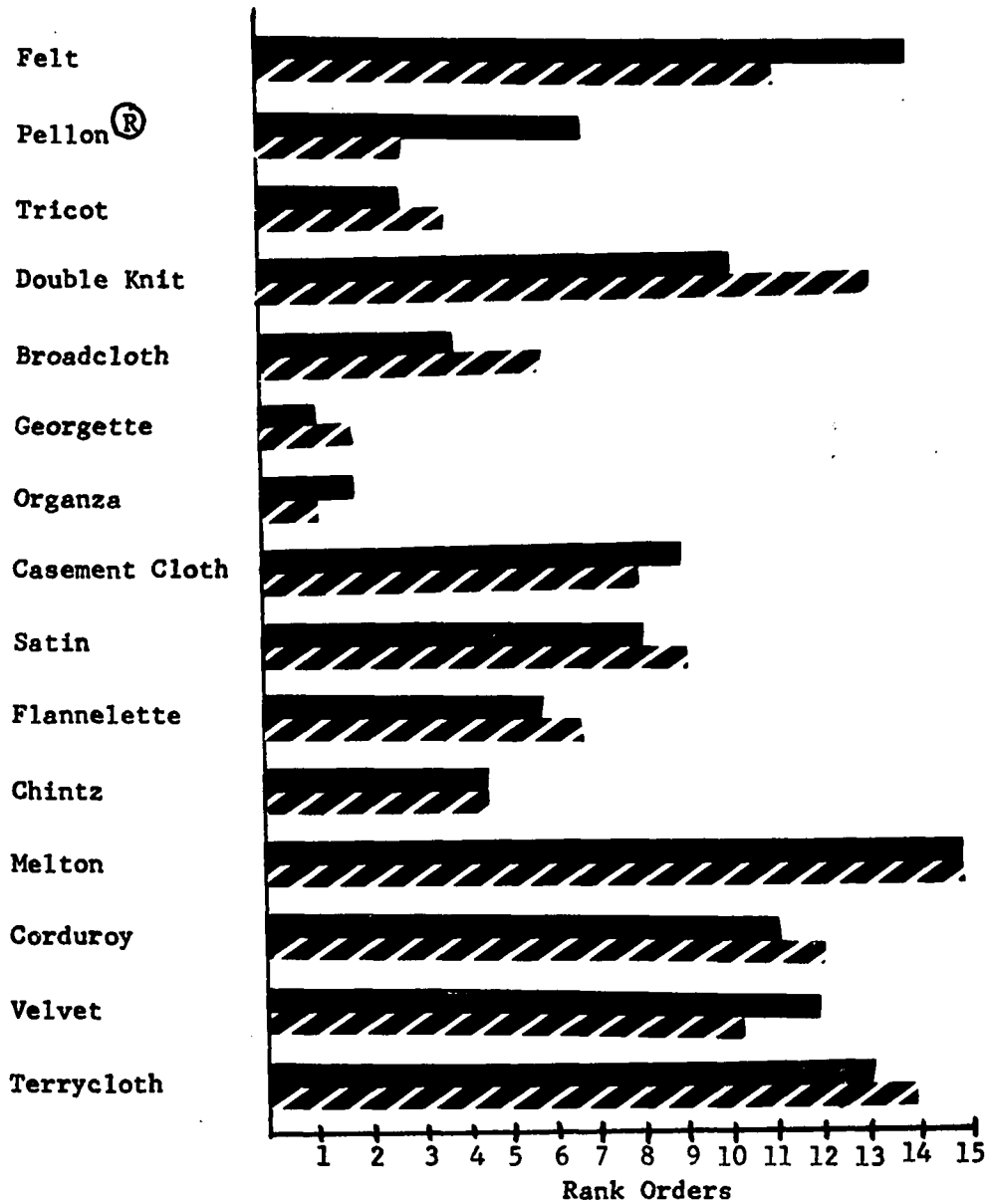

Figure 12

Subjective and Objective Rank Orders of Fifteen Fabrics for Property of Weight Light (1) - Heavy (15)

Key

Subjective Rank

Objective Rank

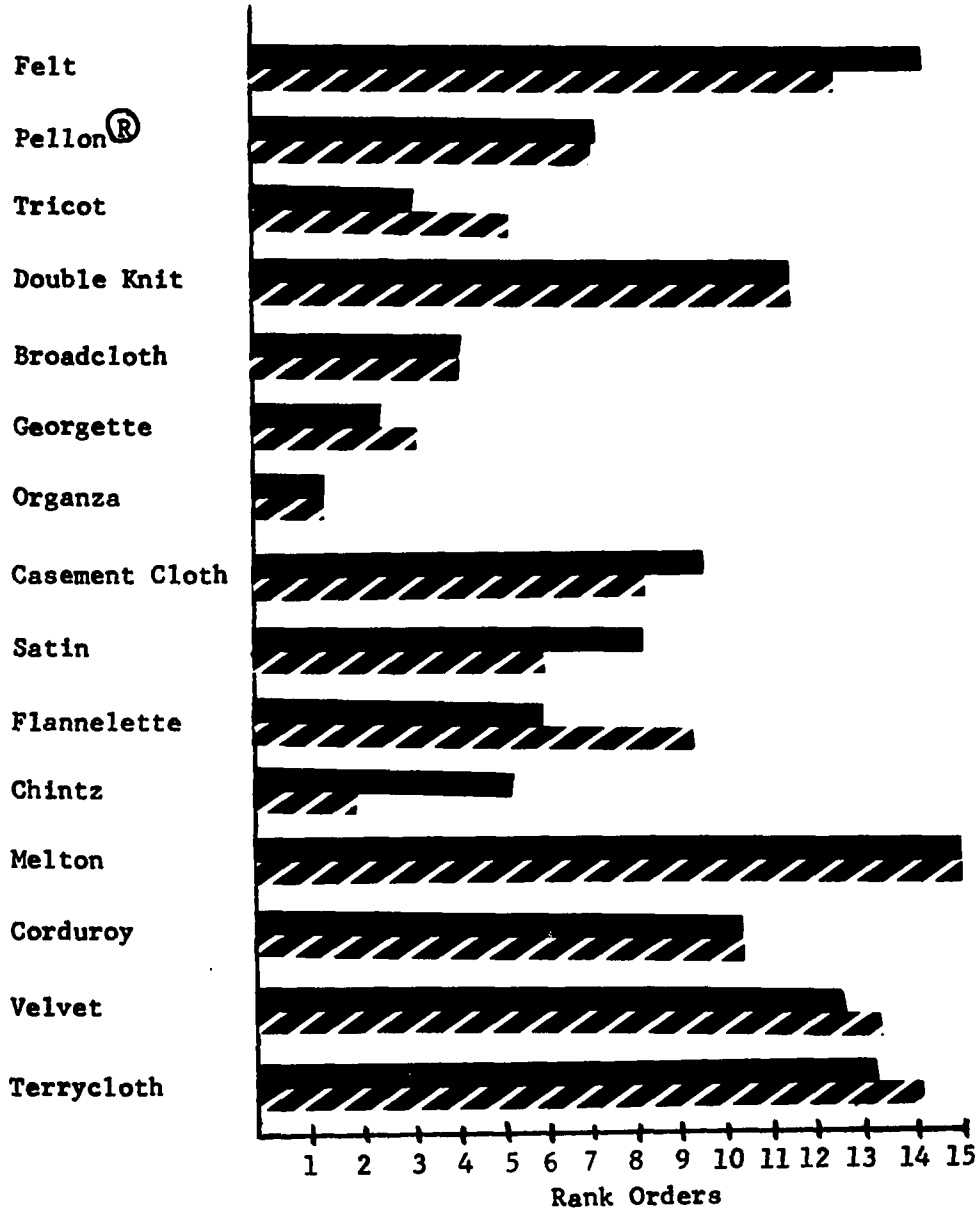

Figure 13

Subjective and Objective Rank Orders of Fifteen Fabrics for Property of Thickness
Thin (1) - Thick (15)

Key

Subjective Rank

Objective Rank

order for thickness under the two methods of evaluation. The greatest difference in rank order occurred in flannelette, as consumers considered the fabric thinner than was indicated by the objective test. The positive correlation was highly significant at .91.

Subjective and objective rank orders of the fifteen fabrics for the property of surface contour are presented in Figure 14. Chintz and organza were ranked equally for the two methods of evaluation. Large differences in rank order occurred for felt, georgette, casement cloth, satin, velvet, and terrycloth. The positive correlation of .453 was slightly below the significant level.

Subjective and objective rank orders of the fifteen fabrics for the property of surface friction are presented in Figure 15. Tricot and corduroy received the same rank for the two methods of evaluation. Greatest differences in rank order occurred in satin and terrycloth. There was a significant positive correlation of .54 for the property of surface friction.

Because of the lack of an objective laboratory test to measure thermal character, no correlation coefficient was obtained between the subjective evaluation and a laboratory test. Rank order of the fifteen fabrics as evaluated subjectively for the property of thermal character is presented in Figure 16.

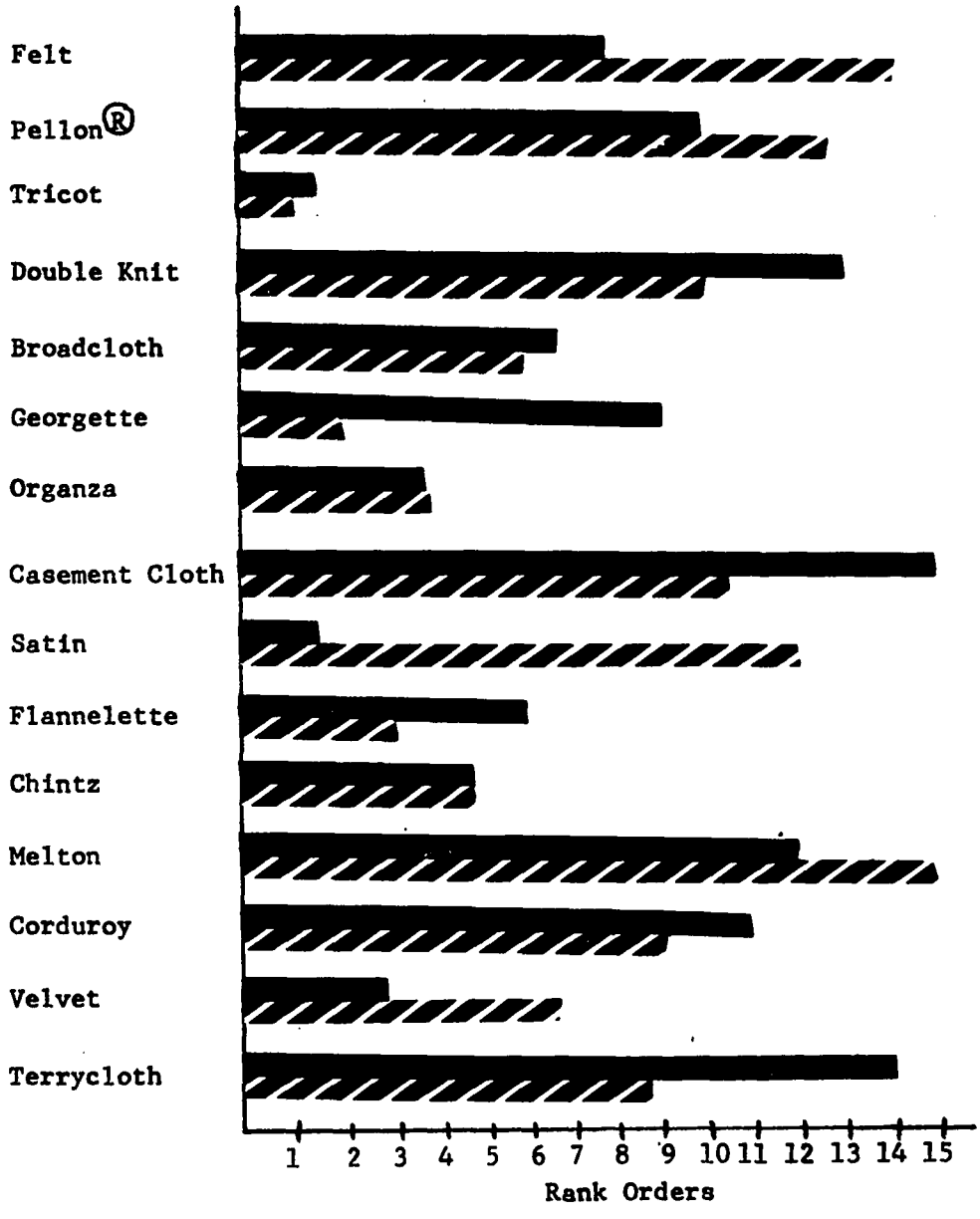

Figure 14

Subjective and Objective Rank Orders of Fifteen Fabrics for Property of Surface Contour Smooth (1) - Rough (15)

Key

Subjective Rank

Objective Rank

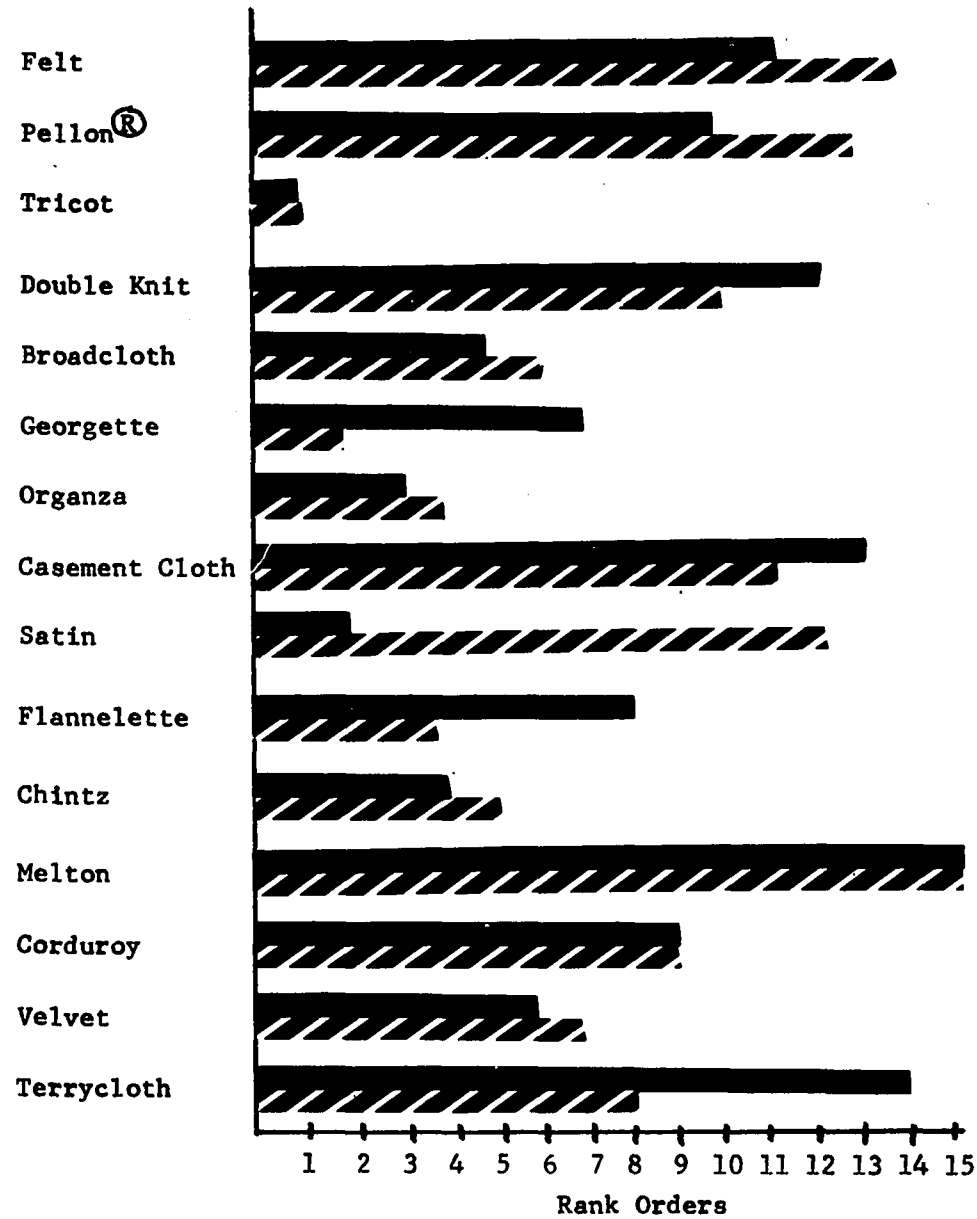

Figure 15

Subjective and Objective Rank Orders of Fifteen Fabrics for Property of Surface Friction Slippery (1) - Harsh (15)

Key

Subjective Rank

Objective Rank

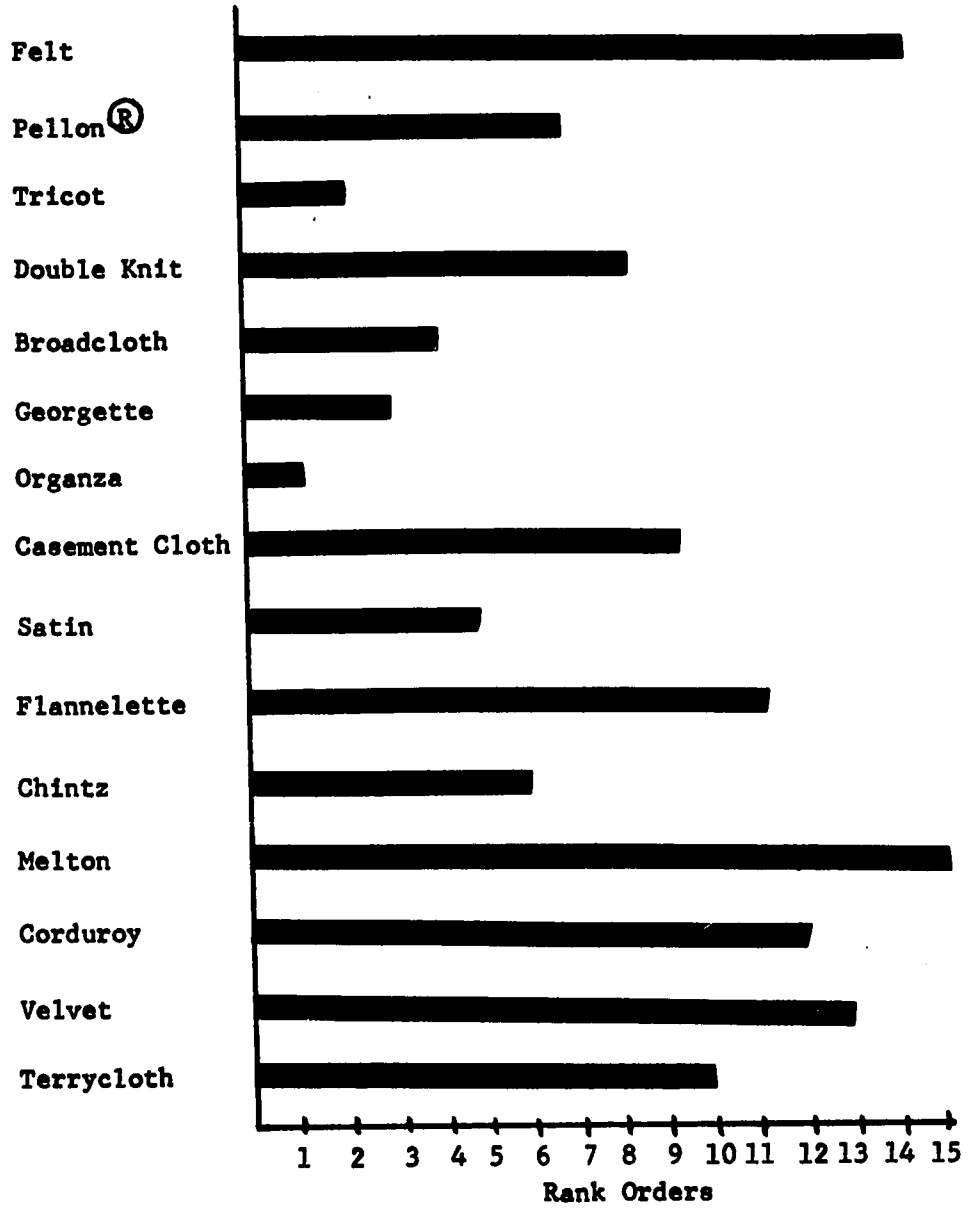

Figure 16

Subjective Rank Order of Fifteen Fabrics
for Property of Thermal Character
Cool (1) - Warm (15)

Key

Subjective Rank

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FURTHER STUDY

SUMMARY

A consumer enters a store and chooses one textile product or fabric over another. Why? In many cases the decision to buy depends upon some aesthetic quality which the textile possesses and which appeals to the consumer's need for self expression, his individual taste, or a search for beauty. Knowing the importance placed upon aesthetic choice by consumers, the textile industry, from fiber producer, to fabric manufacturer, to dyer and converter, must offer and maintain a diversity of products for the public. Thus, the consideration of aesthetic qualities by consumers, as well as the emphasis placed upon maintenance of such qualities by the industry, are indicative of the significance that should be placed upon studies of aesthetic qualities.

Among the many aesthetic qualities which a textile product may possess, the property of hand is one which is of mutual concern to industry and consumer. Many fabrics and finishes have been developed by the industry which have been unacceptable to consumers, primarily because of an unpleasing hand. To prevent such unacceptable products from reaching the market, the industry needs to have procedures available which can be used to estimate those attributes and properties creating the hand of fabrics. In addition, the results obtained from those procedures should approximate consumer reaction to the same properties. Research, therefore,

is needed to establish the objective laboratory procedures which can be used to assess the property of hand and to determine whether the results can be correlated with subjective reaction to the same property.

The specific objectives of this study were:

1. To determine the degree of importance of hand to consumers of textiles.

    a. To determine those properties of hand which were most important to consumers of textiles.

    b. To determine those descriptive terms used by consumers of textiles to evaluate hand of fabric.

    c. To determine the degree to which the property of hand was evaluated by consumers through visual, tactile, or a combination of visual and tactile means.

2. To determine those objective tests which could be used to measure the property of hand in textile fabrics.

3. To determine whether a correlation exists between subjective evaluation and objective laboratory measurement of the property of hand in textile fabrics.

This study was designed to test the following hypotheses:

1. Differences exist in the terms used by consumers to describe hand of fabrics.

2. Differences exist in hand of fabrics as subjectively evaluated by (a) visual examination only, (b) tactile examination only, (c) visual/tactile examination.

3. Differences exist in hand of fabric as measured by objective laboratory tests.

4. There is a correlation between subjective evaluation and objective laboratory measurement of hand of textile fabrics.

The data for this study were obtained by subjective evaluation and by objective laboratory measurements of fifteen fabrics representative of fabrics used by consumers either for apparel or for decorative purposes. The fifteen fabrics, all white, included felt, Pellon®, tricot,

double knit, broadcloth, georgette, organza, casement cloth, satin, flannelette, chintz, melton, corduroy, velvet, and terrycloth. The properties of hand evaluated subjectively and objectively included flexibility, compressibility, extensibility, resilience, weight, thickness, surface contour, surface friction, and thermal character.

The subjective evaluation of the fifteen fabrics was made by fifty consumers. Data were obtained from an opinion questionnaire used to determine those properties of hand considered important by these subjects and to elicit the descriptive words used to evaluate fabric hand. Ratings of subjective terminology used by consumers in describing the hand of the selected fabrics were obtained under three different testing conditions-visual examination only, tactile examination only, and a combination of visual and tactile examination. Rank orders of the fifteen fabrics for the nine properties also were obtained from each of the subjects.

A series of laboratory tests measured objectively the hand of the fifteen selected fabrics. Standard test methods used to evaluate the properties of hand included: (1) ASTM D-1388-64 (Reapproved 1970), Stiffness of Fabrics, (2) ASTM D-1682-64 (Reapproved 1970), Breaking Load and Elongation of Textiles, (3) ASTM D-1295-67, Wrinkle Recovery of Woven Textile Fabrics Using the Vertical Strip Apparatus, (4) ASTM D-1910-64, Construction Characteristics of Woven Fabrics, (5) ASTM D-1777-64 (Reapproved 1970), Measuring Thickness of Textile Materials, (6) Instruction Manual, Thwing-Albert Handle-O-Meter.

An analysis of variance was the statistical procedure used to determine significant differences in hand of fabrics as subjectively

evaluated by visual, tactile and visual/tactile examinations. The same procedure was also used to determine significant differences in hand of fabric as measured by objective laboratory measurement. Findings were considered significant at the .05 level and highly significant at the .01 level. Coefficients of correlation between the subjective evaluation of the property of hand and the laboratory measurement of the same property were obtained using Spearman's Rank Correlation Coefficient.

Subjective Evaluation of Hand

Consideration of fabric hand was widely expressed by the subjects. In articles of apparel, both innerwear and outerwear, and in home furnishing items, consumers felt that fabric hand was one of the most important qualities to be evaluated. Usage of descriptive terms indicated that properties of hand considered by consumers to be important included flexibility, compressibility, extensibility, resilience, weight, thickness, surface contour, surface friction, and thermal character.

The mean evaluations calculated following the visual examination were consistently lower than the mean evaluations for either the tactile or visual/tactile examinations. By visual examination only, consumers considered the fabrics to be more pliable, softer, stretchier, springier, lighter, thinner, smoother, slipperier, and cooler than by the other examinations.

In the tactile examination, mean evaluations were consistently higher than mean evaluations for either the visual or visual/tactile examinations. By tactile examination only, consumers judged the fabrics to be stiffer, harder, less stretchy, more limp, heavier, thicker, rougher, harsher and warmer than judged by the other examinations.

In the visual/tactile examination, mean evaluations consistently fell between mean evaluations of the visual examination only and the mean evaluations of the tactile examination only. By visual/tactile examination, consumers considered the hand of the fabrics to lie between the extremes of the means of all nine properties.

Due to the variety of fabrics chosen for testing, differences significant at .0001 were found between all fifteen fabrics as evaluated subjectively for each of the nine properties. Differences in the hand of the fifteen fabrics were significant between the three methods of testing for the properties of flexibility, compressibility, extensibility, weight, thickness, surface contour and thermal character. There were no significant differences between tests for the properties of resilience and surface friction.

Objective Evaluation of Hand

Though analysis of laboratory tests used to evaluate the properties of hand also indicated differences significant at .0001 between the fifteen fabrics, some relationships were seen between the various properties. Fabrics such as tricot and flannelette which were among the most pliable and softest fabrics also showed the least resistance to slipping in the test for surface friction. Fabrics such as Pellon®, felt, and melton, which were the stiffest and hardest fabrics, showed greatest resistance to surface friction.

A similar relationship was observed between the properties of extensibility and resilience. Broadcloth, georgette, flannelette, melton, corduroy and velvet were all ordered within one rank of each other for the properties of extensibility and resilience.

A more obvious relationship in objective testing was evident between weight and thickness. Fabrics which were lighter in weight, such as organza and georgette, were thinner, while heavier fabrics such as melton, terrycloth, corduroy, velvet, and felt were thicker.

Relation of Subjective Evaluation to Objective Laboratory Measurement of the Property of Hand

Correlation coefficients between the subjective evaluation and objective laboratory measurement of hand of the fifteen fabrics were computed using Spearman's Rank Correlation Coefficient. Highly significant positive correlations of .01 were found between the two methods of evaluation for the properties of flexibility, compressibility, weight, and thickness. Significant correlations of .05 were found between the two methods for the properties of resilience and surface friction. No significant correlations existed between the two methods of evaluation for the properties of extensibility and surface contour. Lack of a significant correlation for those properties may indicate a lack of understanding of terminology by consumers. Because no objective test is available to measure thermal character, no correlation coefficient could be obtained.

CONCLUSIONS

The results of this study indicate the following conclusions:

1. The property of hand was an important consideration to consumers of textile products including textiles for apparel and for decorative purposes.

2. Those properties of hand which were considered important by consumers as expressed by terminology used included flexibility, compressibility, extensibility, resilience, weight, thickness, surface contour, surface friction, and thermal character.

3. Consumers were able to identify, differentiate, and evaluate properties of hand of textile fabrics by using a combination of visual and tactile means.

4. There were significant differences in the hand of the fifteen selected fabrics as evaluated subjectively.

5. There were significant differences between methods of evaluation - visual, tactile, visual/tactile - for properties of hand in the fifteen selected fabrics.

6. There were significant differences in the hand of the fifteen selected fabrics as evaluated objectively.

7. A series of objective tests could be used to measure the properties of hand in textile fabrics.

8. There was a significant relationship between subjective evaluation of the hand of fabrics and objective laboratory measurement of the same property.

RECOMMENDATIONS FOR FURTHER STUDY

Further study is needed to evaluate aesthetic properties of textiles. The following recommendations are made for further study:

1. Compare subjective evaluation and objective laboratory measurements of other aesthetic properties such as drapeability, luster, and color.

2. Determine the relative importance of various aesthetic qualities such as hand, drape, luster, and color to consumers and to the textile industry.

3. Develop a laboratory test procedure which could be used to measure thermal character of textile fabrics.

4. Compare subjective evaluation and objective laboratory measurements of similar fabrics, differing in fiber content, yarn size, and/or finishing treatment.

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APPENDIXES

APPENDIX A

CONSUMER OPINION QUESTIONNAIRE

As a consumer of textiles, you are aware of the aesthetic qualities of certain fabrics. These aesthetic qualities include color, design, luster, drape, and hand. Many consumers buy apparel and decorative fabrics because of the way fabrics feel. In the textile industry the property of feel is designated as hand. This questionnaire is designed to determine your ideas concerning the way fabrics feel.

Name: Sex: M_____ F_____

Address: Phone _____

Age: 15-25 _____
26-35 _____
36-45 _____
46-55 _____
56-65 _____
Over 65 _____

Highest educational level completed:

High School: 1 2 3 4

College: 1 2 3 4 5 6

In what ways have you had experience in handling or working with textile fabrics? Please list.

In what ways have you had experience in construction of apparel or home furnishing items? Please list.

1. Below is a series of words which might describe the way fabrics feel to the touch. Please check only those words you would use to describe the way fabrics feel. Indicate in the correct column whether this word has a pleasant association (PA) or an unpleasant association (UA). If the word may have both pleasant and/or unpleasant associations (P/U), indicate in the correct column.

WORDS	PA	UA	P/U	WORDS	PA	UA	P/U	WORDS	PA	UA	P/U
Beefy				Fuzzy				Scroopy			
Bitey				Greasy				Sheer			
Boardy				Hard				Shiny			
Bouncy				Harsh				Sleazy			
Bulky				Heavy				Slick			
Bristly				Hungry				Slippery			
Clammy				Lean				Smooth			
Clean				Leathery				Snappy			
Clinging				Light				Soft			
Comfortable				Limp				Springy			
Compliant				Lively				Stiff			
Cool				Lofty				Stretchy			
Crinkly				Luster				Supple			
Crisp				Mushy				Thick			
Cottony				Mussy				Thin			
Dead				Nonstretchy				Thready			
Downy				Papery				White			
Dry				Pliable				Warm			
Elastic				Resilient				Waxy			
Extendable				Rough				Wet			
Firm				Rubbery				Wrinkled			
Full				Scratchy				Wiry			
Furry				Sandy							

Are there any other terms which you might use to describe the way fabrics feel to the touch? Please list.

2. Describe the way the following fabrics feel to you. If you do not recognize the fabric named, please omit the description.

FABRICS	YOUR DESCRIPTION
Nonwoven Pellon® - 100% Polyester	
Felt - 50% Wool, 50% Rayon	
Tricot - 100% Triacetate	
Broadcloth - Durable Press Finish 65% Polyester, 35% Cotton	
Double Knit - 100% Polyester	
Georgette - 100% Rayon	
Organza - 65% Rayon, 35% Silk	
Casement Cloth - 100% Glass	
Chintz - 100% Cotton	
Satin - 100% Acetate	
Flannelette - 100% Cotton	
Corduroy - 100% Cotton	
Velvet - 100% Rayon	
Melton - 100% Wool	
Terrycloth - 100% Cotton	

3. For what consumer textile products would you consider hand (feel) to be important?

a. Apparel Items

b. Decorative (Home Furnishings) Items

APPENDIX B

I.

EVALUATION OF FABRIC HAND

Below is a list of words which can be used to describe the way fabrics feel - the hand of fabrics. Evaluate each of the fifteen fabrics by placing an X in the block which best describes your opinion of the property.

PROPERTIES OF HAND	FABRICS														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FLEXIBILITY - Ease of Bending															
Pliable 1															
Medium 2															
Stiff 3															
COMPRESSIBILITY - Ease of Squeezing															
Soft 1															
Medium 2															
Hard 3															
EXTENSIBILITY - Ease of Stretching															
Stretchy 1															
Medium 2															
Nonstretchy 3															
RESILIENCE - Ability to Recover from Crushing															
Springy 1															
Medium 2															
Limp 3															

V T V/T

PROPERTIES OF HAND	FABRICS														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WEIGHT -															
Light 1															
Medium 2															
Heavy 3															
THICKNESS -															
Thin 1															
Medium 2															
Thick 3															
SURFACE CONTOUR - Differences in Fabric Surface															
Smooth 1															
Medium 2															
Rough 3															
SURFACE FRICTION - Resistance to Slipping															
Slippery 1															
Medium 2															
Harsh 3															
THERMAL CHARACTER - Differences in Fabric Temperature															
Cool 1															
Medium 2															
Warm 3															

APPENDIX C

II.

EVALUATION OF FABRIC HAND

Please rank each of the fabrics on each property of hand according to given directions.

1. FLEXIBILITY - Ease of Bending

   A. Choose the 5 fabrics you consider to be most pliable. Rank these 5 fabrics in order of increasing pliability - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

   B. Choose the 5 fabrics you consider to be stiffest. Rank these 5 fabrics in order of increasing stiffness - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

   C. Rank the remaining 5 fabrics from pliable (1) to stiff (5).

Rank	1	2	3	4	5
Fabric No.					

2. COMPRESSIBILITY - Ease of Squeezing

   A. Choose the 5 fabrics you consider to be softest. Rank these 5 fabrics in order of increasing softness - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

   B. Choose the 5 fabrics you consider to be hardest. Rank these 5 fabrics in order of increasing hardness - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

   C. Rank the remaining 5 fabrics from soft (1) to hard (5)

Rank	1	2	3	4	5
Fabric No.					

3. EXTENSIBILITY - Ease of Stretching

A. Choose the 5 fabrics you consider to be most stretchy. Rank these 5 fabrics in order of increasing stretch - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

B. Choose the 5 fabrics you consider to be least stretchy. Rank these 5 fabrics in order of decreasing stretch - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

C. Rank the remaining 5 fabrics from stretchy (1) to nonstretchy (5).

Rank	1	2	3	4	5
Fabric No.					

4. RESILIENCE - Ability to Recover from Crushing

A. Choose the 5 fabrics you consider to be most springy. Rank these 5 fabrics in order of increasing springiness.

Rank	1	2	3	4	5
Fabric No.					

B. Choose the 5 fabrics you consider to be limpest. Rank these 5 fabrics in order of increasing limpness - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

C. Rank the remaining 5 fabrics from springy (1) to limp (5).

Rank	1	2	3	4	5
Fabric No.					

5. WEIGHT

A. Choose the 5 fabrics you consider to be the lightest in weight. Rank these 5 fabrics in order of increasing lightness - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

B. Choose the 5 fabrics you consider to be the heaviest in weight. Rank these 5 fabrics in order of increasing heaviness - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

C. Rank the remaining 5 fabrics from light (1) to heavy (5).

Rank	1	2	3	4	5
Fabric No.					

6. THICKNESS

A. Choose the 5 fabrics you consider to be thinnest. Rank these 5 fabrics in order of increasing thinness - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

B. Choose the 5 fabrics you consider to be thickest. Rank these 5 fabrics in order of increasing thickness - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

C. Rank the remaining 5 fabrics from thin (1) to thick (5).

Rank	1	2	3	4	5
Fabric No.					

7. SURFACE CONTOUR - Differences in Fabric Surface

A. Choose the 5 fabrics you consider to be smoothest. Rank these 5 fabrics in order of increasing smoothness - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

B. Choose the 5 fabrics you consider to be roughest. Rank these 5 fabrics in order of increasing roughness - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

C. Rank the remaining 5 fabrics from smooth (1) to rough (5).

Rank	1	2	3	4	5
Fabric No.					

8. SURFACE FRICTION - Resistance to Slipping

A. Choose the 5 fabrics you consider to be slipperiest. Rank these 5 fabrics in order of increasing slipperiness - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

B. Choose the 5 fabrics you consider to be harshest. Rank these 5 fabrics in order of increasing harshness - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

C. Rank the remaining 5 fabrics from slippery (1) to harsh (5).

Rank	1	2	3	4	5
Fabric No.					

9. THERMAL CHARACTER - Differences in Fabric Temperature

A. Choose the 5 fabrics you consider to have the coolest surface temperature. Rank these 5 fabrics in order of increasing coolness - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

B. Choose the 5 fabrics you consider to have the warmest surface temperature. Rank these 5 fabrics in order of increasing warmth - 1 to 5.

Rank	1	2	3	4	5
Fabric No.					

C. Rank the remaining 5 fabrics from cool (1) to warm (5).

Rank	1	2	3	4	5
Fabric No.					