CONSUMER ACCEPTANCE OF WOOL-COTTON BLENDS FOR SHIRTS AS INDICATED BY PUPILLOMETRIC, SKIN CONDUCTANCE, AND SUBJECTIVE ASSESSMENTS

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CHAPTER I

INTRODUCTION

Orientation to the Study

The rapidity of consumer acceptance of changes in fashion has renewed the textile industry's interest in natural fibers. For hundreds of years all clothing and textile items were made from fibers produced by nature. In the years following World War II, however, remarkable advances in the petrochemical industry made possible the production of high purity chemicals that led to the development of large quantities of man-made fibers.

Consumers readily accepted the new man-made fibers that met the demands of modern living by providing such properties as easy care, wrinkle recovery, shape retention, and durability. Despite the fact that these fibers provided many of the properties desired by the consumer, they did not provide the comfort and other desirable characteristics of natural fibers. Research in recent years, therefore, has concentrated on the development of blends that combine the case of care properties of man-made fibers with the comfort and aesthetic properties of the natural fibers.

According to a national consumer study reported by Wingate (71), consumers' chief concerns in the selection of clothing are comfort, value, durability, shape retention, shrinkage, fabric feel, ease of care, and wrinkle resistance. Men, women, and teens, who participated in the survey, ranked comfort as the most important characteristic when selecting apparel. Factors relating to comfort have been designated as thermal resistance, moisture regain, lack of electrostatic charge, non-allergenic reactions, density, freedom of movement, and fabric hand. Interest in assessing the relationship between comfort related factors and acceptance by consumers of textile materials necessitated development of research methods for determining comfort sensations of fabric surfaces.

Although many attempts to measure the acceptance of textile products have been made in the past, the Association of Administrators of Home Economics (60), in research projections of national goals and guidelines, have selected comfort, function, and aesthetic considerations as areas in which future research is needed. Emphasis also has been placed by this organization on the need for studies showing inter-relationships among clothing comfort levels, activity, environmental factors, garment design, and fabric properties.

In the past, research on consumer acceptance of textile products has, for the most part, either relied upon surveys and questionnaires, or has involved objective measurements of fabric properties on laboratory samples. There is evidence, however, that responses to fabric stimulation can be measured in quantitative ways by physiological monitoring devices that provide pupillary and skin response assessments.

The response of pupil dilation to various stimuli is, in many respects, one of the most promising physiological measurement techniques. Hess (23) substantiated that a person's eye, especially the pupil, furnished an objective index of sensory, emotional, and mental activity. Lowenfeld (39) stated explicitly:

> It was recognized at an early period of physiological research that stimulation of any sensory nerve in the body will elicit bilateral pupillary dilation. The reaction is so sensitive and reliable that it was often used as an indicator for sensation in physiological experiments. (p. 277)

Searching for a method to study sensory stimulation by fabrics, Olsen (55) used a technique for interpreting pupillary responses to textiles. Results of this study revealed that a relationship existed between the levels of subjective comfort ratings and the dilation or constriction of the pupil. Dilation was greatest for the most comfortable subjective level while constriction was evident for the least comfortable level. Conclusions of the study indicated that pupillometric assessment provided a much needed quantitative means of measuring fabric comfort and, moreover, since there has been no previous research relating pupillary response to textile products, the procedure presented many possibilities.

Skin conductance responses as indices of the general level of activation to sensory stimuli have a history dating back to the work of Féré (15) in 1888. Since that time hundreds of experiments have employed electrodermal responses as dependent variables in physiological research. Gracz (20) investigated the prestart emotions of 26 Olympic athletes and concluded that systematic control of skin resistance can be used as a significant factor in psychological evaluation.

Combinations of physiological tests, such as pupillometric and galvanic skin response tests, have been used by investigators to evaluate mental activity of individuals. Kahneman et al. (34) compared pupillary, heart rate, and skin resistance changes during a mental task and concluded that the three autonomic reactions gave similar results. In a study comparing pupillary response and galvanic skin response during an imagery task relating to concrete and abstract nouns, Coleman (6) found that the galvanic skin response correlated with the pupillary reaction.

Since physiological tests have proved to be successful in the areas of problem-solving, food acceptance, interest, and emotion, there is reason to believe that they also would be useful in evaluating individual acceptance of items of apparel. Because the responses being measured are under involuntary control of the individual, they may yield more accurate information than can be obtained from personal opinion samples.

Since long range goals indicate a need for research related to consumer acceptance of textiles and the technology is not available for recording physiological and psychological reactions, this study was undertaken to investigate the pupillometric, skin conductance, and personal opinion responses as measures of sensory perception of blend level, fiber length, and type of yarn. Such physiological and psychological responses allow use of quantitative data which provide new concepts of analyzing individual reactions to sensory stimulation by various fabrics.

Definitions and/or Explanations of Terms

The following definitions and/or explanation of terms were established for clarification of terminology used in the study:

Comfort. The capability of the surfaces of the fabric to give physiological and psychological ease when perceived by sensory receptors of the skin (73).

Consumer. A person who uses goods or services.

Pupillary response. A change in pupil size through dilation or constriction as a result of sensory stimulation.

Sensory perception. The conveying of impulses from the skin to a nerve center where the impulses are comprehended.

Skin conductance response. An electrodermal response associated with activity of the sweat gland.

Subjective response. The personal opinion of the participant with regard to his/her acceptance of the fabrics being tested according to the scale for rating acceptability of shirt fabrics (figure 7).

Statement of the Problem

The research problem investigated in this study was: Do the fiber percentage, fiber length, and type of yarn used in the construction of intimately blended wool-cotton fabrics affect the acceptance of these fabrics for shirts by male and female consumers? The specific problems investigated are reflected in the following null hypotheses:

<u>Hypothesis 1</u>. Pupillary response in regard to consumer acceptance of wool-cotton blends for shirts is not affected by the following fabric variables:

a. Fiber content
b. Fiber length
c. Yarn type

<u>Hypothesis 2</u>. Skin conductance response in regard to consumer acceptance of wool-cotton blends for shirts is not affected by the following fabric variables:

a. Fiber content
b. Fiber length
c. Yarn type

<u>Hypothesis 3</u>. Subjective response in regard to consumer acceptance of wool-cotton blends for shirts is not affected by the following fabric variables:

a. Fiber content
b. Fiber length
c. Yarn type

<u>Hypothesis 4</u>. There are no significant differences between male and female responses to the experimental fabrics as measured by:

a. Pupillary assessment
b. Skin conductance assessment
c. Subjective assessment

<u>Hypothesis 5</u>. There are no significant differences among body area responses to:

a. Pupillometric assessment
b. Skin conductance assessment

<u>Hypothesis 6</u>. There is no significant relationship among pupillometric, skin conductance, and subjective assessments as means of measuring the effects of the following fabric variables on consumer acceptance:

a. Fiber content
b. Fiber length
c. Yarn type

CHAPTER II

REVIEW OF RELATED LITERATURE

The general purpose of this research study was to ascertain the effect of fiber content, fiber length, and type of yarn upon male and female acceptance of shirt-like garments composed of wool-cotton blends. Pupillometric, skin conductance, and subjective questioning assessments were chosen as the means for measuring the participants' responses to the experimental fabrics.

Although studies refer directly to pupillometric and skin conductance techniques as methods of obtaining objective data, few researchers have attempted to apply these techniques to the analysis of textile products. None have included a combination using pupillometric, skin conductance, and personal opinion responses as indicators of sensory stimulation of fabrics, or compared the reactions of these assessments between male and female participants. It was necessary, therefore, for this investigator to utilize a wide range of resources and literature in order to develop, implement, and complete the proposed project.

For simplicity in presentation, the review of literature has been divided into the following major headings: (1) consumer acceptance of wool-cotton blends, (2) pupillary responses to physiological and psychological stimuli, (3) skin conductance and other electrodermal responses to physiological and psychological stimuli, (4) relationship between pupillary and skin conductance responses to physiological and psychological stimuli, and (5) subjective assessments relating to consumer attitude toward textile products.

Consumer Acceptance of Wool-Cotton Blends

"The consumer today is not so passive as before and never again will be," according to Bernard Miller of The Textile Research Institute, Princeton, New Jersey (50). Textile manufacturers in response to the new consumer who is impacting the market with definite wants and needs are now trying to anticipate future requirements according to scientific studies. This in turn results in a healthier market situation and more profitability for the producer.

Several consumer studies attempting to isolate consumer interests have been reported. Jenkins and Dickey (30) studied consumer types based on evaluative criteria such as appearance and practicality to identify underlying clothing decisions. They concluded that efforts with consumers might be more successful if research were conducted to find out what was wanted and needed rather than on the basis of assumptions.

Winakor, Kim, and Wolins (70) investigated the tactile sensory assessment of fabrics using differences in the physical dimensions of stiffness, roughness, thickness, and fiber content to determine consumer preference. The goal, according to the authors, was to determine if sensory or physical measures or some combination of these could predict consumer preference. Results of the study showed that sensory responses to all of the physical dimensions being tested differed significantly among participants indicating that the semantic differential and the scale functioned well in the assessment of the fabrics.

An example of the consumer role in dictating marketable products is the "back to natural" trend that has become a popular concept not only in textile fibers but also in foods, cosmetics, and home furnishings. After World War II, the synthetic fibers were widely accepted because of their easy care, wrinkle recovery, shape retention, and durability properties. Because of a desire for aesthetics and comfort in their textile products, consumers in recent years have promoted the use of natural fibers. An area in which excellent acceptance has been achieved is the use of natural fibers in blends with other fibers.

In recent research, O'Connell, Pardo, and Fong (54) established that wool-cotton blends could achieve good durable press and easy-care characteristics with a lower degree of polymer application than was necessary for either fiber alone. This was possible because of an additive contribution from the cross-linked cellulose, yet the wool hand and aesthetics were retained throughout the garment life. Additional advantages of the wool-cotton blend were that normal home care gave excellent results; soil was easily removed; and wrinkles were not permanently set when the garments were allowed to cool during the final minutes in the dryer. Results of laboratory tests indicated that strength and abrasion resistance were impaired by the durable-press and shrink-resistant treatments, but were justified in view of the complete ease-of-care properties.

In an additional study by the O'Connel research team (53) using double knits containing wool-cotton fibers, durable-press performance was determined to be superior in blends containing a high degree of cellulose while retaining the wool-like aesthetics. Wool-cotton fabric blends ranging from 50/50 to 80/20 were used with results indicating that problems with fuzziness and crease retention developed with the use of higher percentages of wool.

Fiber length is known to affect the texture and feel of the fabric into which it is incorporated. Gawne and Oerke (18) point out that shorter wool fibers twisted together make a soft yarn that presents a fuzzy appearance. In worsted yarns the short fibers, called noils, are combed out. The yarns with longer fibers have greater twist and result in firm-textured, smoother fabrics that are also lighter in weight.

Ramey, Lawson, and Worley (59) examined fiber properties including fiber length relating to ring and open-end spinning at the Agricultural Research Service Cotton Quality Laboratories at Knoxville, Tennessee. Findings indicated that yarn strength was more positively correlated with the fiber length and tenacity than other fiber properties.

Several research studies allude to comparisons between ring and open-end spun yarns. However, few relate to differences between the feel and comfort of fabrics made from these yarns on the body.

Morris and Prato (51) developed methods to evaluate consumer acceptance and end-use performance of denim fabrics made from open-end spun yarns. Fabric made from ring spun yarns was used as the control fabric while open-end spun yarns served as the test fabric. Fabrics were utilized in boys' jeans that were worn for 26 wash/wear cycles. Results of the wear study confirmed a superior performance by the ring spun yarns. Consumer acceptance, however, was greater for the garments constructed from open-end spun yarns.

McKinney and Broome (48), in comparing the two types of yarn, found that open-end spun yarns produced fabrics with greater abrasion resistance, superior pilling resistance, less compression, less hairiness, but with a harsher and rougher hand. Schumann (62) also alluded to the greater harshness of fabrics constructed from open-end spun yarns. In addition, he stated that while open-end yarns were well accepted for coarse yarns, energy usage increased dramatically for middle and finer counts making this a serious problem for spinning mills.

Lyle (45) stated that open-end spinning showed advantages in bulkier yarns, better dyability, greater uniformity and strength, and resistance to pilling. She agreed with the previous authors, however, by stating that ". . . open-end spinning is less versatile and results in a harsher hand, crisper feel, and stiffer fabric."

Pupillary Response to Physiological and Psychological Stimuli

Pupil dilation independent of light changes has been recognized since the eighteenth century. One of the first detailed accounts of pupillary dilation caused by physical and psychological stimuli appeared in the work of Fontana (16) in 1765. As early as 1920, Lowenstein (40) reported that increases in attention resulted in dilation of the pupil.

Interest among psychologists in pupil response reached an apex during the decade of the sixties due in part to the positive contribution of Eckhard H. Hess and his popularization of applications for pupillometry to current research issues. Hess's contribution has not been without controversy, especially the aversion-constriction hypothesis, yet his work has been a starting point for most researchers interested in learning about the pupil of the eye. Janisse (29) reviewed the literature that followed Hess's investigations and concluded that the aversion-constriction phenomenon was found only when using pictures and that this particular type of stimulus was too open to light reflex to provide trustworthy data. Lowenfeld (38) also indicated that well-controlled research previous to that of Hess had shown that the pupil was made to dilate by all stimuli except light. Janisse (29) concluded that

> . . . the pupil cannot be used to distinguish the attraction dimension from the interest dimension, nor can it be used to determine whether the attraction is positive or negative. However, if one does know the quality of an effect, emotion, or feeling, under properly controlled circumstances, the pupil is quite likely to be a good indicant of the strength or intensity of that state. (p. 59)

Physiological Aspects of the Pupil

The size of the pupil of the eye depends on the balance between the activity of the two smooth muscles in the iris. The dilator pupillae, controlled by the sympathetic nervous system, tends to dilate the pupil. The muscle involved in constriction of the pupil, the sphincter pupillae, is controlled by the parasympathetic system. This set of opposing muscles exercises a fine but extensive control over the pupil. Lowenstein and Loewenfeld (42) observed that pupil diameter ranges from 1.5 to more than 9 millimeters in man, and reacts to stimulation in as little as 0.2 seconds.

The sympathetic nervous system becomes active in states of emotional excitement, attention, or arousal by the release of catecholamines from the adrenal medulla located above the kidneys. Due to increased sympathetic activity, many physiological changes occur throughout the body, but those that are applicable to this study are pupil dilation and sweating.

Variables Associated with Pupillometric Assessment

Due to pupil sensitivity, several variables have been identified in the literature that were considered when planning this research. They are: the near vision reflex, age, fatigue, habituation, alcohol, stimulants, and drugs.

The near vision reflex is the tendency for the pupil to constrict when focusing on a point relatively near the subject for several seconds. Kahneman and Beatty (32) found a 10 percent increase in pupil diameter when changing from a fixation distance of six inches to six feet. Relatively lengthy testing will promote pupil size variation because the participant may tire or lose interest, thus causing a change in focus.

Bernick (2) studied 20 former heroin addicts who had been drug-free from one to eight weeks and who were from 19 to 49 years of age. Results indicated that age and pupil size were negatively related: the older the subject, the smaller the pupil. In addition, Kummick (36) found decreased diameter and increased variability with age. Lowenstein, Feinberg, and Loewenfeld (43) also reported that with older subjects the pupil tended to be smaller in darkness.

Fatigue also decreases diameter as well as increases the frequency of hippus, a tremor of the iris characterized by rapid construction and dilation of the pupil. Results of research studies have shown that fatigue is associated with changes in the shape of the pupillary light reflex, increased variability in pupil size, and an overall generally smaller pupil size. The general assumption is that the size of the pupil slowly diminishes from early morning until late at night due to fatigue. Lowenstein and Loewenfeld (41) found that when subjects were fatigued, the pupil was quiescent at first, then decreased in size while also showing greater instability.

Another variable associated with measuring pupil size is habituation, defined as the process of becoming accustomed to specific stimuli by repetition or periods of long exposure. Lowenstein and Loewenfeld (41) reported that after repeated measures the pupil diameter and the magnitude reflex decreased, while speed of contraction decreased.

Alcohol, stimulants such as caffeine, and some drugs also cause dilation. As a result of this study of the influence of alcohol on the pupillary light reflex in man, Skoglund (64) reported that alochol dilates the pupil in proportion to the percentage of alcohol in the blood.

Pupillometric Research Studies

Numerous fields of research have utilized the measurement of pupillary activity since the decade of the sixties. In these investigations, researchers have attempted to measure a wide range of human characteristics and ideologies by applying a stimulus to one or more of the five senses. The following research studies have been categorized according to the sensory receptor involved: visual, auditory, gustatory, olfactory, and tactile.

Visual. In the first of a series of studies, Hess and Polt (25) measured pupillary changes to pictorial stimuli in four men and two women. Pupillary responses were scored by the percentage of increase in pupil size from a test slide over a preceding control slide, both of which were processed to control brightness. Results showed that women gave larger dilation responses to pictures of a baby, mother and baby, and a nude male, while men showed greater responses to a picture of a nude female. This was interpreted by Hess and Polt to mean that dilation of the pupil could show preference.

In another study, Hess, Seltzer, and Schlien (27) found that pupillary responses discriminated between homosexual and heterosexual males. Five of these subjects were known to be homosexual, and five were heterosexual. Fifteen picture slides were shown alternately with a medium gray control slide. Five of the slides were pictures of females, five were pictures of males, and five were neutral slides of an artistic nature. All heterosexual males showed a larger pupil response to pictures of women than to pictures of men. Four of the five homosexual males showed a greater pupil dilation to pictures of male nudes. According to Hess, this indicated that pupil response had discriminating power when both preference and behavior had been indicated, even though concealed.

Woodmansee, Newsome, and Kirby (74) conducted a modified replication of the single trial design that Hess had used. This test consisted of a stimulus photograph of the gruesome murder of a local college coed that had taken place in the previous two weeks. The picture of the murdered girl was shown to eight female college students who were "repelled, disgusted, or sickened" by it and to six female college students with either neutral or positive feelings about it. Each subject viewed the picture nine times, each time viewing the photograph for two minutes before testing began to allow for the transition from a state of arousal to a state of aversion. All trials of the aversive group resulted in dilation, while eight of the neutral group's trials resulted in dilation.

Hess (23), in additional research, showed a group of 20 men a series of pictures including two photographs of an attractive young woman. The photographs were identical except that the eyes in one were retouched to make the pupils larger. While the pupillary response of the participants was more than twice as large in response to the picture with large pupils, the men were unable to detect any difference. Hess concluded that, since the pupil indicated different responses to stimuli that at the verbal level seemed quite similar, the pupil was a more sensitive indicator of change.

Gerall, Sampson, and Boslow (19) attempted to study the effect of different stimuli on pupil dilation by a classical conditioning procedure. The three types of stimuli were: shock paired with light offset, light offset alone, and shock alone. The subjects were divided into five groups including two control groups. The subjects exposed to shock manifested a conditioned behavior as measured by anticipatory and maximum pupillary dilation changes. The other groups showed no consistent change and were not statistically different from each other. A conclusion drawn from the results was that a known reinforcer does affect the conditioning of a response predominantly governed by the autonomic nervous system.

Related pupillographic studies representing research in psychiatric medicine have been reported. Streltsova (66) found that the pupillary dilation orienting reaction, which is the ability of the pupil to orient itself to changes in light, is considerably stronger in hysterical patients than in normal persons. This was attributed to subcortical excitation and weakening of cortical regulation. Chronic alcoholics, schizophrenics, and epileptics displayed reactions that were weaker than normal or absent entirely. Streltsova also found that some drugs, such as strychnine or caffeine, stimulated the pupillary orienting reaction when given in small doses, but inhibited it when given in larger doses. Streltsova concluded that the pupillary orienting reactions could possibly be used in determining optimal individual medication.

Auditory. The second study published by Hess and Polt (26) was the first one to deal with the relationship between problem difficulty and pupil size. Four verbally presented multiplication problems of increasing difficulty (7 x 8; 8 x 13; 13 x 41; and 16 x 23) were individually presented to four men and one woman. Graphs of pupil size of each of the five subjects showed a gradual dilation, beginning with the presentation of the problem and reaching its peak immediately before the subject's verbal report. This was followed by constriction to original size.

Kahneman and Beatty (32) carried out a series of studies using pupil size as an index of "processing load" in which pupillary measurements were carefully time-locked to paced performance of mental tasks. These experiments demonstrated a characteristic response pattern consisting of dilation as material is presented to the subject for mental processing, and constriction at the completion of the task. In a series of follow-up studies, Kahneman, Beatty, and Pollack (33) had subjects perform a visual detection task and a digit transformation and recall task both separately and simultaneously in an attempt to validify the assumption that pupil size is specifically sensitive to the degree of mental effort expended. The results showed that performance on the visual detection task was significantly better and pupillary dilation smaller when this task was performed alone. A parallel between the amount of pupillary dilation and mental effort was evident from results found under simultaneous conditions.

Collins, Ellsworth, and Helmreich (7) studied changes in pupil size and semantic differential ratings.

Three defined dimensions of attitude covered 14 polar adjective pairs. There were eight pairs of evaluative adjectives: good-bad, clean-dirty, sweet-sour, pleasant-unpleasant, fragrant-foul, beautiful-ugly, nice-awful, and sacred-profane. There were three pairs of adjectives in the activity scale: active-passive, sharp-dull, and fast-slow; and three pairs of words in the potency scale: strong-weak, large-small, and heavy-light. Eight Yale undergraduates served as subjects. Draft and compulsory military service were the concern of 10 stimuli (seven verbal, three pictorial), 11 (seven verbal, four pictorial) were concerned with miscegenation, and 11 (seven verbal, four pictorial) with Yale University parietal hours. Results showed that the potency dimension was positively related to changes in pupil size. The evaluative and active dimension, however, were not related to pupillary change.

Noise has been the subject of at least three pupillometric studies. Patrick (56) introduced noise levels from 73 to 96 decibels (db) to subjects performing a visual-scanning task. Greater pupil dilation was found in the presence of noise than in its absence. Nunnally and Riliegh (52) had subjects listen to tones of 64.2, 74.2, 84.2, and 94.2 decibels. Pupil size was significantly larger for 94.2 decibels than for the other three tones. Frith (17) exposed subjects to a 95 decibel tone and found that it was accompanied by an increase in pupil size but that the effect diminished after two presentations. This led to the conclusion that pupil size response reflects arousal level which increases with the changes in stimulation, but rapidly adapts to the changes.

Gustatory. Hess and Polt (25) also tested the hypothesis that pupil response may be closely related to the parietal cortex, the portion of the brain thought to be related to the sense of taste. Five types of orange drinks were chosen as stimuli. Sixteen subjects (four females and 12 males) tasted the drinks that were presented once to each subject with half receiving them in the order of one to five, and the other half receiving them in reverse order (five to one). Water served as a control preceding the tasting of each orange drink. Results demonstrated that there was a significant difference among the responses to the orange drink stimuli and that there was not a significant difference in the pupillary response to the water. According to Hess this indicated a sensitivity of the pupil in distinguishing among stimuli that were too similar for other methods to differentiate.

Olfactory. Kennedy (35) studied 35 hospitalized alcoholics, biweekly, for a 16 week period. The subjects were allowed to sniff water and the alcoholic beverage of their choice while having their pupillary response recorded. A decline in pupillary dilation caused by the odor of the alcohol over the course of treatment and a more dramatic decline in the final weeks of treatment was reported. Kennedy interpreted dilation as indicating positive attitudes toward alcohol and suggested that pupillary response might be used to determine when to discontinue treatment.

Tactile. Olsen's (55) study of pupillary and subjective responses to stimulation by chemically treated fabrics was the foundation on which the current study reported in this manuscript was launched. Eleven college women were participants in the investigation that attempted to determine if pupillary responses could measure the comfort of textile fabrics. Durable press, fire retardant, and fabric softner treatments were applied to broadcloth and flannelette fabrics to give 12 fabric finish combinations. A relationship between dilation and subjective comfort ratings was found to exist: dilation for most comfortable subjective level and constriction for the least comfortable subjective level. Olsen encouraged further investigation in the area as no previous research had attempted to use pupillometric techniques to discern sensory stimulation by different types of fabrics.

Skin Conductance and Other Electrodermal Responses to Physiological and Psychological Stimuli

Historical and Theoretical Perspectives of the Electrodermal Phenomenon

Work on the significance of electrodermal activity and its relationship to physiological and psychological stimulation seems to have begun with Féré (15) in 1888. His interest in the effects of sensory and emotional stimuli led to his investigation of hysterical subjects to which surface electrodes had been applied. Presentation of various visual and acoustical stimuli produced transient decreases in resistance between the two points. His suggestion that the phenomenon could be of value to psychophysiological measurements gave impetus to the use of electrodermal activity as an index of an important research construct.

Soon after Féré's work on the exosomatic response in electrodermal activity, Tarchanoff (67) discovered the potential difference between two points on the body surface. Also called the endosomatic response, this bioelectric event measures the relative activity between two electrode/electrolyte junctions.

Since the work of Féré and Tarchanoff, considerable effort has been devoted to studying the numerous facets of electrodermal activity and as a result several theories attempting to explain the application of this phenomenon to the measurement of physiological and/or psychological stimulation have arisen. Two of these, the arousal and orienting reflex theories, have acted as broad bases upon which much of the current research has developed.

The arousal or activation theory evolved from the early work of Féré (15) and took the position that a major aspect of emotion, as it has been historically labeled, is the general level of energy mobilization. Duffy and Lacey (12), Schlosberg (61), and Malmo (49) pointed to the tonic measures of skin conductance level as indicators of the degree of energy mobilization or activation. Credence to this approach was provided by Lindsley (37) as he showed that activity in the brain stem reticular formation, manifested by increased frequency and decreased amplitude of the electroencephalograph, is related to arousal.

Sokolov (65) was of the opinion that sensitivity to stimulation from the environment can be viewed in terms of the orienting reflex and its specific phasic or tonic responses. The former is created by the novelty of the stimulus and can be distinguished by skin conductance, resistance, and potential responses. The latter appears much more slowly upon habituation and can be represented by skin conductance, resistance, and potential levels. It is, therefore, the phasic orienting responses that are applicable to this investigation.

During the same years that these theories arose, a large body of literature developed which questioned the validity or usefulness of the phenomenon in measuring psychological levels. McCleary (46) in his paper entitled "The Nature of Galvanic Skin Response," concluded that the initial expectations of this activity in psychological research were unfounded. He suggested that although there was certainty of the involvement of the sympathetic nervous system in electrodermal activity, there still remained numerous unanswered questions.

However, in support of the applicability of electrodermal activity to the measurement of physiological and psychological stimulation, Lykken (44) wrote that "it continues stoutly to provide useful data in spite of being abused by measurement techniques which range from the arbitrary to the positively weird."

Physiological Basis and Mechanisms of the Electrodermal Response

Before discussing particular research issues, a basic understanding of the physiological nature of electrodermal response as well as the mechanisms underlying both the exosomatic (skin conductance and resistance) and the endosomatic (skin potential) responses is necessary. Knowledge of underlying physiology is essential for the awareness of potential error and for the development of the usefulness of electrodermal measures.

Many theories have been advanced since mid-century to explain the physiological basis of electrodermal phenomena. McCleary's (46) paper dealt, in part, with this subject, in which he presented three viewpoints: the muscular theory, the arousal theory, and the secretory theory. The first of these met an early end. Both the vascular and the secretory theories, the former being attributed to Féré (15) and the latter to Tarchanoff (67), survive today, with the Tarchanoff theory being more widely accepted.

One version of the vascular theory was suggested by McDowell (47). He argued that a fall in resistance occurred when the blood content of the skin diminished as a result of vasoconstriction, because the resistance of blood is higher than that of extracellular fluid.

There are two versions of the secretory theory. One, which is rejected by McCleary, attributes lowered resistance, and thus increased conductance, to the presence of sweat in or on the skin. A similar theory projected by Darrow (11) and Darrow and Gullickson (9) states that it is the sweat ducts that provide the high conductance pathways to deeper parts of the gland, and that the surface recording reflects electrical changes in the epidermis.

The alternative explanation is that the permeability of the membranes involved in the conductance of an imposed current is affected by changes in the sweat glands prior to secretion. This view, advanced by the works of Edelberg, Greiner, and Burch (14) and Wilcott (72), recognizes the active involvement of the epidermal mechanisms in skin conductance and resistance, and emphasizes the role of superficial layers in skin hydration regulation.

As indicated in the preceding paragraphs, there is no single explanation of the electrodermal response, but certain facts are relevant to this investigation. On an elementary level, skin contains eccrine sweat glands that have been shown to exhibit either a change in resistance, conductance, and/or potential when the subject is stimulated. Such changes are linked with the sympathetic division of the autonomic nervous system. Activation causes a subsequent increase in the amount of catecholamines that are released and results in glandular secretion of moisture. Even though further investigation is needed to determine whether the electrodermal responses occur as a reflex to this secretion or the presecretory changes in the body, one can still recognize the importance of these measurements as indicators of activity of the sympathetic nervous system.

As the investigation in the present study attempted to measure the orienting reflex to tactile stimulation, it was, therefore, phasic levels of electrodermal responses with which this investigation was concerned. The appropriateness of skin conductance measures to this study can be further supported when viewed in terms of the method utilized in data collection.

Two different types of measurements have been in common use. In the first, the exosomatic procedure, an externally imposed current is applied to the skin and underlying tissues through an electrode/electrolyte junction. Resistance to or conductance of its passage is measured through a second junction. The second method, referred to as endosomatic, records the skin potential, which is the electrical activity of the skin itself. No current is externally imposed and the junction only serves to connect the body surface to the measuring apparatus. Venables and Christie (69) concluded that as a tool for behavioral use, exosomatic techniques present fewer measurement problems than the endosomatic method, primarily due to the complex multi-phase waveforms.

A great deal of controversy still exists over which is the best indicator of exosomatic measures--skin conductance response or skin resistance response. Review of electrodermal related literature revealed the following findings in support of the use of the former for electrodermal measurements.

Venables and Christie (69) have stated that measurement of exosomatic electrodermal activity in terms of skin conductance rather than resistance is physiologically more reasonable. As the number of active sweat glands increases, there is an increase in the number of conducting pathways, thus increasing the level of conductance.

According to Lykken (44), increases or decreases in the number of active sites will not affect the skin conductance response, whereas the resistance change has been shown by Darrow and Smith (10) to be lowered by decreasing skin resistance level. If an individual has a high resistance level, there are only a few active sweat glands, those able to transmit the current. Response to an imposed current will come at lower densities than those of a person with low skin resistance response according to Prokasy and Raskin (58). This characteristic of electrodermal "saturation" leads to another issue involved in the controversy, selection of the recording circuitry.

There are two circuits widely used for measuring exosomatic responses, constant-current and constant-voltage. Each can be described in terms of Ohm's law, written $I = \frac{R}{V}$ where I is the current, R is resistance, and V is voltage. Skin resistance (R) can be measured $R = \frac{V}{I}$ by holding current constant.

Edelberg (13) reported findings of an experiment which dealt with the practical application of these circuits. The voltage-current curves that he obtained indicated that nonlinearity did not occur in subjects with very low resistance levels until current densities (the amount of current flowing per unit of electrode) of 75 A/cm^2 were imposed. Subjects with very high resistance levels recorded nonlinear voltage-current relationships with densities as low as 4 A/cm^2. The explanation is consistent with the saturation idea. When the number of active sweat glands is high (meaning low skin resistance level), the current will be divided proportionately over the large number. The total current density which may be used before the threshold for nonlinearity is reached may be considerably higher than in the high skin resistance level cases. The constant-current system, by definition, imposes the same current regardless of the activity of the sweat glands. The high skin resistance level subjects, therefore, may exceed their threshold for nonlinearity and provide unreliable data. The voltage used in constant-voltage systems, on the other hand, is independent of the number of active glands and the current through an individual gland remains the same, regardless of the number of active glands.

Further study of the Edelberg voltage-current curves showed linearity for all subjects when the level was below .8V across a single site. He concluded that the ability of the skin to obey Ohm's law is determined by the applied voltage rather than by current density and suggested the use of a value of .5V across a single site to avoid nonlinearity. Both his conclusion and his suggestion have been supported by other researchers and imply the adoption of constant-voltage circuits as means of measuring skin conductance responses of the electrodermal phenomenon.

Research Issues Involving Electrodermal Responses

The theories of electrodermal activity have long been applied to a variety of areas of investigation. The following section reviews specific research issues that have used various indices of measurements and aspects of the subject, environment, and methodology.

Grings, Uno, and Fiebiger (21) conducted a study in which subjects were presented a series of two-second noise stimuli that fell within a range of 60-100 decibels. The magnitude, latency, and recruitment time of skin conductance responses were measured. As the stimulus intensity increased, both the magnitude and recruitment time rose, while a decrease in the two was observed as the number of repetitions increased. This suggests that skin conductance response is indicative of the level of stimulation and the point of habituation.

Complex visual stimuli were employed by Hare and Thorvaldson (22). A series of slides depicting homicides, nude females, and ordinary subjects were presented to male subjects while their skin conductance responses were monitored. Although all three types of stimuli produced responses which habituated upon repeated exposure, there were no differences in magnitude of the responses as a function of stimulus type.

Zinny and Kienstra (75) reported that alterations of stimulus quality, intensity, or temporal characteristics cause the initial response to be reinstated. They reported that when a tone was interpolated among a series of electrical shocks, the magnitude of skin conductance response to the tone was greater than the response illicited by the preceding shock. Increase in skin conductance response did not occur when the tone had been preceded by a series of shocks and tones. This study demonstrates that in some situations the magnitude of the response is determined more by the novelty of the stimulus than by its noxious quality.

A study by Johnson and Campos (31) investigated the effects of cognitive tasks and verbalization instruction on heart rate and skin conductance. Each of two types of tasks were administered under the following three instruction conditions: no verbalization, later verbalization, and concurrent verbalization. It was found that the imagination task recorded changes in heart rate and skin conductance only when the subject was preparing to talk or actually talking, while the mental arithmetic puzzle task resulted in cardiac acceleration and skin conductance increases even when no verbalization was required. The findings of this study suggest that changes are generally due to verbalization requirements and that the effects can be attributed in part to the fear of being evaluated while talking.

The most relevant research study to the investigation reported in this manuscript was undertaken by Andreen, Gibson, and Wetmore (1). Physiological factors such as body surface temperature, electrical conductivity, rate of sweating, total sweat cost, and heart rate were measured as criteria for evaluating the comfort afforded human test subjects by textile apparel. Fabrics were tested in the form of single-layer, coverall-type garments which covered the body from neck to ankle. The routine was usually one of rest, exercise, and rest in the nude, which served as a control, followed by rest, exercise, and rest in one of the garments. Each of the subjects was exposed to four different skin conditions of a warm environment. The electrical conductivity of the skin was measured by converting skin resistance response to the appropriate data. Increase in electrical conductivity was associated with increasing air temperature and humidity and subsequently discomfort. The measurement of skin conductivity appeared to distinguish satisfactorily between environments and between nude and clothed situations. In most cases the physiological recordings confirmed the expected differences in comfort.

Relationship Between Pupillary and Skin Conductance Responses to Physiological and Psychological Stimuli

The association of pupillary response with other physiological response systems has not been widely researched. As one of the many functions associated with the autonomic nervous system, the pupillary response would be expected to be related to a variety of other autonomic variables.

Kahneman et al. (34) raised the question as to whether comparable results can be obtained with other autonomic functions when time-locked to paced mental activity. Ten volunteer college students were tested for pupillary, heart rate, and skin resistance changes using three levels of difficulty of a digit transformation task involving addition. The order of task difficulty was randomized for each subject and the procedure continued until five error-free trials were obtained before beginning the experiment. Results showed that a sympathetic-like increase in activity occurred in all channels (pupillary, heart rate, and skin resistance) during the input stage followed by a decrease in the report phase.

In a study by Scott et al. (63), electrodermal skin response was employed with pupil size. Male and female subjects were exposed to three types of stimuli: a pistol shot, four pictures of semi-nude males, and four pictures of semi-nude females. The data indicated that the skin response was more sensitive than the pupil response to the presentation of the stimuli when each was compared to an appropriate control period. In all other categories the electrodermal response mimicked the pupil response. The investigators, who originally set out to test the aversion-constriction hypothesis, concluded that ". . . the pupillary response variable was found to be similar to skin response in that it is a generalized emotional responder subject to the same limitations as other autonomic variables" (p. 438).

Coleman and Paivio (6), in yet another study comparing pupillary and electrodermal response, required subjects to create images of concrete or abstract words and to press a key when they had formed a mental picture. The abstract words were associated with greater dilations than the concrete words, but the skin response did not distinguish between the two types of words. The authors concluded that pupillary response is more sensitive to changes in cognitive activity occurring during an imagery task. In addition, the results indicated that the latency of such physiological responses could be a more sensitive indicator than the magnitude of the responses.

The general assumptions obtained from research comparing pupillary, skin conductance, and heart rate responses would seem to indicate that each measure may react to variables in a different way, thus implying that multiple measures afford more information and higher detection rates than any single measure. Research is thus needed to assess the relative merits of the different responses as well as to establish the usefulness of comparing various response systems.

Subjective Assessment Relating to Consumer Attitude Toward Textile Products

Numerous research studies can be found in the literature relating to subjective assessment of textile products. However, according to Brand (4), there is no accepted valid method of measuring the aesthetics of fabrics. Few people can agree on what fabric aesthetics are, since it is subjective and apparently means different things to different people. One goal of fabric scientists is to find a numerical process to measure and define aesthetic properties.

Hoffman (28), however, stated that the possible existance of major areas of disagreement is one of the strongest reasons for making studies of consumer opinion. It is his belief that marketers should know when groups of people disagree about products since identification of market segments is more beneficial than attempting to sell the entire market. Hoffman also advanced the theory that even though 95 percent of all clothing purchase decisions involve emotion, little research has been done attempting to isolate psychological aspects of clothing.

Brand (4) investigated the use of "polar-pair" words combined with a mathematical technique called factor analysis which involves identifying the number of distinct mental processes required to account for specific psychological or physiological phenomenon. He suggested that individual judges evaluate a polar-pair category and that factor analysis be used to determine the number of mental processes used by the judge in evaluating the fabrics.

Binns (3) conducted a study using judges from different educational and sociological backgrounds. Twelve fabrics were judged by 22 manufacturers and buyers of dress goods and a group of six boys between the ages of 15-18. Results showed a high statistical correlation between the two groups leading Binns to conclude that the basis of highly skilled judgment appeared to be native and immediate.

The preceding literature gave a basis for the selection of processes to be used by this investigator. The assessment of the relative merits of various materials and procedures was instrumental in determining their inclusion in the current investigation.

CHAPTER III

EXPERIMENTAL PROCEDURES

The purpose of this investigation was to determine the effect of fiber content, fiber length, and yarn type upon the consumer acceptance of shirt-like garments composed of wool-cotton blends. The research design utilized both male and female subjects whose responses to the experimental fabrics were measured by pupillary, skin conductance, and subjective assessments.

The procedure is described under the following categories: (1) description of the experimental garments and swatches, (2) selection of participants, (3) description of instruments and procedures, (4) data evaluation processes, and (5) analysis of data.

Description of the Experimental Garments and Swatches

The five experimental fabrics that were included in the study were provided cooperatively by the Wool Bureau, Inc., the International Wool Secretariat, and the Western Regional Research Laboratories of the United States Department of Agriculture. These fabrics were composed of wool and cotton intimately blended in a

7.5 oz. 2/2 right hand twill weave with a yarn count of 39.4 tex and a fabric count of 67 ends/inch x 64 picks/inch. The fabric construction was engineered under the supervision of Dr. Robert Donnelly of the Western Regional Research Laboratories of the United States Department of Agriculture. Other details related to the fabrics are shown in table 1.

TABLE 1

DETAILS OF EXPERIMENTAL FABRICS

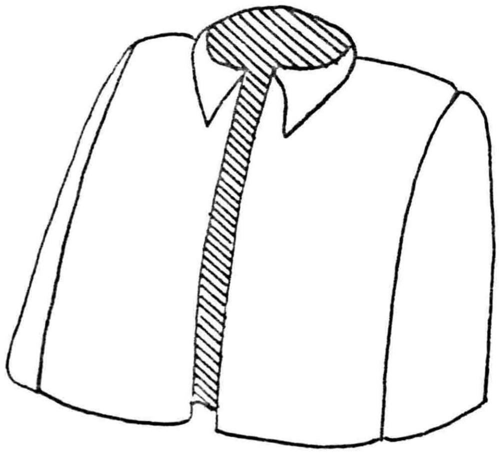
Fabric	Percent Wool/Cotton	Yarn Spinning System	Fiber Length	Yarn Twist (per in.)	
				W	F
A	55/45	ring	1.71	15.5	14.5
B	55/45	ring	3.38	15.5	14.5
C	40/60	ring	1.71	15.5	14.5
D	40/60	open end	1.71	20.1	18.7
E	25/75	ring	1.71	15.5	14.5

Two shirt-like garments of medium size (one of misses' size 12 for the females, and the other of men's size 15 for the males) were constructed from each of the five experimental fabrics and used as simulated garments in evaluating the feel of the fabric on the upper body of the participants. The garments were designed with a shirt collar, cape-like sleeves, and a center front opening with Velcro closures to facilitate ease in application. Figure 1 shows the design details of the experimental garments.

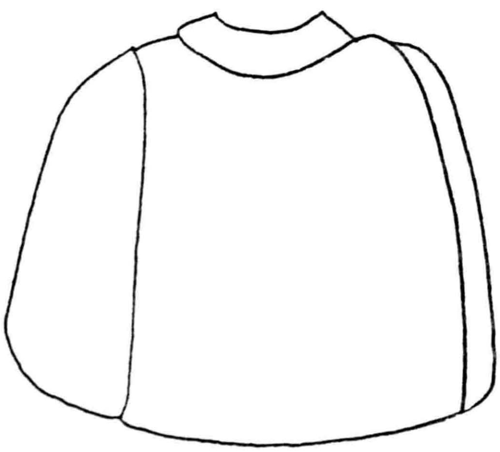
Five flat fabric swatches, 38 x 38 cm., were cut from the experimental fabric and used for the tactile evaluation that was recorded by the pupillometric and skin conductance equipment. These swatches also were used for the personal opinion survey where acceptability ratings for the shirts were made by the participants.

Selection of Participants

The following criteria were used in the selection of the participants: (1) 20-30 years of age; (2) medium size in relation to sex; (3) visual acuity of 20/20 without the assistance of glasses or contact lenses; (4) freedom from allergenic or other skin problems; (5) absence of stimulants on the day of testing (i.e., medication, caffeine); (6) sufficient color variability between the iris and pupil of the eye (i.e., to distinguish the pupil from the iris when measuring pupil size change); and (7) accessibility at the time of the testing sessions.



Front View



Back View

Fig. 1. Design details of the experimental garments.

Subjects were solicited by visits to several classes on the Texas Woman's University and North Texas State University campuses, and sign-up sheets were placed in male and female dormitories. Each sign-up sheet contained the selection criteria.

Two tests were used in screening the subjects who volunteered to serve as participants. These were the Snellen eye test and a skin sensitivity patch test. The visual acuity test was used in screening subjects for participation in the pupillometric assessment. A 20/20 level of visual acuity was considered necessary in order to eliminate variation in pupil changes due to vision problems.

The eye test involved the use of the Snellan Letter Chart which was brightly illuminated with no reflections. The chart was placed at eye level exactly 20 feet from the person being tested. Tests were made on both eyes of each prospective participant by holding a card first over one eye and then over the other, and asking the participant to identify the letters of the chart in relation to the rows on the chart. Only those persons who, according to the test, had a 20/20 visual acuity were selected as participants for the study.

Skin sensitivity tests involved the placement of a 2.54 $cm.^2$ swatch of each of the test fabrics randomly on the interior surface of either arm of the prospective participant. The swatches, which were covered with adhesive patches, were allowed to remain on each participant for 24 hours. At the end of the 24-hour period the patches were removed and the skin was examined for irritation. If no irritation occurred, the person was considered to be a possible participant.

As a result of the screening process 17 female and 15 male volunteers were selected to participate in testing the experimental textile products by pupillary, skin conductance, and personal opinion responses. All of the subjects met the participant selection criteria.

Description of Instruments and Procedures

The following instruments and procedures were used in measuring the consumer acceptance of the experimental garments and swatches: (1) pupillometric recording apparatus, (2) pupillometric measurement apparatus, (3) skin conductance apparatus, (4) scale for subjectively rating acceptability of shirt fabrics, (5) research team, (6) instruction of subjects, and (7) sequence of testing.

Pupillometric Recording Apparatus

Pupillometric changes were recorded by means of a 16 mm-1P recording camera system designed and manufactured by Photosonics, Inc. of Burbank, California (figure 2).

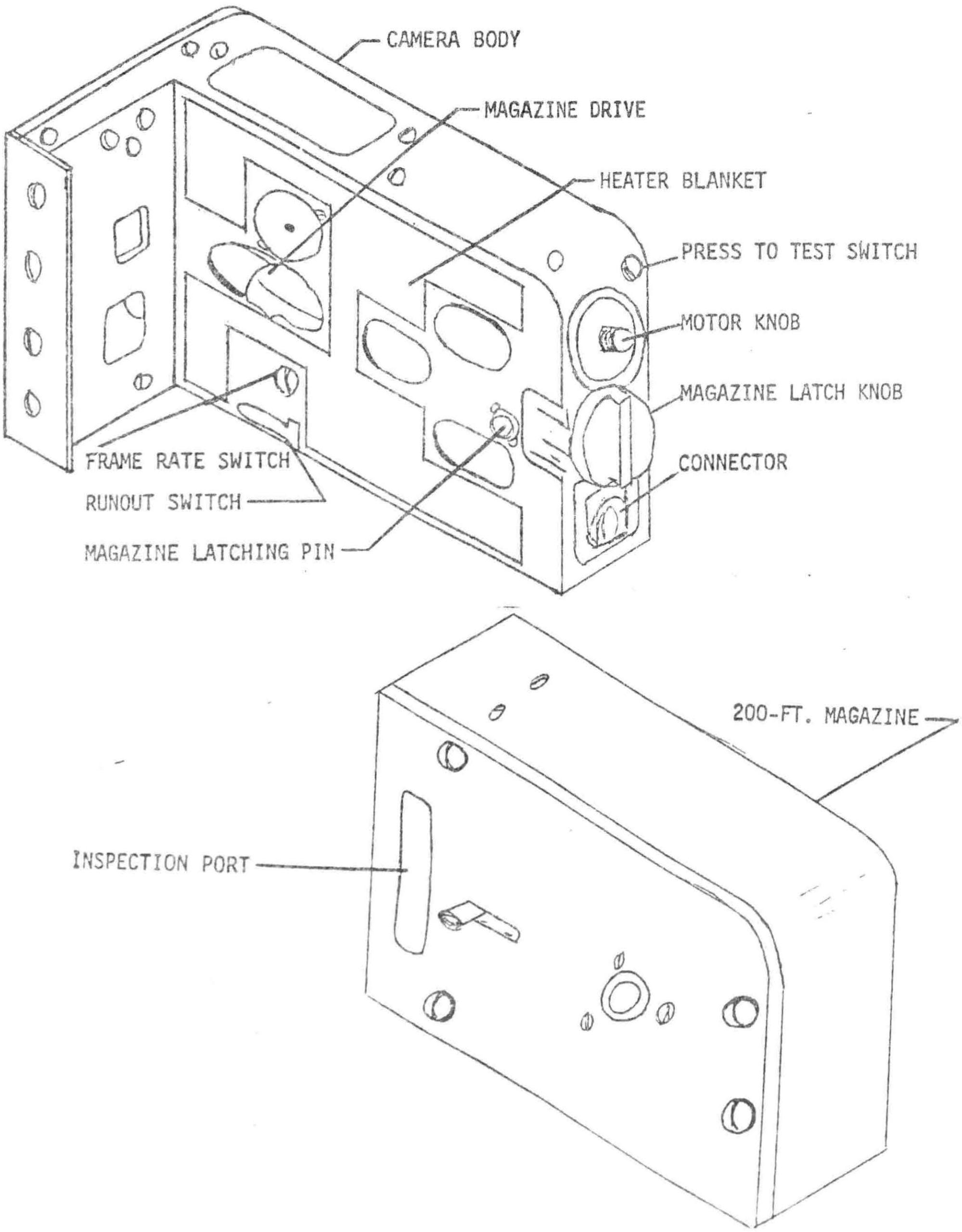


Fig. 2. Pupil recording apparatus.

The camera was placed on an adjustable, heavy-duty tripod. A 28 mm lens with a 5 mm extender was attached to it for focusing to within two and one-half inches of each subject's eye.

A standard opthamologist's headrest with adjustable chin rest was positioned on a stand in front of the camera lens. The camera and headrest were adjustable for differences in physical statue of the participants.

Necessary illumination for photographing the right eye of each participant was provided by a high intensity lamp placed seven inches from the eye. Light intensity was maintained at a constant level with careful attention given to prohibiting the light from shining directly into the participant's eye.

The photographic film was exposed at the rate of 24 frames per second for a 10 second period before stimulus and for a 10 second period during stimulus. The sequence was identical for both the swatches and the garments constructed from the experimental fabrics.

Pupillometric Measurement Apparatus

After commercial processing, the 16 mm film was placed on the film transport of a Vanguard Motion Analyzer (figure 3) and projected on the illuminated screen of the instrument for measurement (figure 4). Using X/Y

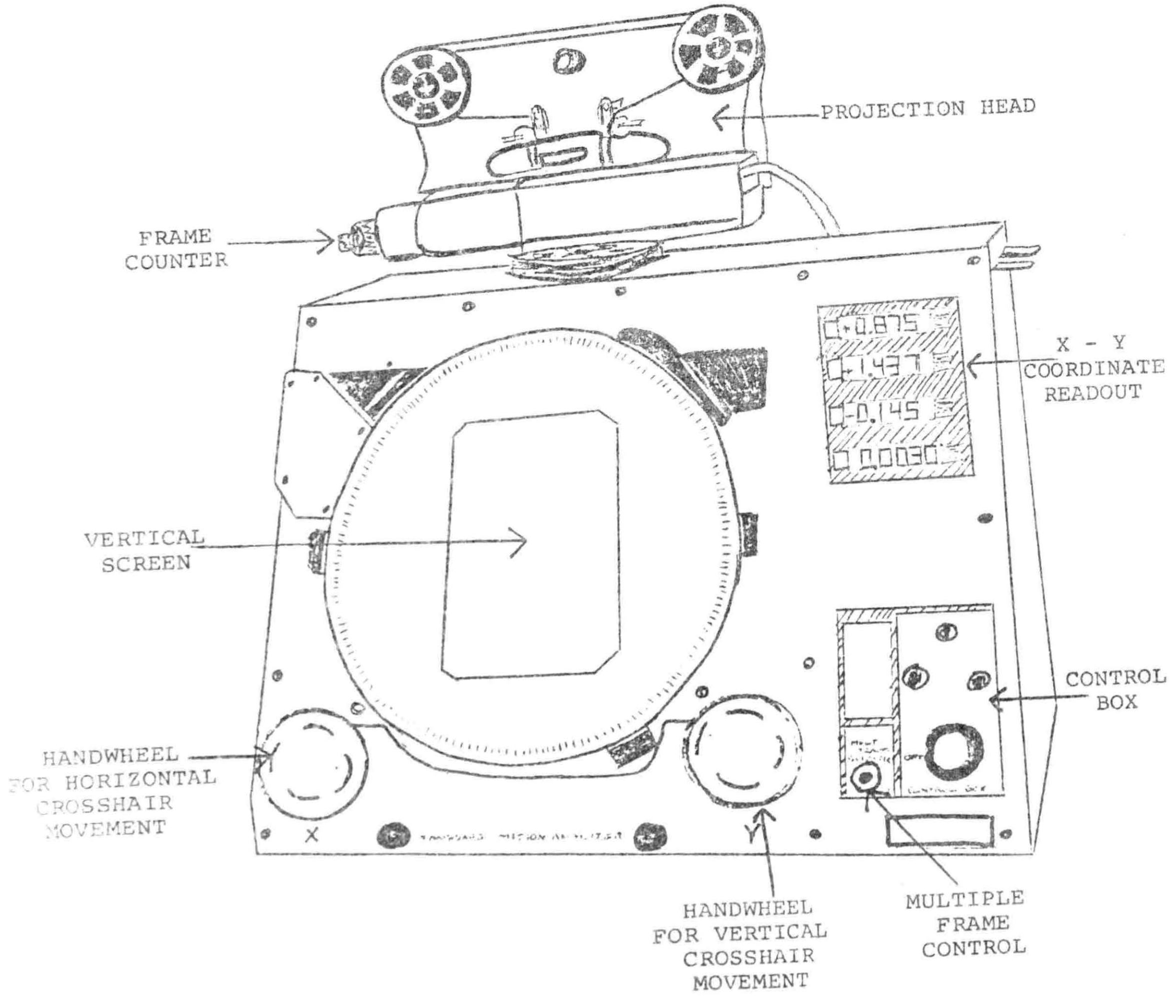


Fig. 3. Vanguard Motion Analyzer.

coordinates, the diameter of the pupil was measured digitally to one-thousandth of an inch.

The analyzer was set to automatically project every sixth frame which allowed measurements of four frames for each second of filming. Measurements before and after stimulus were calculated and the difference between these measurements were recorded as changes in the pupil due to stimulation.

Skin Conductance Apparatus

A R-511 Beckman Dynograph with a Type 9844 Skin Conductance Coupler (figure 5) and Beckman silver/silver chloride three-wire electrodes were used to measure the skin conductance level and skin conductance response of the participants to the experimental garments and fabrics. Electrodes were placed on the palm of each participant's right hand for conditioning 30 minutes before the test (figure 6).

The measure for the basal skin conductance response was in conductance units (micromhos). The skin conductance amplitude was the measure used for skin conductance response.

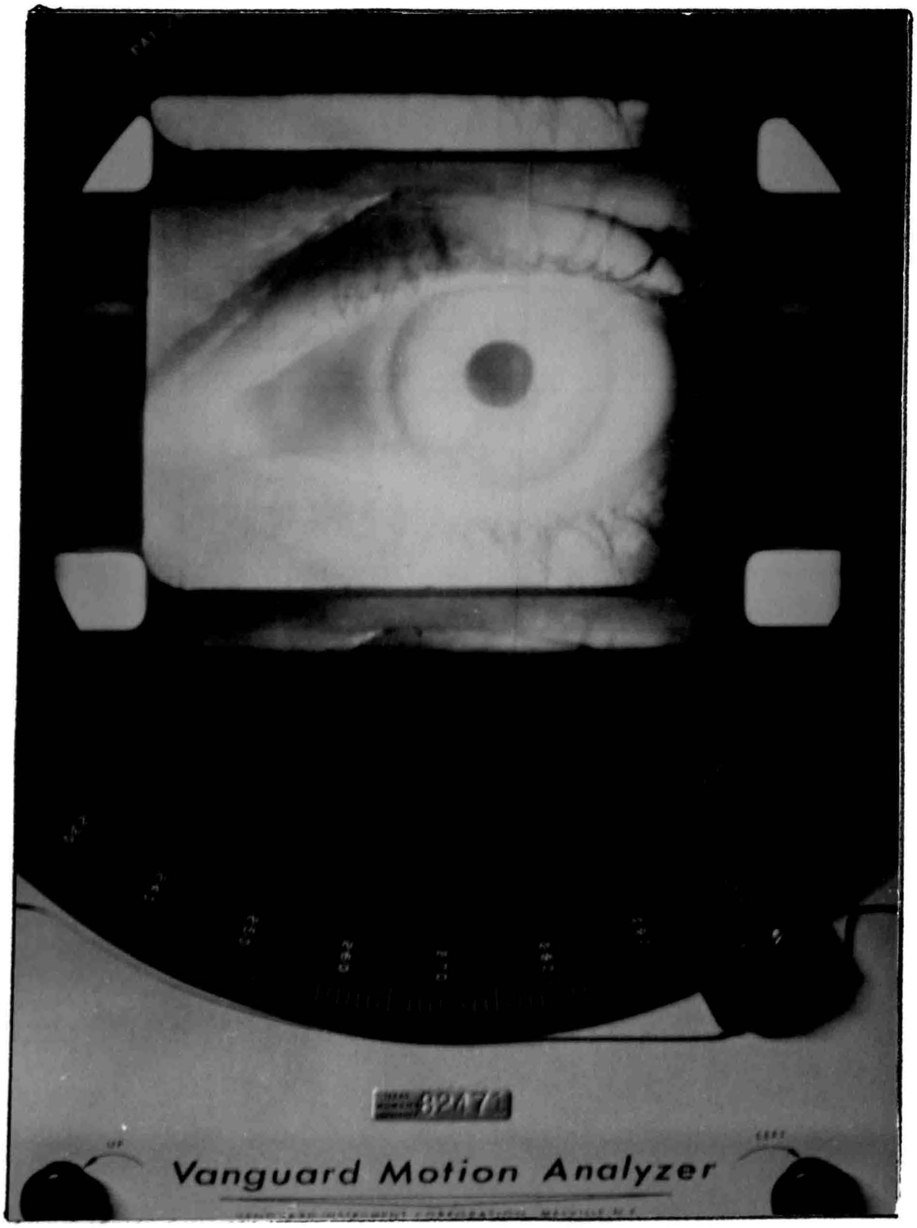


Fig. 4. Photograph of film projected for measurement.

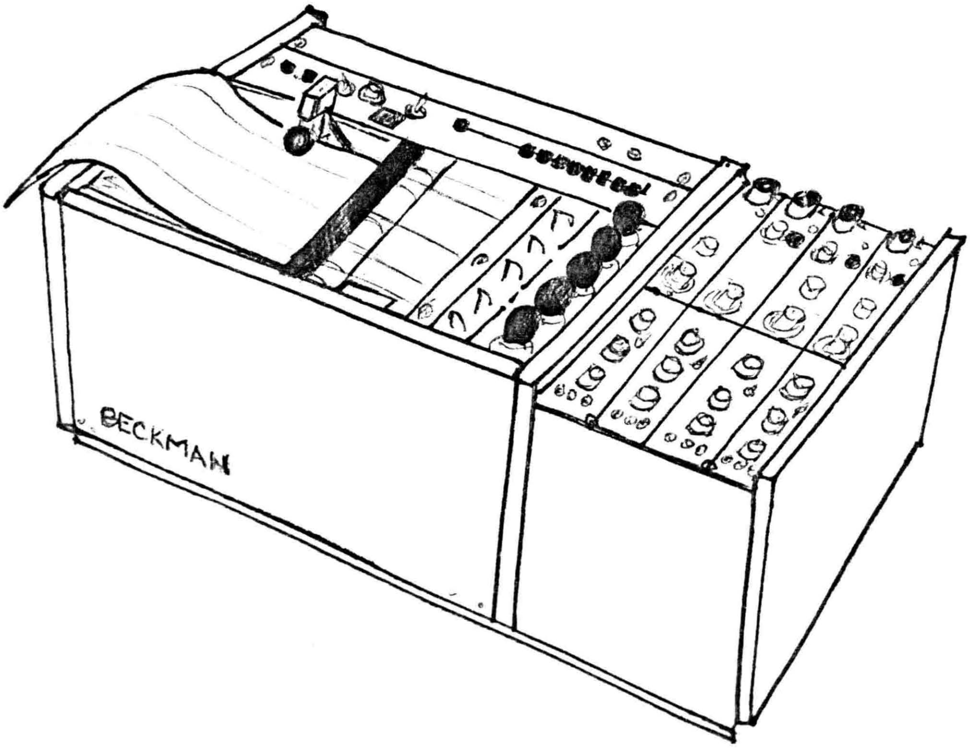


Fig. 5. Skin conductance recording apparatus

Fig. 6. Placement of electrodes on subject's palm

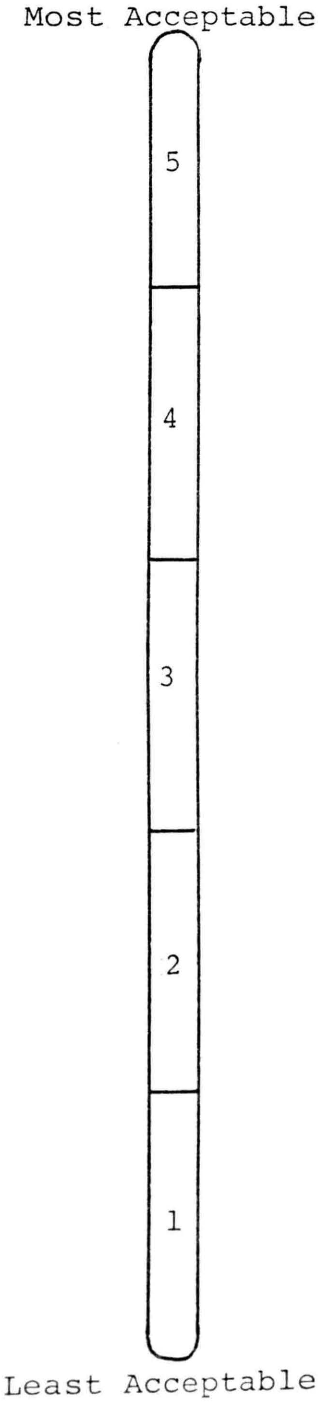
Scale for Rating Acceptability of Shirt Fabrics

An instrument to measure the acceptability of shirt fabrics by personal opinion was designed for the subjective aspect of this research. A document developed by Dr. Taylor of the Menninger Foundation (68) was used as a guide in the construction of the rating scale. Twenty-five persons were interviewed as a means of collecting statements that indicated all aspects of fabric comfort from most comfortable to least comfortable.

Six judges, with similar education and socio-economic background as that of the prospective participants, were then selected to rank-order the examples. These results were calculated statistically to test for interjudge reliability and mean rank stability. From this set of examples the range of ranks was determined, clusters were formed, and the final selection of the most appropriate statements for each part of the scale was determined. The five-part scale, which placed the terms in order from most acceptable to least acceptable is shown in figure 7.

Research Team

A research team of five individuals was required to collect the data. The team members were selected, time schedules were arranged, and training for the particular



Most acceptable overall; the fabric exhibits a feeling of softness, smoothness, and is soothing and of a pleasant weight

Above average acceptability; the fabric exhibits a firm, pliable, non-clingy feeling and is of a pleasant weight

Average acceptability; the fabric exhibits neither pleasant nor unpleasant sensations

Below average acceptability; the fabric exhibits feelings of clinginess; is slightly rough, clammy, and bulky

Least acceptable overall; the fabric is extremely stiff, scratchy, irritating, rough, and harsh to the skin

Fig. 7. Scale for rating acceptability of shirt fabrics.

duty of each member of the research team was conducted. The five team members were given the following responsibilities: (1) a member of the team, by means of a stop watch, recorded the time, projected the time markings on the skin conductance graph, signaled the starting and stopping of the camera, and indicated the time and exposure for the placement of the garments on the participant; (2) a member of the team was responsible for the focusing, loading, and operation of the camera including the indication of the subject number and the specific garment or swatch used; (3) a member was responsible for the calibration of the dynograph between subjects, determination of the basal reading for each garment and swatch for each subject, and for monitoring the data recorded by the skin conductance equipment; (4) a member was responsible for determining the counterbalancing sequence for the garments and swatches, and applying the garments to the body of the participant; and (5) another member assisted in the application of the garment to insure speed and accuracy of placement, and was responsible for the placement of the appropriate swatch in the participant's left hand for the part of the test involving tactile stimulation.

Instruction of Subjects

In order to insure similar thought processes during the stimulation periods, each participant was told that various fabrics made into shirt-like garments would be placed around the upper body in order for the participant to determine how the fabrics felt on the skin. The participant was also told that he or she would be given a fabric swatch to be used for tactile stimulation. Subjects were asked to concentrate on the comfort and suitability of the fabrics for a shirt.

Sequence of Testing

Pupillometric and skin conductance measurements of the acceptance of the experimental garments by the participants were made simultaneously in a test chamber selected to maintain constant light, noise control, temperature, and humidity. The use of one-way mirrored glass controlled interruptions by movements of the team of investigators.

Thirty minutes before entering the test chamber, electrodes to be used in the skin conductance test were placed on the palm of each participant's right hand for conditioning. Techniques involved and information to be gained from the experiment were explained to the participant at this time. Each participant signed a consent form, was given a number, and was then categorized as to sex, age, and body temperature.

Each subject entered the test chamber and was seated in front of the pupillometric apparatus. Any necessary adjustments were made in the heights of the headrest and the camera, and the participant was asked to fixate his or her eyes on a given point in order to control pupil changes due to differences in fixation points. Additionally, the subject was told to remain as motionless as possible and that no further communication would be made between the investigators and the subject as this would affect the responses of the participant. The camera was focused, the boresite removed, and the film magazine was inserted (figure 8). In order to refrain from distracting the subject, the camera was then operated by remote control from a position behind the subject.

After calibration, the dynograph was hooked to the electrodes on the palm of the participant's hand (figure 9). Before the introduction of each garment, the eye was photographed at rest for 10 seconds. During stimulation by the garment, the eye was again photographed for another 10 seconds. One minute intervals before and after the introduction of each garment were recorded on the skin conductance graph. This process was repeated for

Fig. 8. Subject positioned for pupillometric assessment

Fig. 9. Subject connected to skin conductance apparatus

all five garment specimens, and again for all five fabric swatches.

In order to counteract the habituation effect, which research has indicated diminishes in intensity with time for both the pupil response and the galvanic skin response, the order of presentation of the experimental fabrics was counterbalanced according to a 5 x 5 Latin Square layout (5). This insured that each fabric was presented in each sequential position the same number of times.

After the pupillometric and skin conductance assessments of the experimental garments and swatches were made, participants were disconnected from the skin conductance electrodes and moved to another room where they were asked to rate the fabrics subjectively regarding their acceptability as shirts. For this test the participant was seated at a table with a screen behind which a member of the research team handed the participant the experimental fabrics one at a time. The participant was asked to feel the fabric with the fingers, rub it between the hands, and pull it over the arm. After this tactile stimulation, the participant was asked to rate the fabric on a scale from one to five according to the scale shown in figure 7. At no time during the pupillometric, skin conductance, and subjective questioning processes was the participant allowed to view the fabric.

Data Evaluation Processes

Pupillometric data were measured on the Vanguard Motion Analyzer. The calculation of means involved using the last 10 control frames before stimulation and the first 10 frames during stimulation. Hess and Polt (26) had found that the pupil reached a maximum dimension immediately upon stimulation and then reverted back to pre-stimulus dimensions.

To determine differences in the acceptance of the garments and swatches as indicated by the skin conductance test, the following procedure was used: (1) Millimeters from the baseline on the skin conductance graph were calculated and multiplied by the calibration conversion unit which was obtained by dividing micromhos (amount) by millimeters (distance). (2) The calibrated millimeter was then added to the baseline reading obtained from the original reading taken when the basal skin conductance response was recorded for each individual. (3) The last one-half second before stimulation was used for the control while the highest peak during the 10 seconds of stimulus was used to determine the amount of change. A typical skin conductance graph is shown in figure 10.

The evaluation of data from the subjective opinion scale involved a five point rating scale that ranked the acceptance of the experimental fabrics from the most acceptable to the least acceptable as follows:

5 = excellent acceptability

4 = good acceptability

3 = fair acceptability

2 = poor acceptability

1 = not acceptable

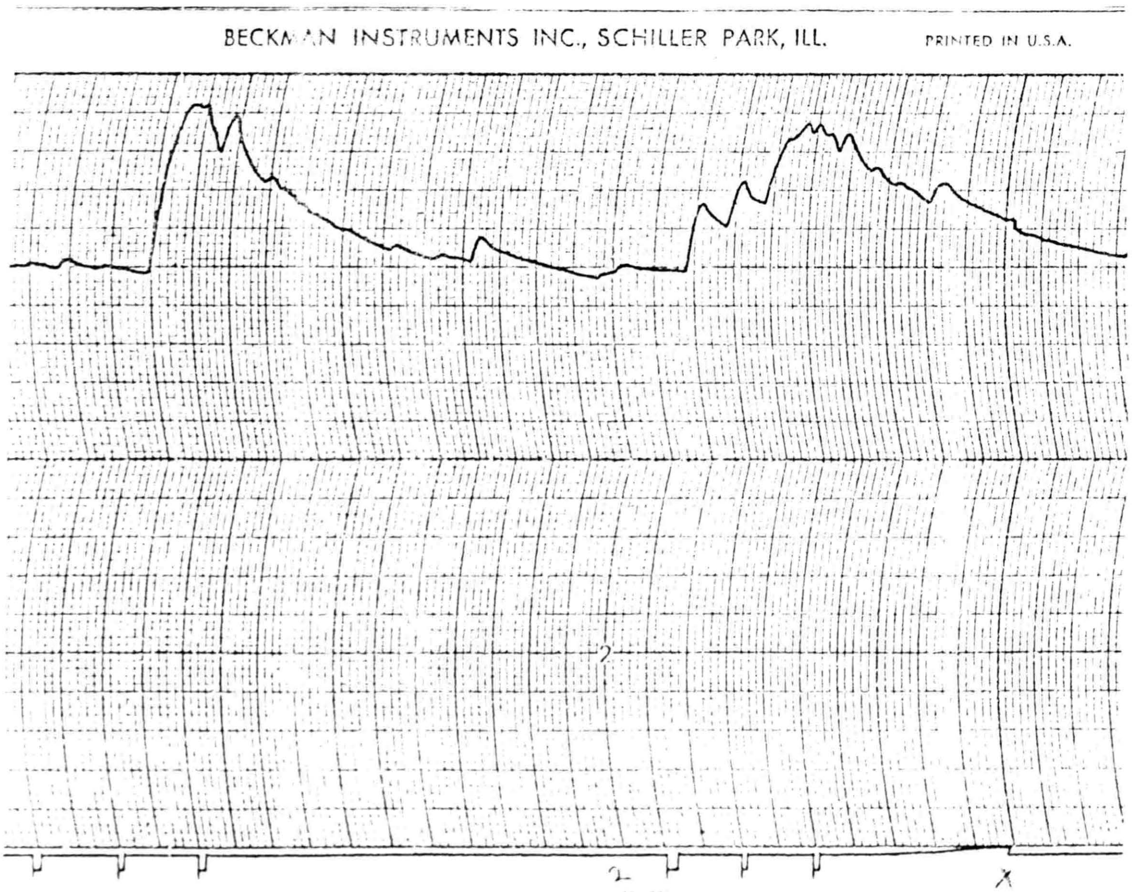


Fig. 10. A typical skin conductance graph

Analysis of Data

Data were analyzed using the BMDP-2V computer program by means of an analysis of covariance with repeated measures procedure for the pupillometric and skin conductance information. Computations involved two repeated factors (body area stimulated and type of fabric) and one grouping factor (sex). Covariate analysis was used to equate the groups with the pre-stimulus means serving as the covariate or control.

Analysis for subjective assessment was computed using an analysis of variance with repeated measures. The data involved a two-factor mixed design with one grouping factor (sex) using repeated measures on fabric type.

Comparisons of the dependent variables were computed on the SPSS statistical program using the Pearson product-moment correlation coefficient. The dependent variables were the pupillometric, skin conductance, and subjective responses.

CHAPTER IV

PRESENTATION OF DATA AND DISCUSSION OF FINDINGS

The acceptance of intimately blended wool-cotton fabrics for shirts by male and female consumers, on the basis of responses to differences in fiber content, fiber length, and yarn type were measured by pupillometric and skin conductance assessments through two body receptors: fingertips and upper body. A subjective scale was utilized to provide personal opinion responses to acceptance of the fabrics for shirt-like garments by the participants.

Results of the data analyses are presented under the following major headings: pupillometric assessment, skin conductance assessment, and subjective assessment. In each category analysis of responses to fiber content, fiber length, yarn type, area of body stimulated, and differences in male-female responses are reported. Tables 2 through 28 contain the pooled adjusted means for all participants as well as for male and female responses to fiber content, fiber length, and yarn type according to body area stimulated by the experimental fabrics.

Graphical illustrations of these means are found in figures 11 through 28. Results of data analyses of covariance and analyses of variance also are included in the above tables.

Comparisons of pupillometric, skin conductance, and subjective assessments as methods of measuring consumer acceptance were analyzed by means of the Pearson Correlation Coefficients. Results of these comparisons are shown in tables 29 through 31.

Pupillometric Assessment

Pupillometric data were obtained by photographing the pupil of the right eye of each participant for 10 seconds before and 10 seconds after stimulation by cape-like garments and flat fabric swatches. Results of the analyses are based on the mean score of the last 10 frames photographed before stimulation and the mean score of the first 10 frames photographed after stimulation. These measurements are presented in the Appendix in tables 32 through 37 and are referred to as pre-test and during-test scores.

Due to technical problems involving filming or film processing, data from six of the 32 participants were not included in the analyses. A total of 5,200 measurements of pupil diameter, 200 for each of 26 subjects, was used in determining the effect of fiber content, fiber length, and yarn type on pupil size.

Pupillometric Responses to Fiber Content

As shown by the mean data represented in table 2, when the upper body was sensitized with the shirt-like garments, pupillometric response was greatest (.840 inches) for the 55/45 wool-cotton followed by the 25/75 wool-cotton garment (.832 inches). Fingertip evaluation of fiber content, however, ranged from .856 inches for the 40/60 wool-cotton to .829 inches for the 55/45 wool-cotton swatch. From an overall point of view the upper body evaluation indicated more response to the experimental fabrics containing the highest percentage of wool but when finger sensitivity was involved the 40/60 caused the greatest response. This information is presented graphically in figure 11.

A comparison of male and female responses to fiber content (table 3) showed that, after adjustments for differences between groups, female pupil size responses were consistently lower than those of the males for both upper body and fingertip areas of stimulation (see figure 12). Pupil dilation of the male participant, as a result of upper body stimulation by the experimental garments, gradually increased according to the amount of wool

TABLE 2

ADJUSTED MEANS FOR PUPILLOMETRIC RESPONSES OF ALL PARTICIPANTS TO FIBER CONTENT ACCORDING TO BODY AREA STIMULATED

Fiber Content	Mean Pupil Size (inches)*	
	Upper Body	Fingertips
55/45 Wool-Cotton	.840	.829
40/60 Wool-Cotton	.828	.856
25/75 Wool-Cotton	.832	.837

*Pupil size as indicated by the Vanguard Motion Analyzer.

TABLE 3

ADJUSTED MEANS FOR MALE AND FEMALE PUPILLOMETRIC RESPONSES TO FIBER CONTENT ACCORDING TO BODY AREA STIMULATED

Body Area Stimulated	Mean Pupil Size (inches)*					
	55/45 Wool-Cotton		40/60 Wool-Cotton		25/75 Wool-Cotton	
	Male	Female	Male	Female	Male	Female
Upper Body	.857	.827	.854	.807	.845	.821
Fingertips	.840	.820	.863	.849	.845	.830

*Pupil size as indicated by the Vanguard Motion Analyzer.

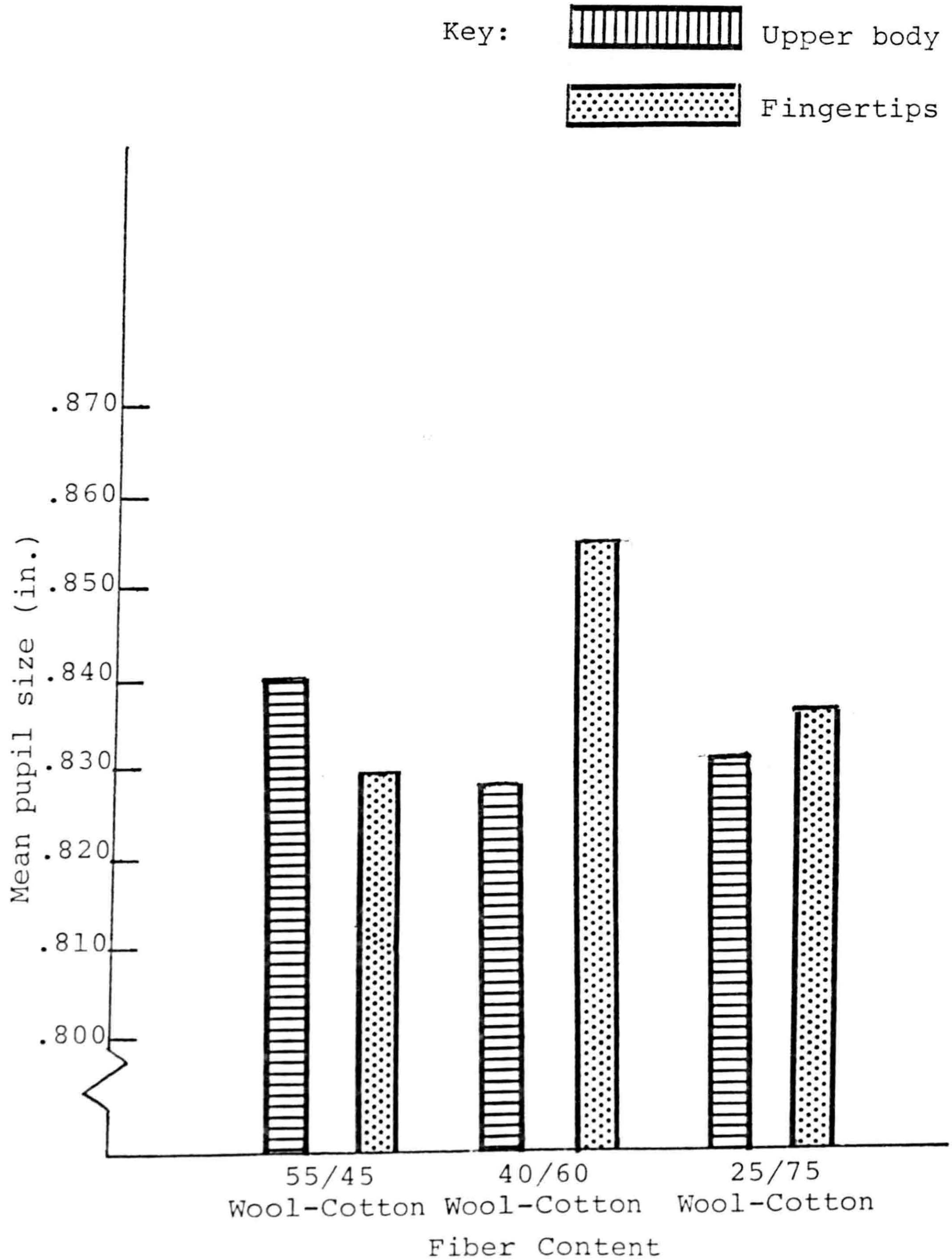


Fig. 11. Adjusted means for pupillometric responses of all participants to fiber content according to body area stimulated.

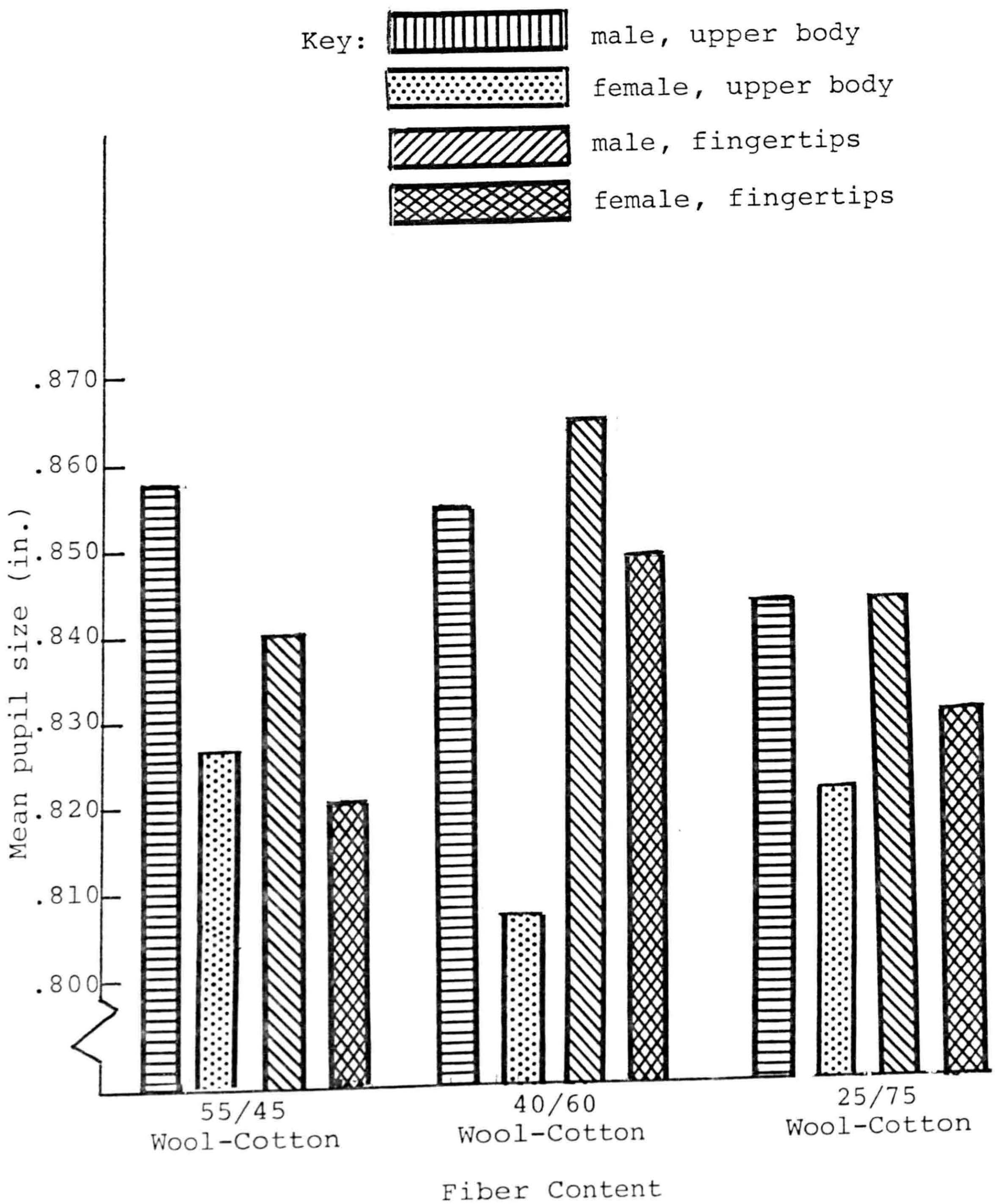


Fig. 12. Adjusted means for male and female pupillometric responses to fiber content according to body area stimulated.

contained in the blend (.845 for the 25/75 wool-cotton, .854 for the 40/60 wool-cotton, and .857 for the 55/45 wool-cotton blend). Upper body stimulation of females by the experimental garments also elicited the greatest dilation for the 55/45 wool-cotton fabric (.827), but gave the least dilation response (.807) to the 40/60 wool-cotton blend.

According to Corbman (8) when fibers are combined and blended, the properties of individual fibers are also combined, although modified. Wool fibers are known to have warmth, absorbency, body and hand, while softness, strength, and absorbency are attributed to cotton. In addition, wool is known to have a scale-like outer portion that causes irritation to some skins. As the percentage of cotton increases in the blend, it is reasonable to assume that the fabrics would become softer and less irritating to the skin. This pattern was observed to some extent in the upper body responses but did not hold true for fingertip stimulation.

According to the results of the analysis of covariance for repeated measures, fiber content did not significantly affect the pupillometric responses of the participants with regard to either upper body or fingertip stimulation. Specific information concerning the analysis of covariance results may be observed in table 4.

TABLE 4

SUMMARY OF ANALYSIS OF COVARIANCE FOR PUPILLOMETRIC RESPONSES TO FIBER CONTENT

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-Ratio	Probability
Area of Body Stimulated (Upper body vs. fingers)	1	473.896	473.896	.39	.540
Pretest	1	100139.534	100139.534	81.72	
Error	24	29408.598	1225.358		
Fiber Content (Fabrics A, C, E)	2	1939.925	969.962	.46	.634
Pretest	1	142196.439	142196.439	67.43	
Error	49	103330.821	2108.792		
Area of Body Stimulated x Fiber Content	2	6564.571	3282.285	1.86	.166
Pretest	1	44618.898	44618.898	25.33	
Error	49	86299.987	1761.224		

Pupillometric Responses to Fiber Length

The range of pupillometric values for the participants' responses to fiber length from upper body stimulation were from .843 inches for short wool fibers to .840 inches for the longer fibers according to an observation of the mean pupil size presented in table 5. An opposite pattern occurred in the responses to fingertip stimulation. More dilation was exhibited for the long wool fibers (.835) than for the short wool fibers (.832). Pupil dilation response from stimulation by the upper body was greater than that resulting from fingertip stimulation (see figure 13).

Adjusted means for male and female pupillometric responses in regard to fiber length are shown in table 6. Similar patterns were evident for each sex with responses associated with the short fibers being somewhat greater than the responses to the long fibers as shown graphically in figure 14. An exception, however, was the greater response shown by males to fingertip stimulation when exposed to the long wool fibers.

Gawne and Oerke (18) indicated that shorter wool fibers twisted together are soft and fuzzy while longer yarns result in firm-textured, smoother fabrics. Results of the pupillometric responses in this investigation would

TABLE 5

ADJUSTED MEANS FOR PUPILLOMETRIC RESPONSES OF ALL PARTICIPANTS TO FIBER LENGTH ACCORDING TO BODY AREA STIMULATED

Fiber Length	Mean Pupil Size (inches)*	
	Upper Body	Fingertips
1.71 inches (wool)	.843	.832
3.38 inches (wool)	.840	.835

*Pupil size as indicated by the Vanguard Motion Analyzer.

TABLE 6

ADJUSTED MEANS FOR MALE AND FEMALE PUPILLOMETRIC RESPONSES TO FIBER LENGTH ACCORDING TO BODY AREA STIMULATED

Body Area Stimulated	Mean Pupil Size (inches)*			
	1.71 inches		3.38 inches	
	Male	Female	Male	Female
Upper Body	.857	.827	.855	.822
Fingertips	.840	.820	.852	.816

*Pupil size as indicated by the Vanguard Motion Analyzer.

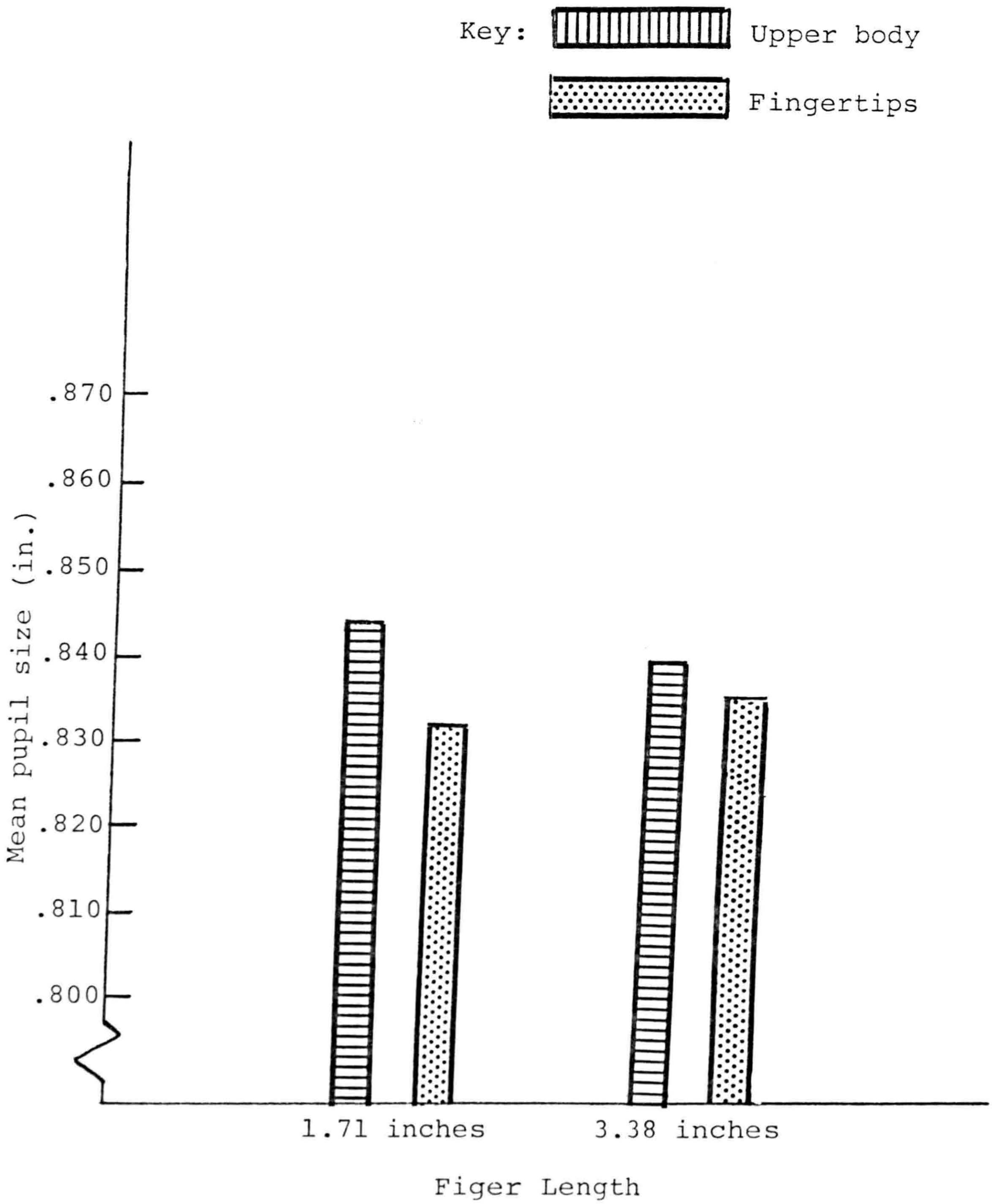


Fig. 13. Adjusted means for pupillometric responses of all participants to fiber length according to body area stimulated.

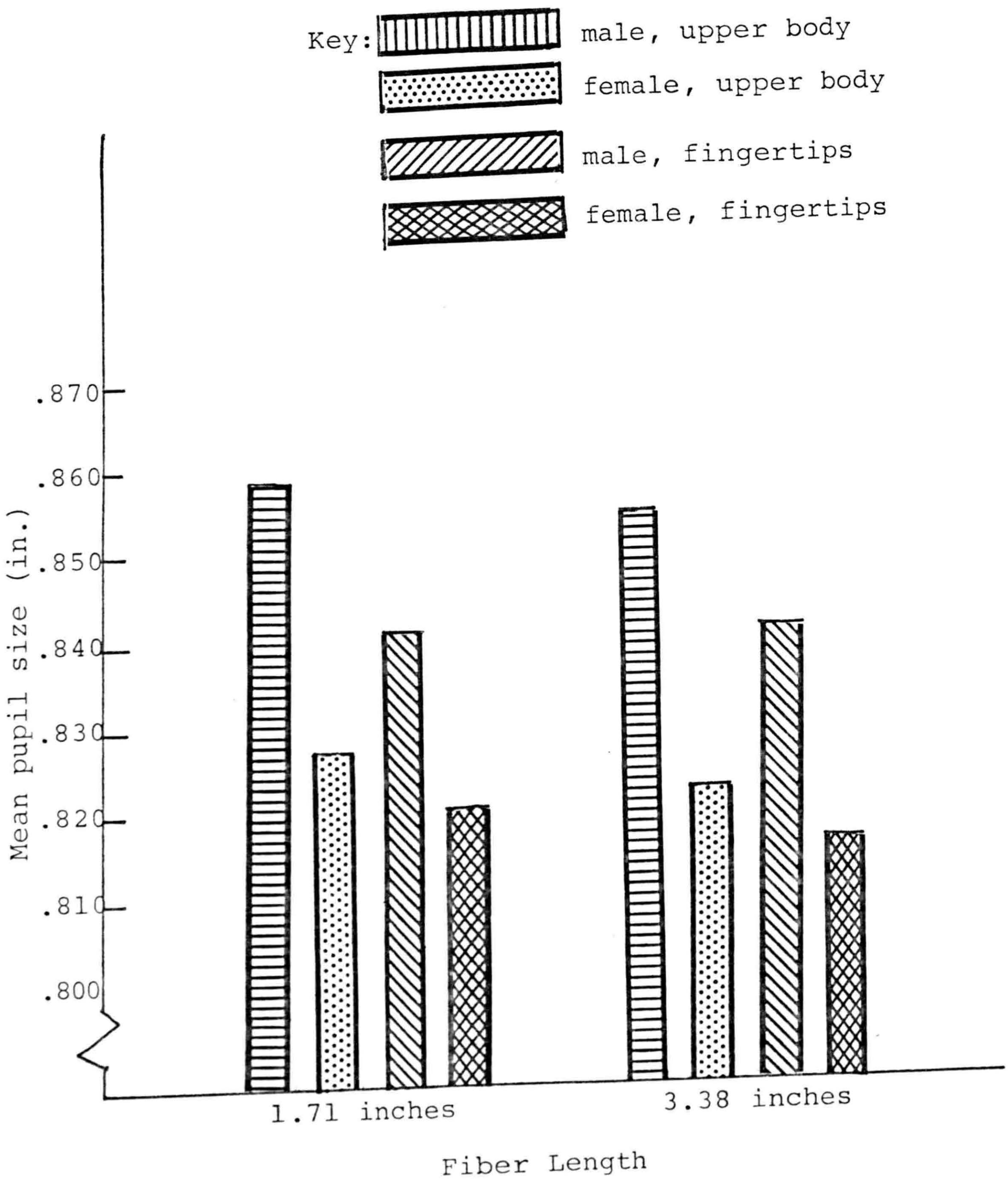


Fig. 14. Adjusted means for male and female pupillometric responses to fiber length according to body area stimulated.

indicate that the soft, fuzzy, shorter fibers stimulated the upper body to a greater degree than did the long wool fibers.

Results of the analysis of covariance with repeated measures indicated that no significant effect was exerted by the use of the upper body or the fingertips as the body area stimulated by the experimental fabrics, or by the use of short or long wool fibers. The interaction effect of the body area used as the receptor of the fabric stimuli and the length of the fiber was also nonsignificant. Table 7 gives results concerning the analysis of covariance for pupillometric response to fiber length.

Pupillometric Responses to Type of Yarn

The fabrics composed of open-end spun yarns elicited more pupil dilation than those from ring spun yarns when the upper body was stimulated by fabrics containing yarns made by the two spinning methods. Stimulation of the fingers by ring spun yarns, however, evoked an even greater response as shown in table 8 and figure 15. The area of the body used for stimulation was not a factor when open-end spun yarns were involved as the pupil response was the same for both areas of

TABLE 7

SUMMARY OF ANALYSIS OF COVARIANCE FOR PUPILLOMETRIC RESPONSES TO FIBER LENGTH

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-Ratio	Probability
Area of Body Stimulated (Upper body vs. fingers)	1	1919.760	1919.760	.86	.362
Pretest	1	59971.129	59971.129	26.99	
Error	24	53318.265	2221.594		
Fiber Length (1.71 vs. 3.38)	1	25.046	25.046	.01	.911
Pretest	1	26636.586	26636.586	13.69	
Error	24	46699.169	1945.799		
Area of Body Stimulated x Fiber Length	1	1377.110	1377.110	1.54	.227
Pretest	1	7219.224	7219.224	8.07	
Error	24	21479.378	894.974		

stimulation (.837). When mean pupil sizes for both upper body and fingertip stimulation were averaged, similar measures were found for each body area stimulated.

When the adjusted means of male and female pupillometric responses were compared, females showed less response than males in regard to the body area stimulated and the type of yarn used in the test fabrics. The greatest response (.863 inches) was displayed by males using fingertips to evaluate the ring spun yarns, while the least response was evident in the reaction of the females' upper body to fabrics containing ring spun yarns (see table 9). The fingertips of the female participants appeared to be more sensitive indicators of stimulus sensation than did the upper body, especially in the case of ring spun yarns. Male sensitivity, however, also was greatest for the fingertips when ring spun yarns were used, and for the upper body when open-end spun yarns were tested. These results are presented graphically in figure 16.

McKinney and Broome (48) and Schumann (62) allude to a harsher and rougher hand for open-end spun yarns. As may be expected then, more reaction would result from the open-end yarn fabrics, but this was the case only for female upper body stimulation. Ring spun yarns elicited

TABLE 8

ADJUSTED MEANS FOR PUPILLOMETRIC RESPONSES OF ALL PARTICIPANTS TO TYPE OF YARN ACCORDING TO BODY AREA STIMULATED

Yarn Type	Mean Pupil Size (inches)*	
	Upper Body	Fingertips
Ring Spun	.825	.854
Open-end Spun	.837	.837

*Pupil size as indicated by the Vanguard Motion Analyzer.

TABLE 9

ADJUSTED MEANS FOR MALE AND FEMALE PUPILLOMETRIC RESPONSES TO YARN TYPE ACCORDING TO BODY AREA STIMULATED

Body Area Stimulated	Mean Pupil Size (inches)*			
	Ring Spun Yarns		Open-end Spun Yarns	
	Male	Female	Male	Female
Upper Body	.854	.807	.847	.835
Fingertips	.863	.849	.843	.836

*Pupil size as indicated by the Vanguard Motion Analyzer.

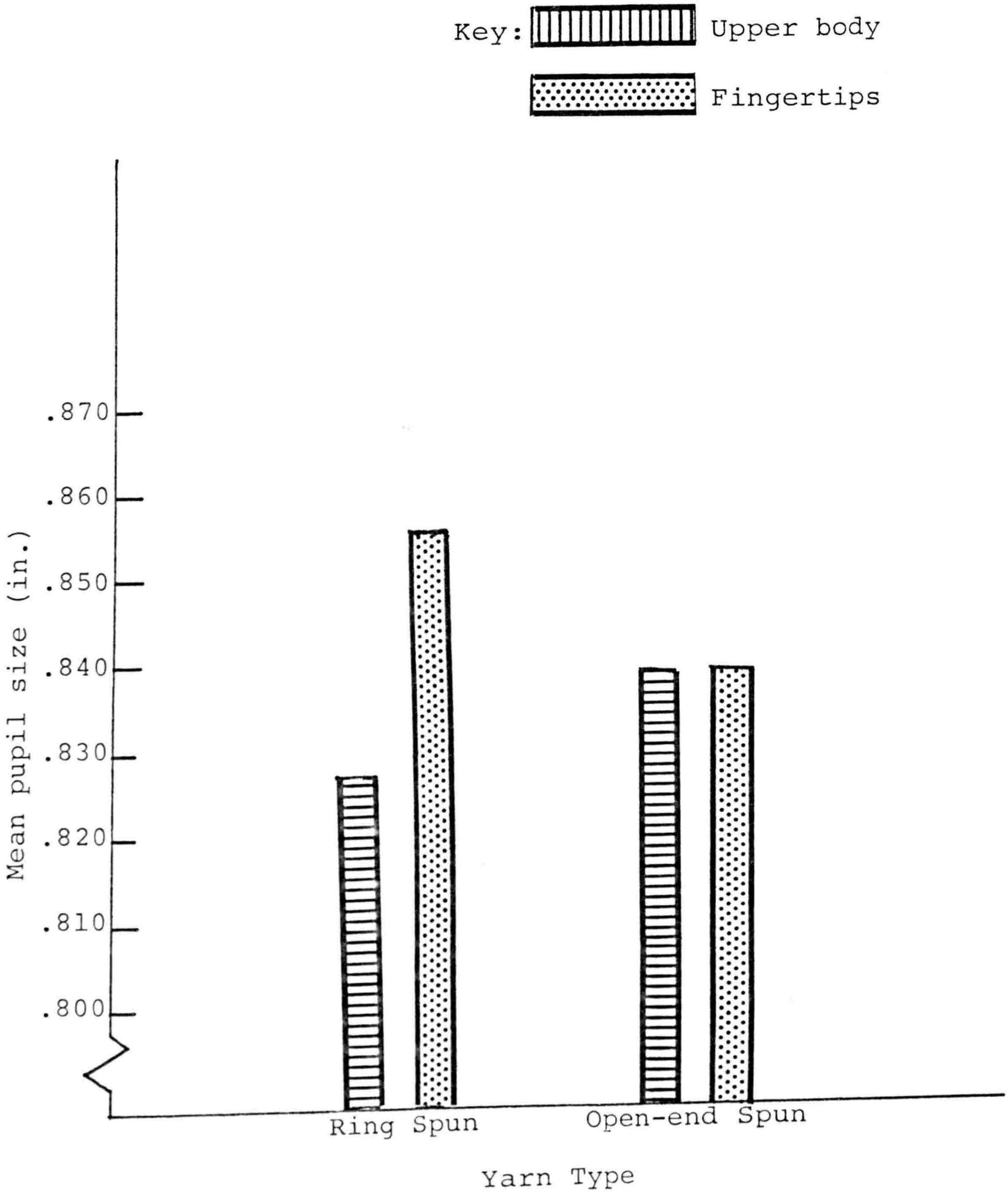


Fig. 15. Adjusted means for pupillometric responses of all participants to type of yarn according to body area stimulated.

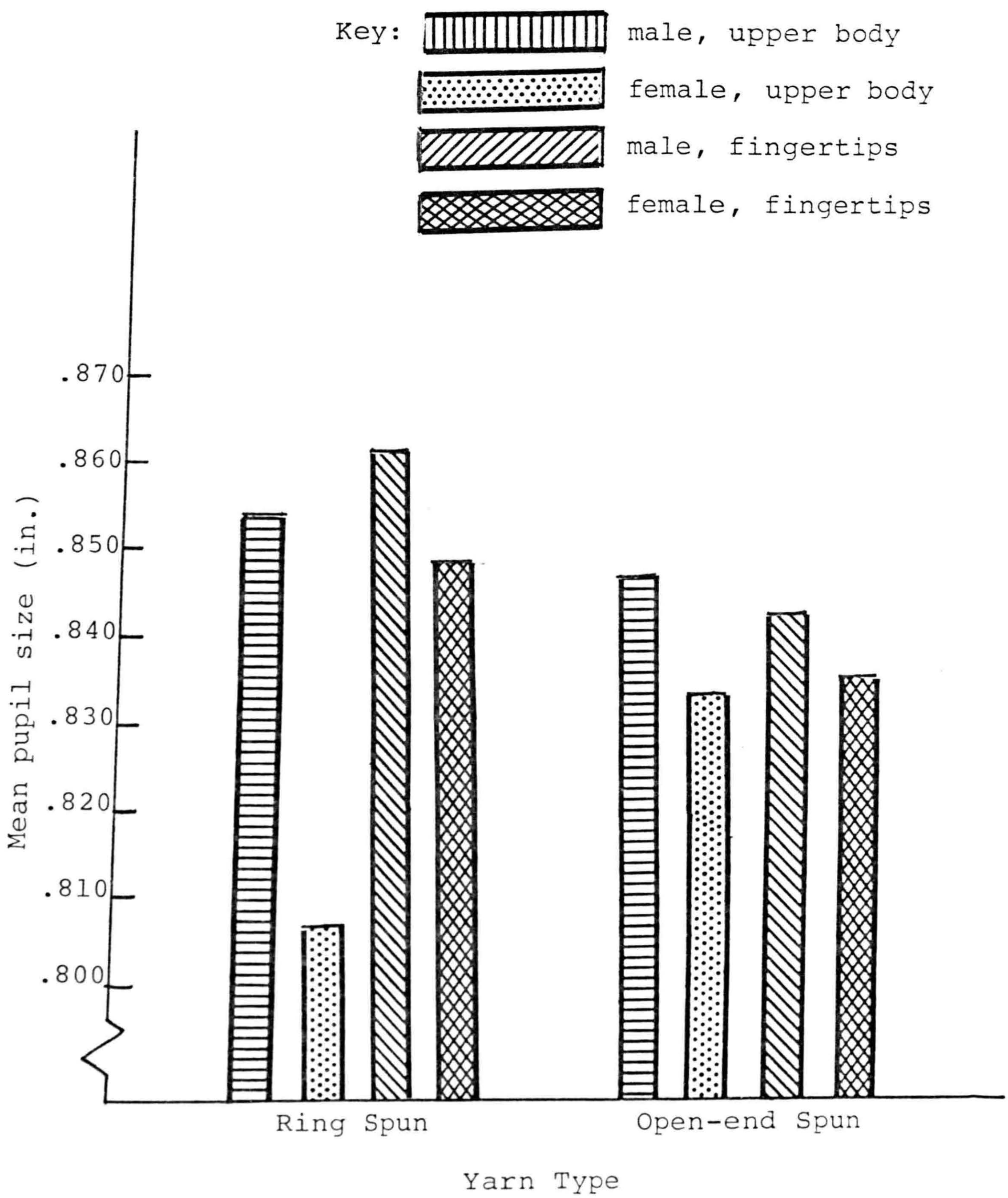


Fig. 16. Adjusted means for male and female pupillometric responses to yarn type according to body area stimulated.

more reaction for both male upper body and fingertip stimulation and for female fingertip stimulation.

According to results of the analysis of covariance, as tabulated in table 10, there was no significant effect for the body area stimulated or for the type of yarn used in the experimental fabrics. The interaction effect of the area of the body stimulated and the type of yarn used, however, was highly significant at the $\alpha = 0.01$ level.

Skin Conductance Assessment

Skin conductance data were obtained by measuring responses of the participants to the experimental garments and swatches through the relative activity between two electrode/electrolyte junctions located on the palm of each participant's right hand. Measurements were made with a dynograph and the amount of skin conductance response was recorded in micromho units. Analyses were based on changes between the last one-half second before stimulation and the highest peak during the 10-second stimulus period. The means of these pre-test and during test measurements for each participant are found in the Appendix in tables 38 through 43.

A total of 640 measurements from the 32 participants was used to determine skin conductance change in response to the fiber content, fiber length, and yarn type

TABLE 10

SUMMARY OF ANALYSIS OF COVARIANCE FOR PUPILLOMETRIC RESPONSES TO YARN TYPE

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-Ratio	Probability
Area of Body Stimulated (Upper body vs. fingers)	1	2309.835	2309.835	1.13	.299
Pretest	1	70614.145	70614.145	34.53	
Error	24	49084.730	2045.197		
Type of Yarn (Fabrics C, D)	1	146.158	146.158	.09	.768
Pretest	1	54827.908	54827.908	33.46	
Error	24	39325.678	1638.570		
Area of Body Stimulated x Type of Yarn	1	4662.917	4662.917	7.75	.010*
Pretest	1	18036.101	18036.101	29.97	
Error	24	14442.525	601.772		

*Significant at $\alpha = 0.01$ level.

of the experimental fabrics. Mean data of the skin conductance responses according to fiber content, fiber length, and yarn type are presented in tables 11, 14, and 17. Illustrative displays in the form of bar graphs are also included (see figures 17, 19, and 21). This information embodies a combination of both male and female responses that were analyzed, in addition, to determine differences between sexes. These are shown in tabular form (tables 12, 15, and 18) and graphically in figures 18, 20, and 22. Results of the analysis of covariance can be found in tables 13, 16, and 19.

Skin Conductance Responses to Fiber Content

Table 11 presents the adjusted mean skin conductance measurements for both male and female participants in relation to fiber content and body area stimulated. The upper body area responded to a greater extent (12.389 micromhos) to the 55/45 wool-cotton blend while the least response (12.136 micromhos) was caused by the 40/60 wool-cotton fabric. Fingertip response, however, was greatest for the 40/60 wool-cotton blend and least for the fabric with the smallest amount of wool (25 percent). Comparisons of body areas with regard to skin conductance response for the combined data of the male and female participants revealed similar reactions to both upper body and fingertip stimulation for the fabric specimens with the highest wool content (55 percent). These comparisons are presented in the graph shown in figure 17. Important differences were evident between responses which resulted from stimulation to the upper body and to the fingertips by the 40/60 wool-cotton fabric. The fingertips appeared to be more highly sensitive to the 40/60 wool-cotton blend while the upper body was slightly more sensitive to the experimental fabric with the lowest wool content (25 percent).

When comparing skin conductance responses of males and females to fiber content, the highest amplitudes recorded (12.8 micromhos) were in response to fingertip stimulation of males by the 40/60 wool-cotton fabric and to fingertip stimulation of females by the 55/45 wool-cotton blend (see table 12). Reactions from stimulation by the 25/75 wool-cotton fabric resulted in similar responses for both fingertip and upper body stimulation by males (12.1 micromhos) and by females (12.4 micromhos).

Table 13 depicts the results of the analysis of covariance with repeated measures for skin conductance response to fiber content. No significant effect was noted for the area of body stimulated, the fiber content, or the interaction between the area of body stimulated and the fiber content.

TABLE 11

ADJUSTED MEANS FOR SKIN CONDUCTANCE RESPONSES OF ALL PARTICIPANTS TO FIBER CONTENT ACCORDING TO BODY AREA STIMULATED

Fiber Content	Skin Conductance Response (micromhos)	
	Upper Body	Fingertips
55/45 Wool-Cotton	12.389	12.421
40/60 Wool-Cotton	12.136	12.598
25/75 Wool-Cotton	12.151	12.131

TABLE 12

ADJUSTED MEANS FOR MALE AND FEMALE SKIN CONDUCTANCE RESPONSES TO FIBER CONTENT ACCORDING TO BODY AREA STIMULATED

Body Area Stimulated	Skin Conductance Response (micromhos)					
	55/45 Wool-Cotton		40/60 Wool-Cotton		25/75 Wool-Cotton	
	Male	Female	Male	Female	Male	Female
Upper Body	12.7	12.3	12.3	12.2	12.1	12.4
Fingertips	12.2	12.8	12.8	12.6	12.1	12.4

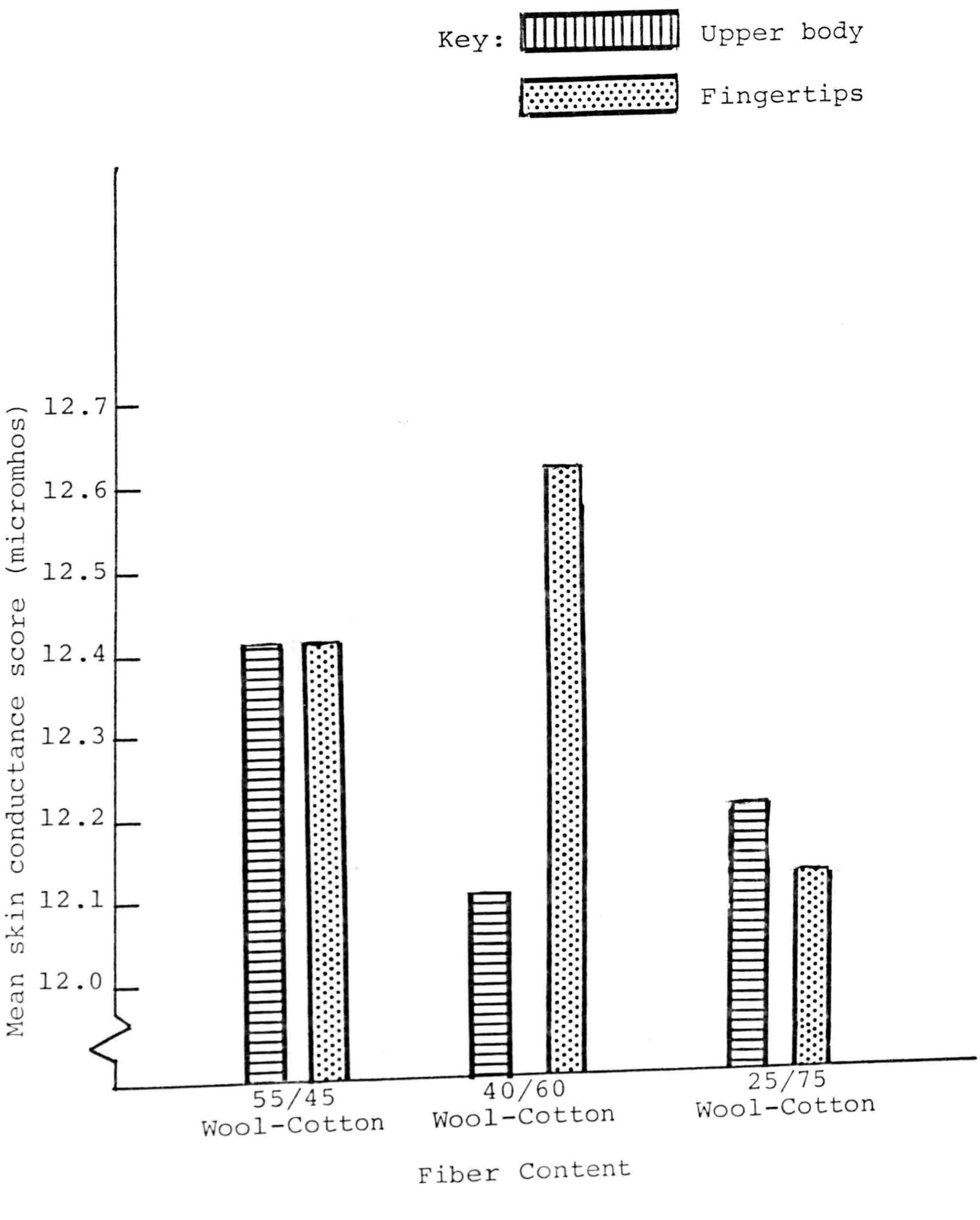


Fig. 17. Adjusted means for skin conductance responses of all participants to fiber content according to body area stimulated.

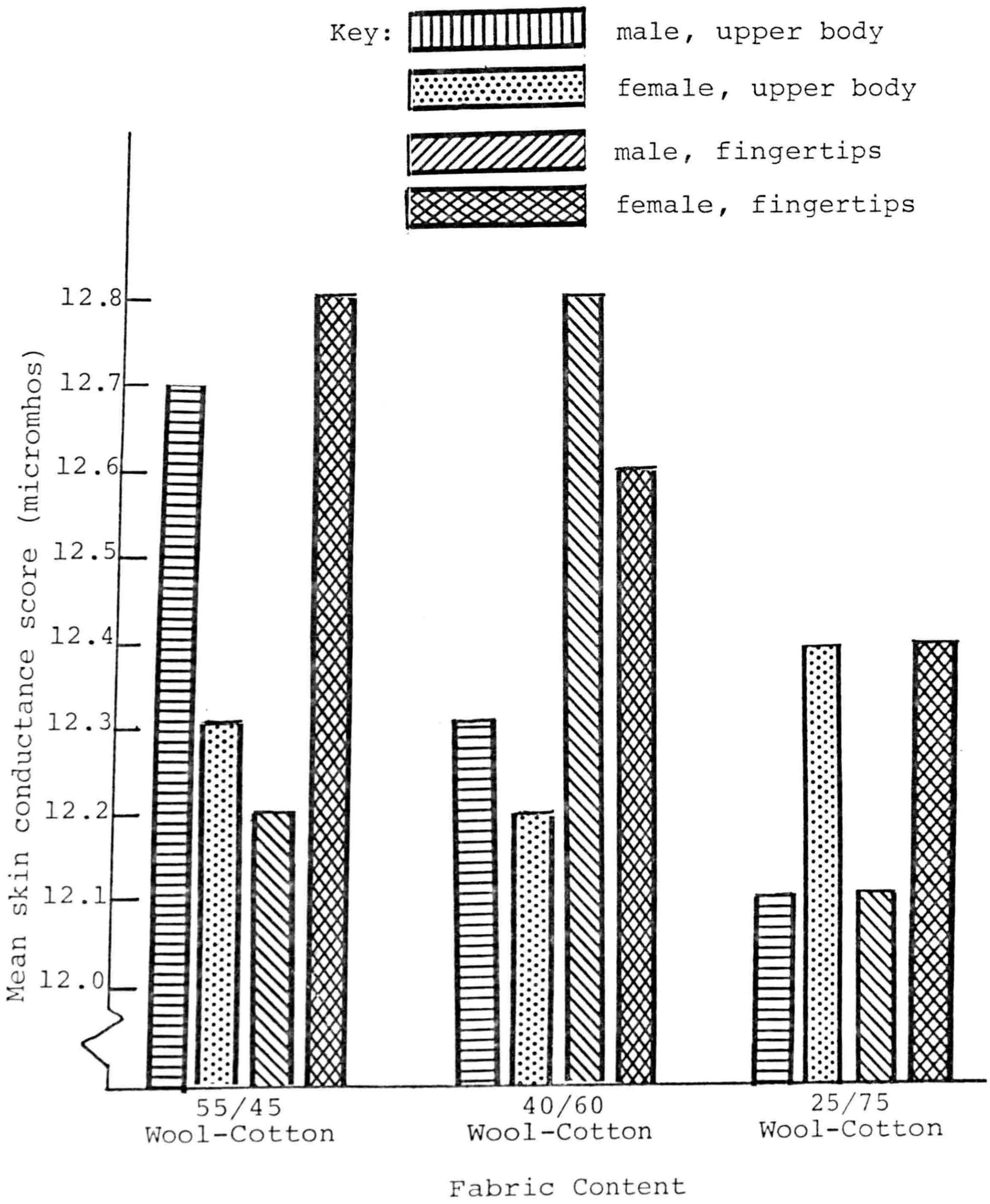


Fig. 18. Adjusted means for male and female skin conductance responses to fiber content according to body area stimulated

TABLE 13

SUMMARY OF ANALYSIS OF COVARIANCE FOR SKIN CONDUCTANCE RESPONSES TO FIBER CONTENT

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-Ratio	Probability
Area of Body Stimulated (Upper body vs. fingers)	1	.129	.129	.08	.775
Pretest	1	93.162	93.162	59.88	
Error	30	46.672	1.556		
Fiber Content (Fabrics A, C, E)	2	1.940	.970	.83	.442
Pretest	1	5.305	5.305	4.53	
Error	61	71.485	1.172		
Area of Body Stimulated x Fiber Content	2	3.382	1.691	1.70	.190
Pretest	1	.005	.005	.01	
Error	61	60.515	.992		

Skin Conductance Responses to Fiber Length

The adjusted mean skin conductance responses in relation to fiber length and body area stimulated are shown in table 14. The greatest amount of participant response (12.633 micromhos) appeared to be the result of the fingertip stimulation by the short (1.71 inches) wool fibers. The upper body stimulation by these short fibers provided similar (12.606 micromhos) results. Fingertip stimulation by the fabric containing the long wool fibers (3.38 inches) produced a higher amplitude (12.479 micromhos) than was produced by the upper body stimulation (12.283 micromhos) as shown graphically in figure 19.

The adjusted means associated with male and female skin conductance responses to fiber length according to body area stimulated is given in table 15. Observation of table 15 and figure 20 reveals that the greatest values were in response to the short fibers. Responses of the two sexes were very similar when the upper body was sensitized by means of the fabrics with the longer wool fibers (3.38 inches). Females responded to both fiber lengths to a greater extent than did males when fingertips were stimulated.

Results of an analysis of covariance with repeated measures for skin conductance response to fiber length, as

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TABLE 14

ADJUSTED MEANS FOR SKIN CONDUCTANCE RESPONSES OF ALL PARTICIPANTS TO FIBER LENGTH ACCORDING TO BODY AREA STIMULATED

Fiber Length	Skin Conductance Response (micromhos)	
	Upper Body	Fingertips
1.71 inches (wool)	12.606	12.633
3.38 inches (wool)	12.283	12.479

TABLE 15

ADJUSTED MEANS FOR MALE AND FEMALE SKIN CONDUCTANCE RESPONSES TO FIBER LENGTH ACCORDING TO BODY AREA STIMULATED

Body Area Stimulated	Skin Conductance Response (micromhos)			
	1.71 inches		3.38 inches	
	Male	Female	Male	Female
Upper Body	12.731	12.293	12.155	12.195
Fingertips	12.247	12.802	12.286	12.494

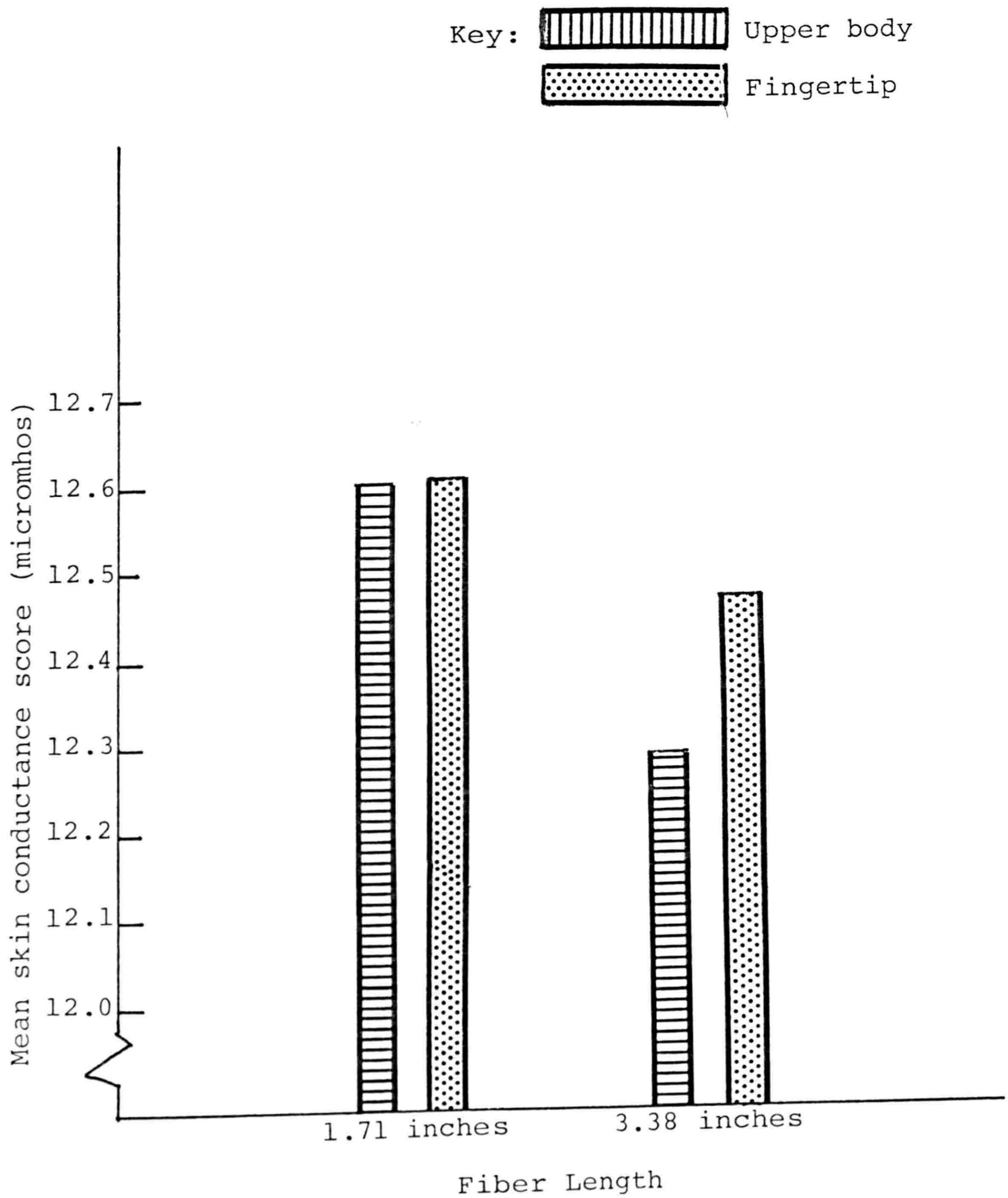

Fig. 19. Adjusted means for skin conductance responses of all participants to fiber length according to body area stimulated

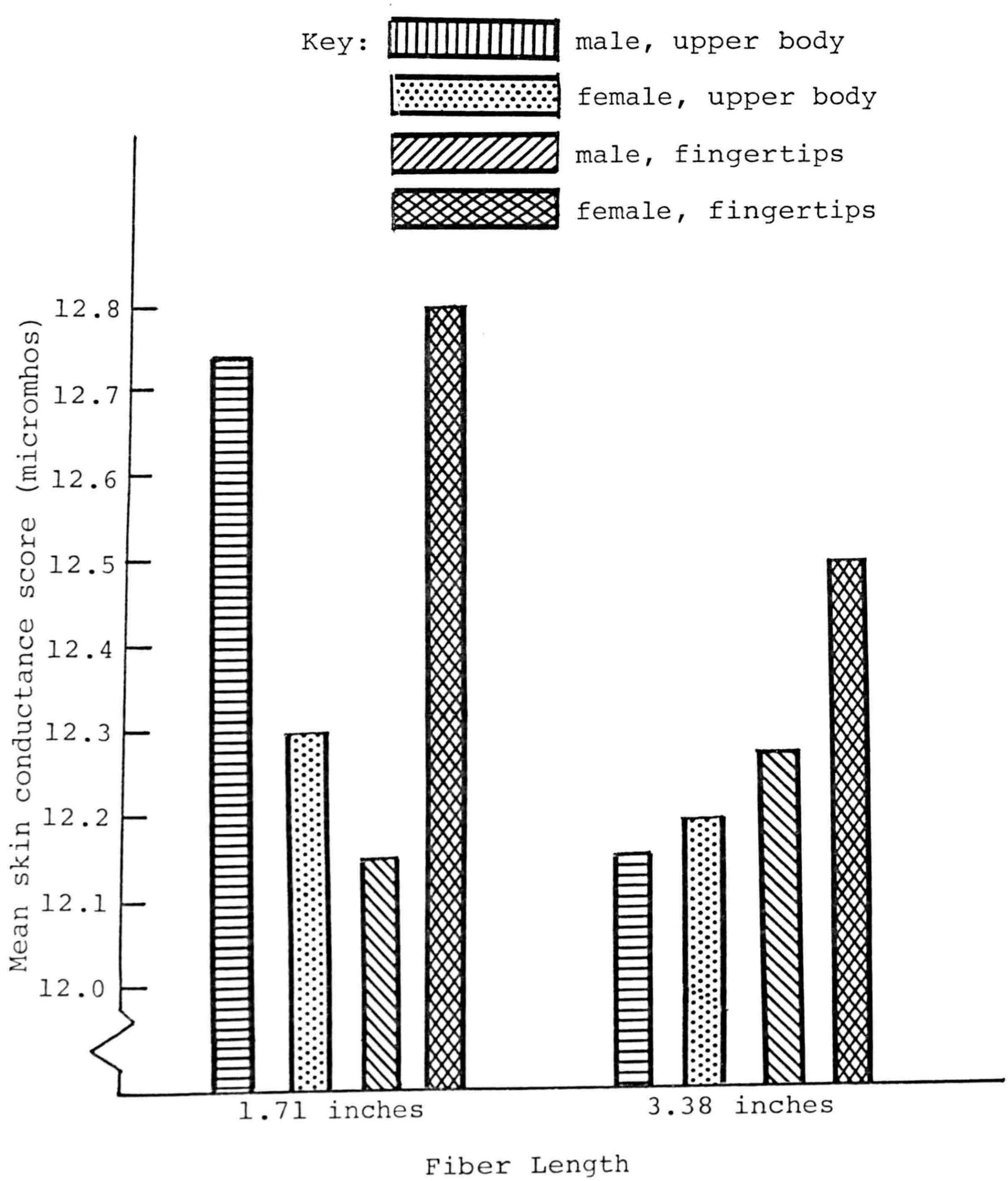

Fig. 20. Adjusted means for male and female skin conductance responses to fiber length according to body area stimulated.

shown in table 16, revealed no significant effects. This finding indicates that use of the upper body is not different from that of the fingertips in predicting acceptance of fabrics based on the length of fibers used in yarn construction as measured by the electrodermal activity of the skin.

Skin Conductance Responses to Type of Yarn

The adjusted mean skin conductance measurements in relation to type of yarn and body area stimulated are shown in table 17. The fingertips displayed a greater sensitivity to both ring and open-end spun yarns than did the upper body. When the responses to the two types of yarn were compared as to upper body and fingertip stimulation, ring spun yarns elicited more response than did the open-end spun yarns (see figure 21).

Comparisons between the adjusted means for male and female skin conductance responses to type of yarn according to body area stimulated are shown in table 18. The greatest skin response was attributed to fingertip stimulation of males by the ring spun yarns, while the least was associated with male fingertip stimulation by the open-end spun yarns. The graph displayed in figure 22 indicates that overall the ring spun yarns elicited a greater degree of response than did the open-end spun yarns.

TABLE 16

SUMMARY OF ANALYSIS OF COVARIANCE FOR SKIN CONDUCTANCE RESPONSES TO FIBER LENGTH

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-Ratio	Probability
Area of Body Stimulated (Upper body vs. fingers)	1	.828	.828	.60	.444
Pretest	1	91.291	91.291	66.24	
Error	30	41.348	1.378		
Fiber Content (Fabrics A, B)	1	1.198	1.198	2.51	.123
Pretest	1	59.906	59.906	125.71	
Error	30	14.297	.477		
Area of Body Stimulated X Fiber Content	1	.220	.220	.48	.494
Pretest	1	39.056	39.056	85.25	
Error	30	13.743	.458		

TABLE 17

ADJUSTED MEANS FOR SKIN CONDUCTANCE RESPONSES OF ALL PARTICIPANTS TO TYPE OF YARN ACCORDING TO BODY AREA STIMULATED

Yarn Type	Skin Conductance Response (micromhos)	
	Upper Body	Fingertips
Ring Spun	12.184	12.635
Open-end Spun	12.074	12.167

TABLE 18

ADJUSTED MEANS FOR MALE AND FEMALE SKIN CONDUCTANCE RESPONSES TO TYPE OF YARN ACCORDING TO BODY AREA STIMULATED

Body Area Stimulated	Skin Conductance Response (micromhos)			
	Ring Spun Yarns		Open-end Spun Yarns	
	Male	Female	Male	Female
Upper Body	12.280	12.211	12.219	12.062
Fingertips	12.835	12.616	11.968	12.515

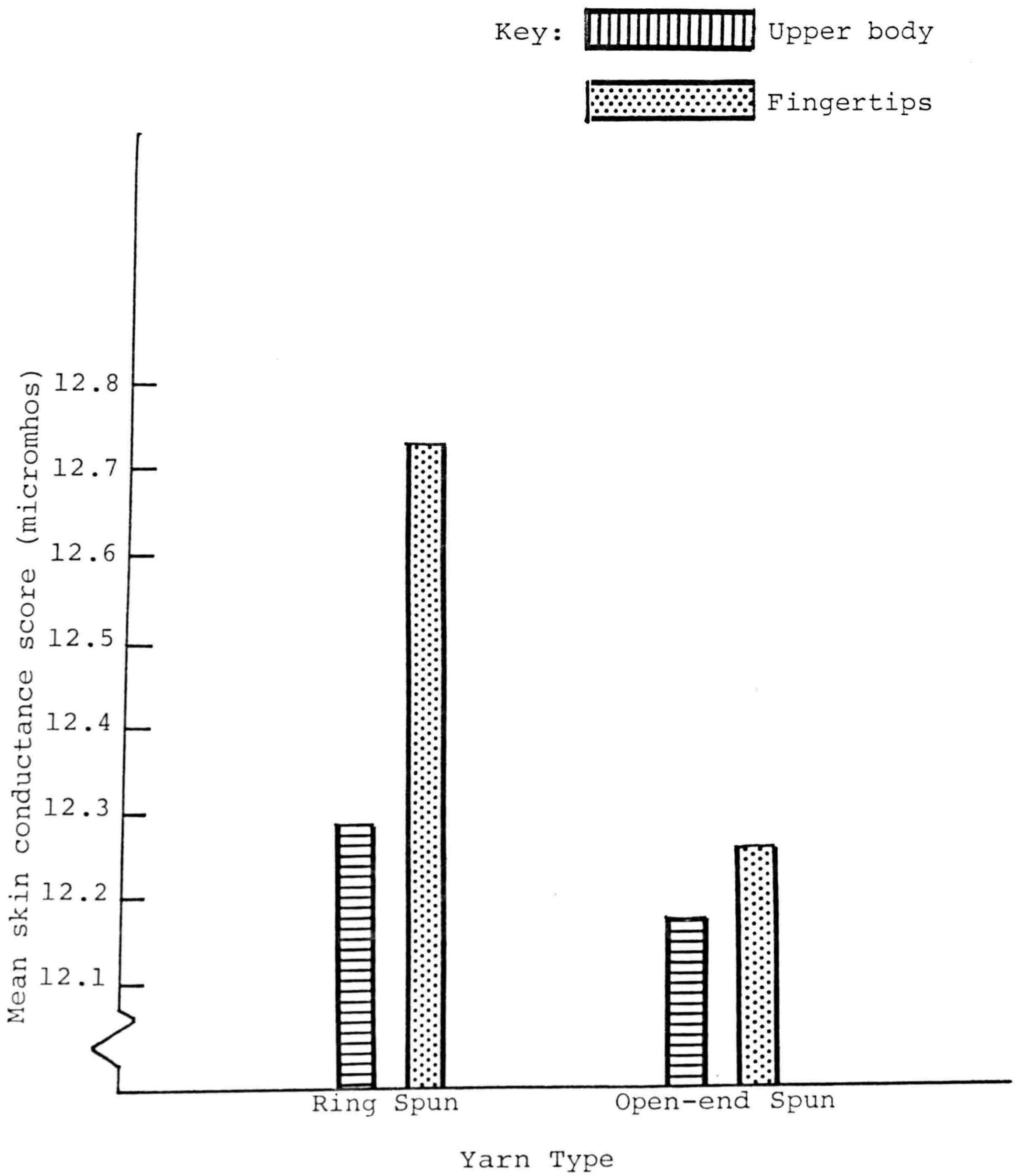

Fig. 21. Adjusted means for skin conductance responses of all participants to type of yarn according to body area stimulated.

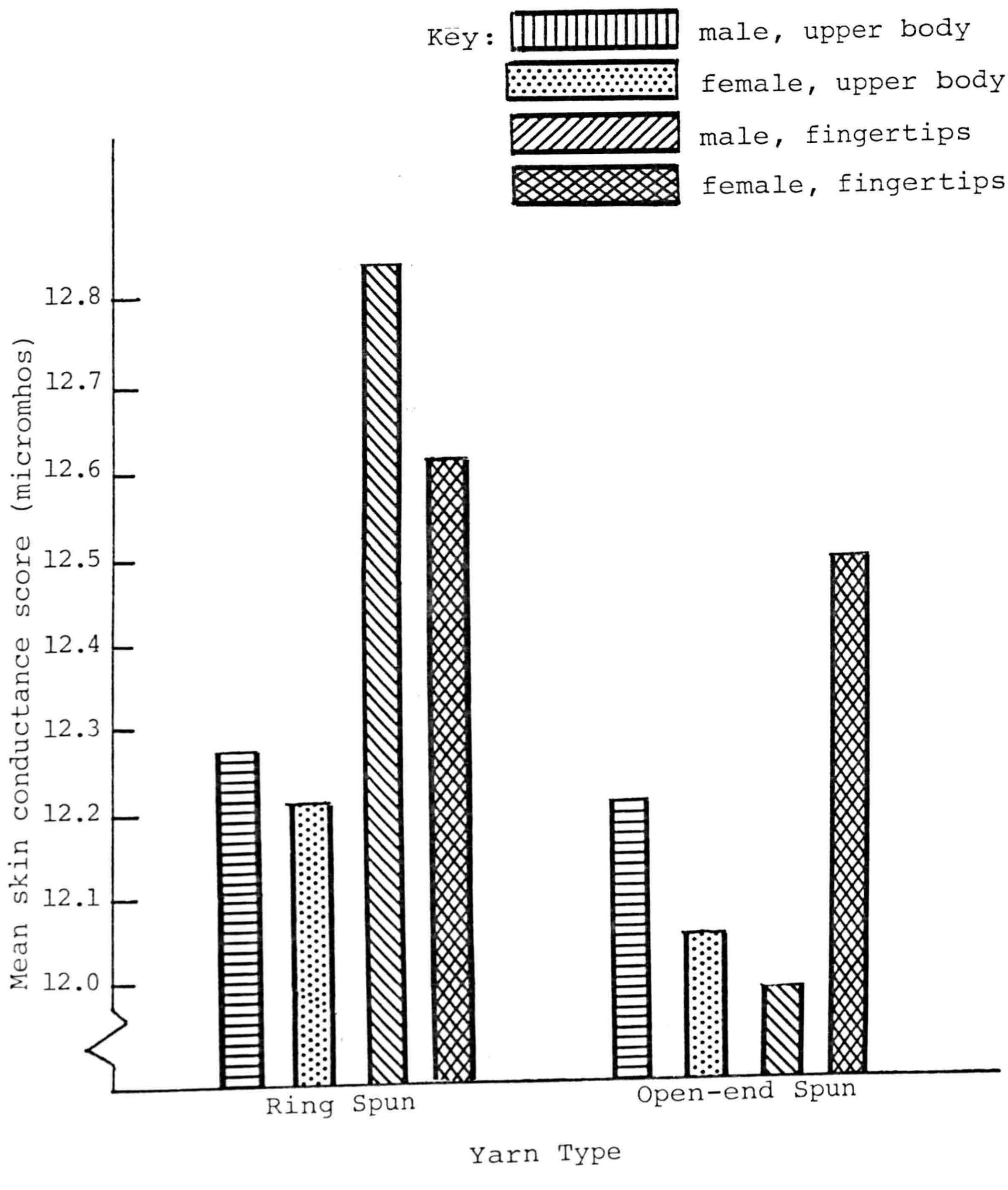

Fig. 22. Adjusted means for male and female skin conductance responses to type of yarn according to body area stimulated.

When an analysis of covariance with repeated measures was used to test for significant effects of areas of body stimulated and types of yarn on the skin conductances responses, the information in table 19 resulted. These results revealed no significant effects on skin responses at the $\alpha = 0.05$ level in regard to the area of body stimulated, the type of yarn used, or the interaction between area of body stimulated and type of yarn.

Subjective Assessment

Subjective data were obtained from the participants who rated the acceptability of the experimental fabrics for a shirt according to the scale shown in figure 7. As the test fabrics, representing differences in fiber content, fiber length, and type of yarn were presented to each participant a screen was used to prevent the participant from viewing the specimens. After being asked to feel the fabric with the fingers, to rub it between the palms, and to pull it over the arms, participants ranked the experimental fabrics according to the following scale:

5 = most acceptable

4 = above average acceptability

3 = average acceptability

2 = below average acceptability

1 = not acceptable

TABLE 19

SUMMARY OF ANALYSIS OF COVARIANCE FOR SKIN CONDUCTANCE RESPONSES TO TYPE OF YARN

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-Ratio	Probability
Area of Body Stimulated (Upper body vs. fingers)	1	2.314	2.314	1.71	.201
Pretest	1	76.198	76.198	56.17	
Error	30	40.695	1.357		
Type of Yarn (Fabrics C, D)	1	.014	.014	.01	.922
Pretest	1	.306	.306		
Error	30	43.789	1.460		
Area of Body Stimulated x Fiber Content	1	.056	.056	.04	.837
Pretest	1	.029	.029	.02	
Error	30	38.887	1.296		

Mean subjective ratings for each fabric type by each participant are found in tables 44, 45, and 46 in the Appendix. Tables 20, 23, and 26 of the text depict the mean subjective scores representative of the effects of fiber content, fiber length, and type of yarn, respectively, while tables 21, 24, and 27 show a comparison of the male and female subjective responses related to these fabric types. The mean data, displayed graphically, for overall means and male-female comparisons are represented in figures 23 through 28. Results of the analysis of variance with repeated measures for subjective assessment of fiber content, fiber length, and type of yarn are found in tables 22, 25, and 28.

Subjective Responses to Fiber Content

The mean subjective assessment ratings associated with the fiber content of the experimental fabrics are presented in table 20. These data show that the 25/75 wool-cotton blend received a higher rating (3.593) than the 55/45 wool-cotton fabric (3.500) indicating more acceptability by the participants. The lowest personal opinion rating (3.125) was received by the 40/60 wool-cotton fabric. These responses are displayed graphically in figure 23.

The mean male and female subjective responses to fiber content are reported in table 21. These data show

TABLE 20

MEAN SUBJECTIVE RATINGS OF ALL PARTICIPANTS FOR FIBER CONTENT

Fiber Content	Rating
55/45 Wool-Cotton	3.500
40/60 Wool-Cotton	3.125
25/75 Wool-Cotton	3.593

TABLE 21

MEANS FOR MALE AND FEMALE SUBJECTIVE RATINGS FOR FIBER CONTENT

Fiber Content	Rating	
	Male	Female
55/45 Wool-Cotton	3.267	3.705
40/60 Wool-Cotton	3.000	3.235
25/75 Wool-Cotton	3.666	3.529

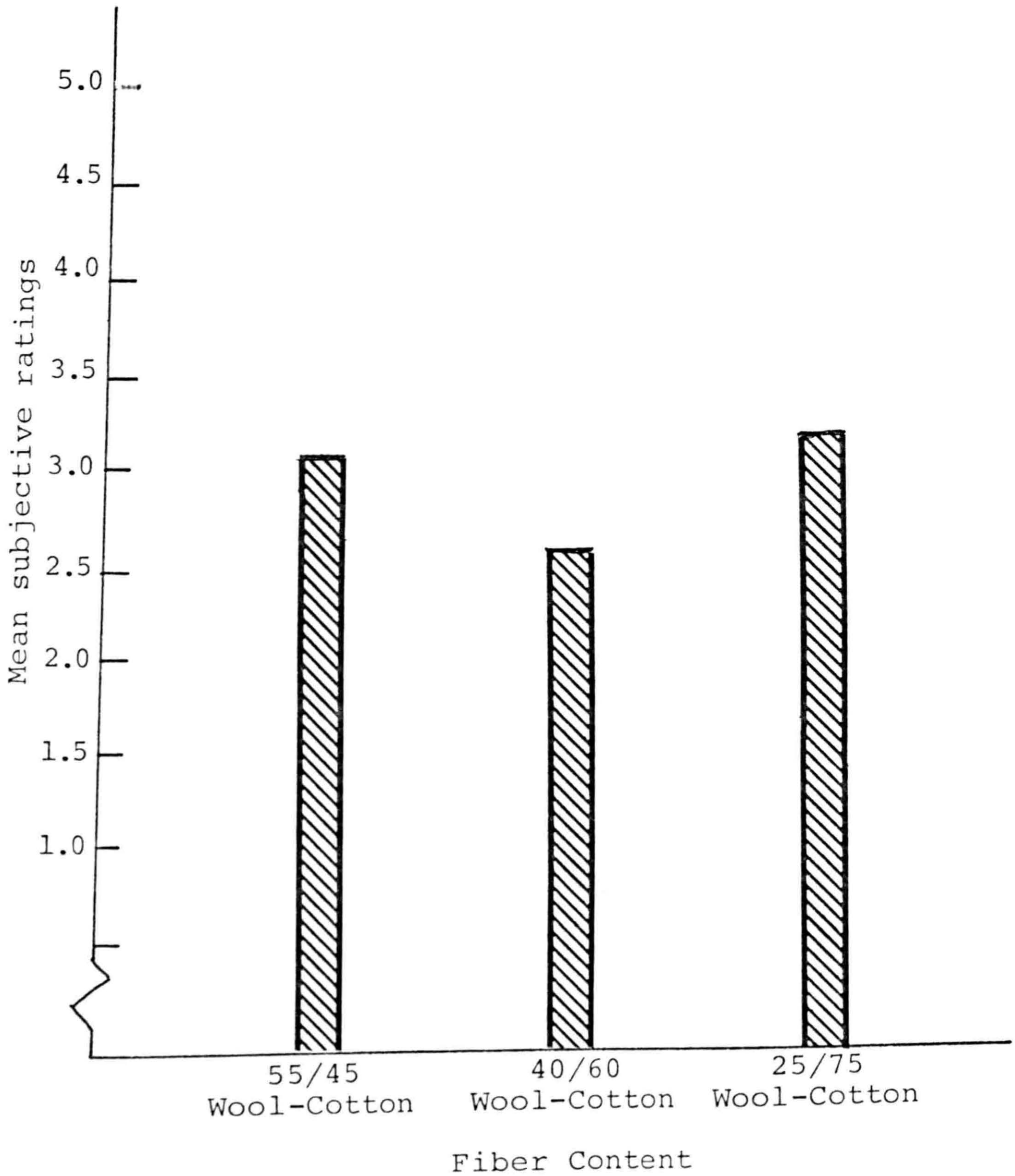

Fig. 23. Means for subjective ratings by all participants for fiber content.

that males gave higher ratings to the 25/75 wool-cotton specimens while females rated the 55/45 wool-cotton fabrics highest. Both groups gave the 40/60 wool-cotton blend the lowest rating. The relationships of males and female subjective responses to fiber content are presented in figure 24.

Table 22 displays results of the analysis of variance with repeated measures for subjective assessment of fiber content. With an F-value of 2.50, these results approached significance with a probability of $\alpha = 0.09$ but failed to measure up to the $\alpha = 0.05$ level set as the level of significance for this study. Fiber content, therefore, did not significantly affect the acceptability of the fabrics for shirts.

Subjective Responses to Fiber Length

Table 23 depicts the mean subjective responses of the participants as to the acceptability of the fabric specimens according to fiber length. As may be noted, the fabric containing the shorter wool fibers (1.71 inches) was more acceptable to the participants than the one with the longer wool fibers (3.38 inches). This information is shown in graph form in figure 25.

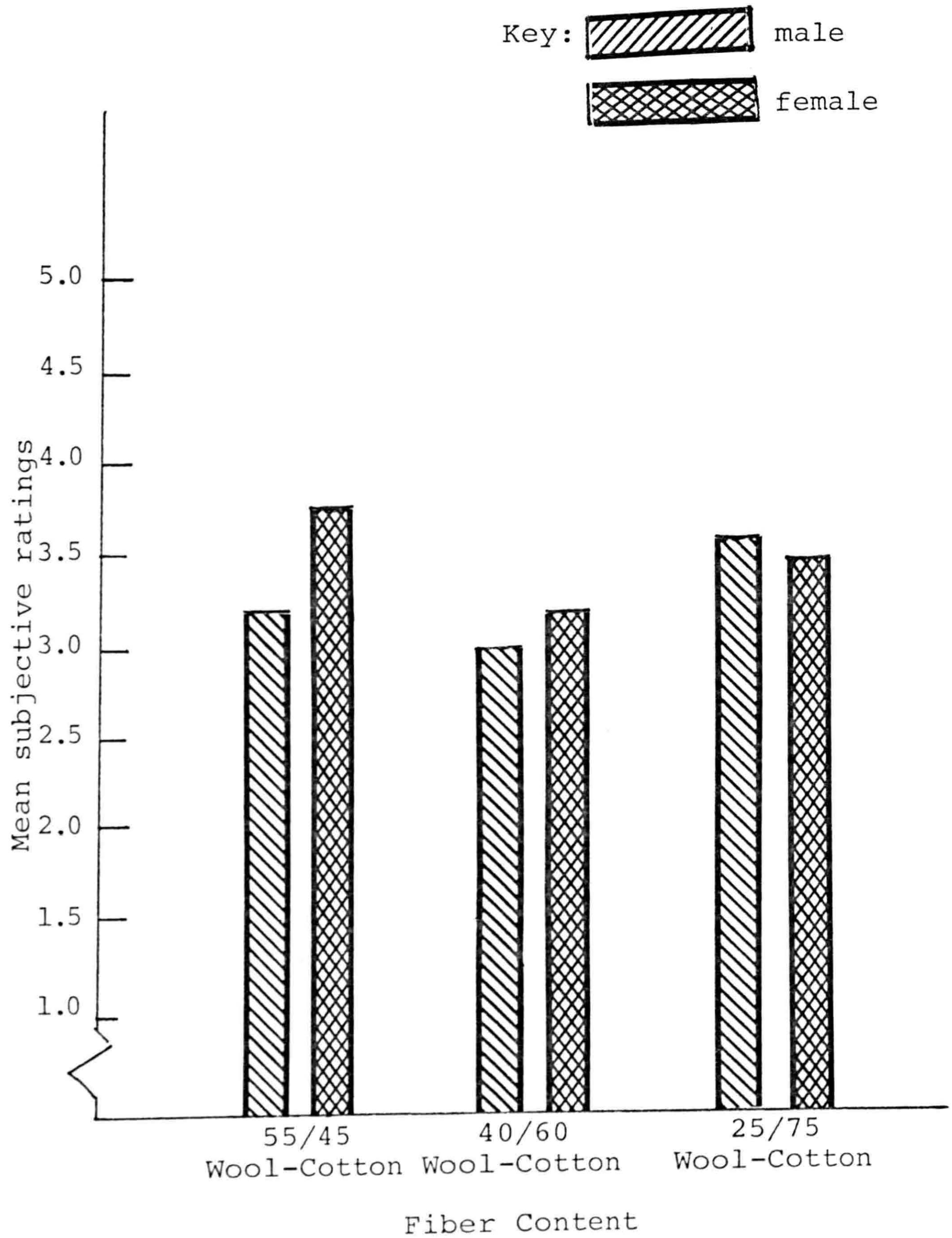

Fig. 24. Means for male and female subjective ratings for fiber content.

TABLE 22

SUMMARY OF ANALYSIS OF VARIANCE FOR SUBJECTIVE ASSESSMENT OF FIBER CONTENT

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-Ratio	Probability
Fiber Content	2	3.938	1.969	2.50	.090
Error	62	48.729	.786		

Comparisons between male and female participants showed that female participants gave a substantially higher subjective rating to the short fibers, while the longer fibers were evaluated similarly by both groups. This information is shown numerically in table 24 and graphically in figure 26.

Table 25 reveals results of the analysis of variance with repeated measures that shown an F-value of 5.74 which is significant at the $\alpha = 0.02$ level. This indicates that when the scores resulting from male and female assessment were pooled and compared for each of the two fabrics representative of fiber length, the shorter wool fibers (1.71 inches) were significantly more acceptable than were the longer ones.

Subjective Responses
to Type of Yarn

Ring spun yarns with a mean rating of 3.125 as compared to 2.375 for open-end spun yarns, were preferred by the participants as indicated in table 26 and figure 27. Table 27 shows that both males and females preferred the ring spun yarns over the open-end spun yarns with females showing greater acceptability than males for both types of yarns (see figure 28).

The results of the analysis of variance with repeated measures shown in table 28 indicates that the

TABLE 23

MEAN SUBJECTIVE RATINGS OF ALL PARTICIPANTS FOR FIBER LENGTH

Fiber Length	Rating
1.71 inches (wool)	3.500
3.38 inches (wool)	3.030

TABLE 24

MEANS FOR MALE AND FEMALE SUBJECTIVE RATINGS FOR FIBER LENGTH

Fiber Length	Rating	
	Male	Female
1.71 inches (wool)	3.267	3.705
3.38 inches (wool)	3.067	3.000

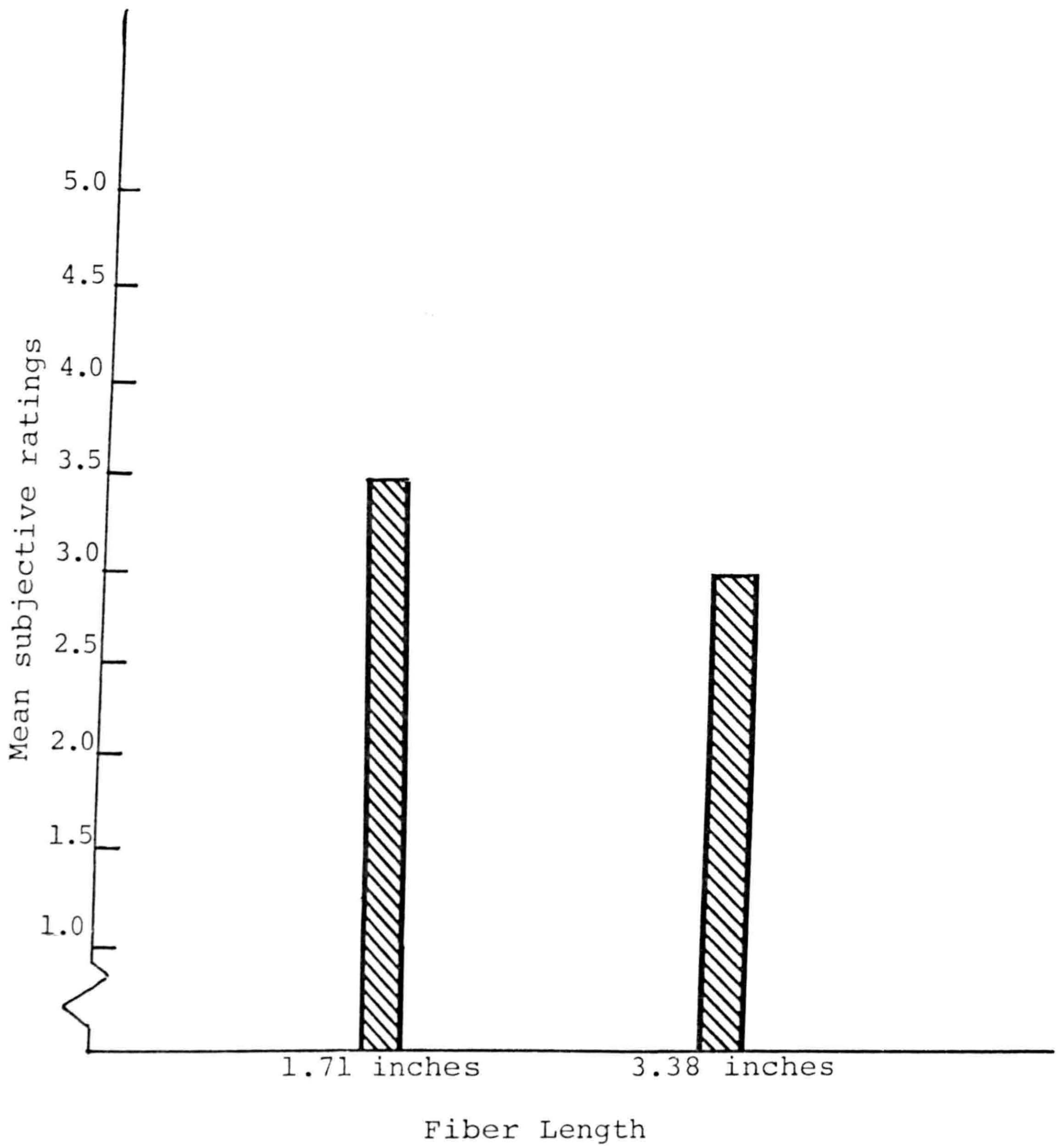

Fig. 25. Means for subjective ratings by all participants for fiber length.

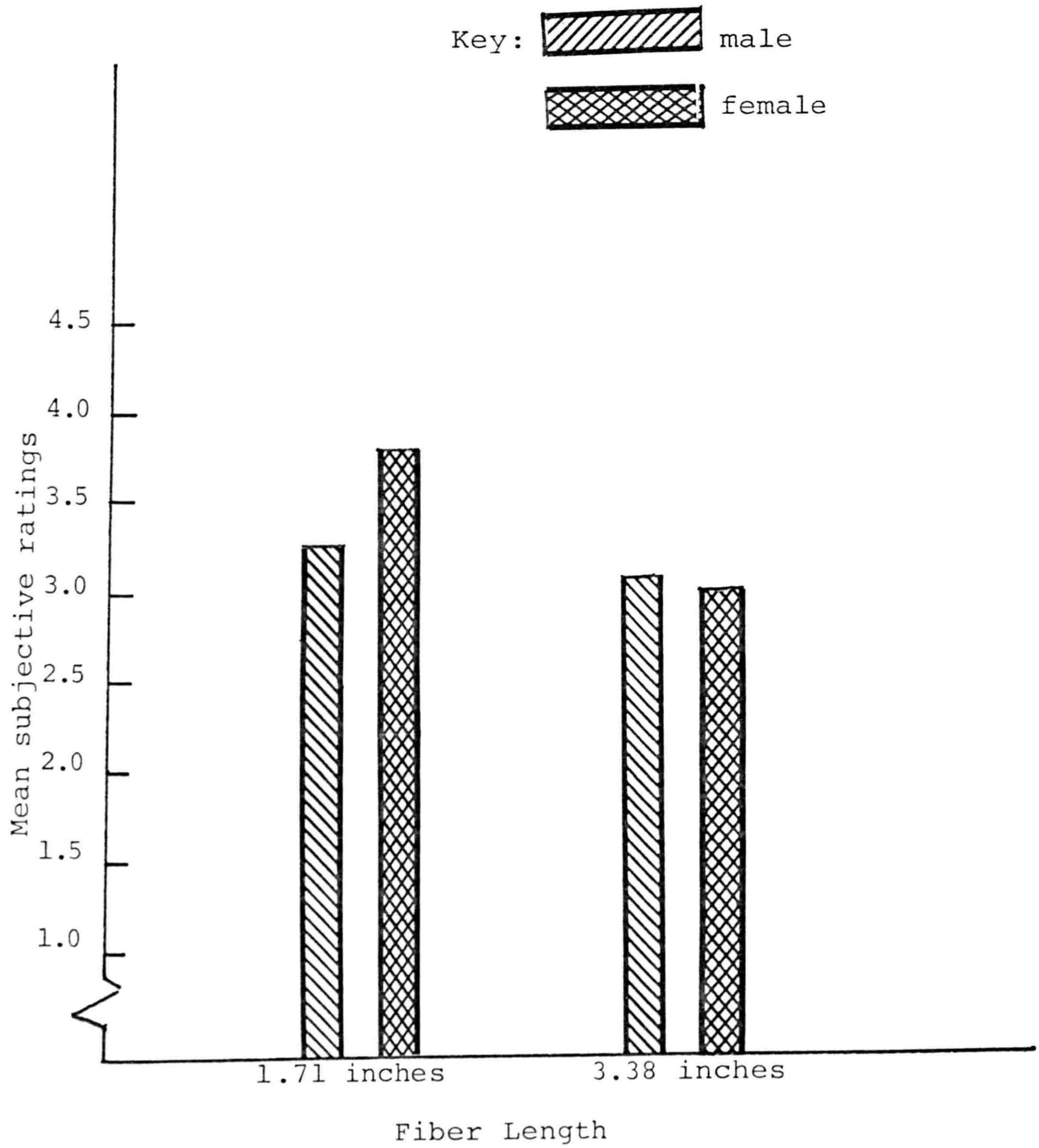

Fig. 26. Means for male and female subjective ratings for fiber length

TABLE 25

SUMMARY OF ANALYSIS OF VARIANCE FOR SUBJECTIVE ASSESSMENT OF FIBER LENGTH

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-Ratio	Probability
Fiber Length	1	3.516	3.516	5.74	.023*
Error	31	18.984	.612		

*Indicates significance at $\alpha = 0.05$ level.

TABLE 26

MEAN SUBJECTIVE RATINGS OF ALL PARTICIPANTS FOR TYPE OF YARN

Type of Yarn	Rating
Ring Spun	3.125
Open-end Spun	2.375

TABLE 27

MEANS FOR MALE AND FEMALE SUBJECTIVE RATINGS FOR TYPE OF YARN

Type of Yarn	Rating	
	Male	Female
Ring Spun	3.000	3.235
Open-end Spun	2.133	2.588

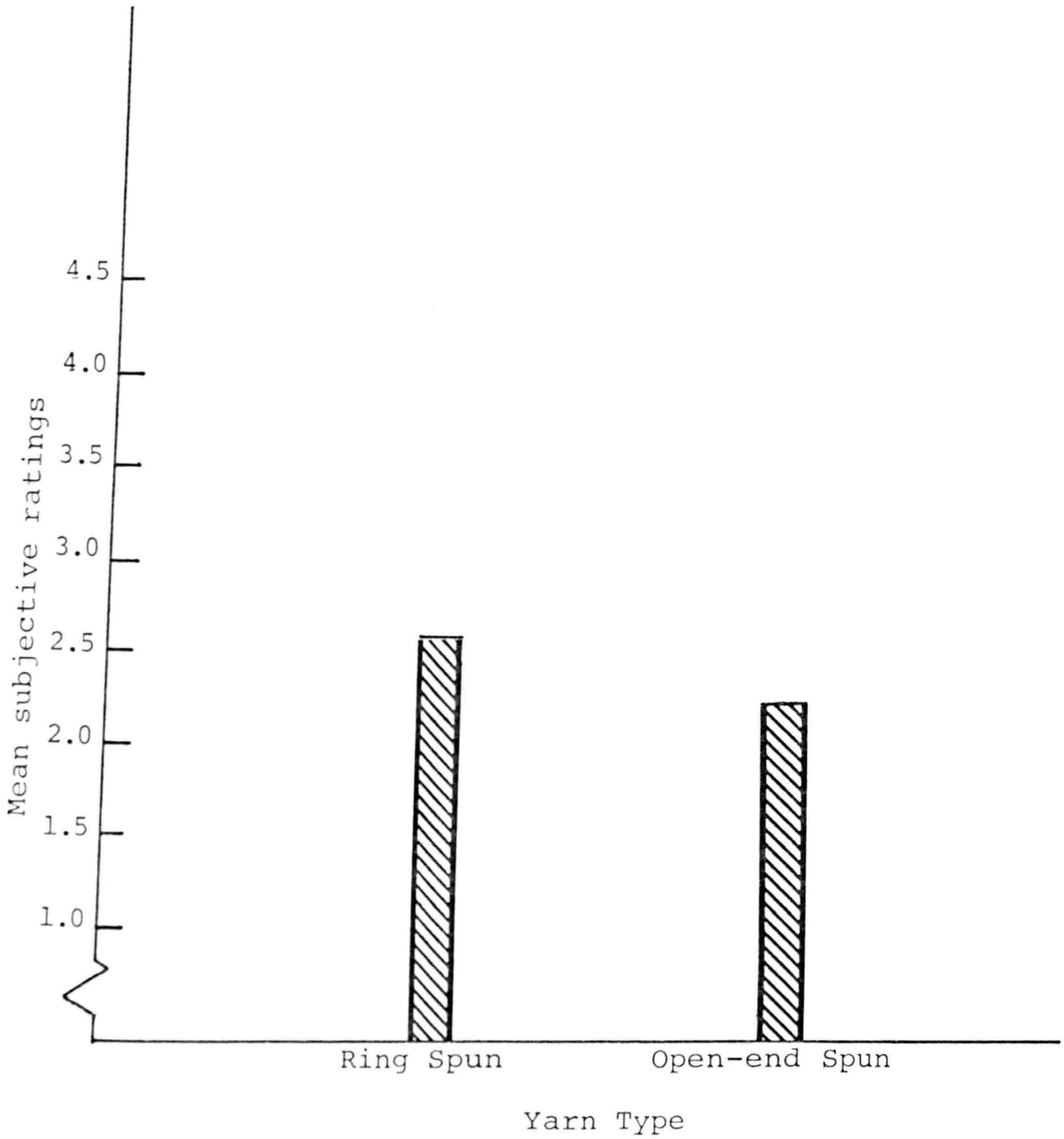

Fig. 27. Means for subjective ratings by all participants for type of yarn.

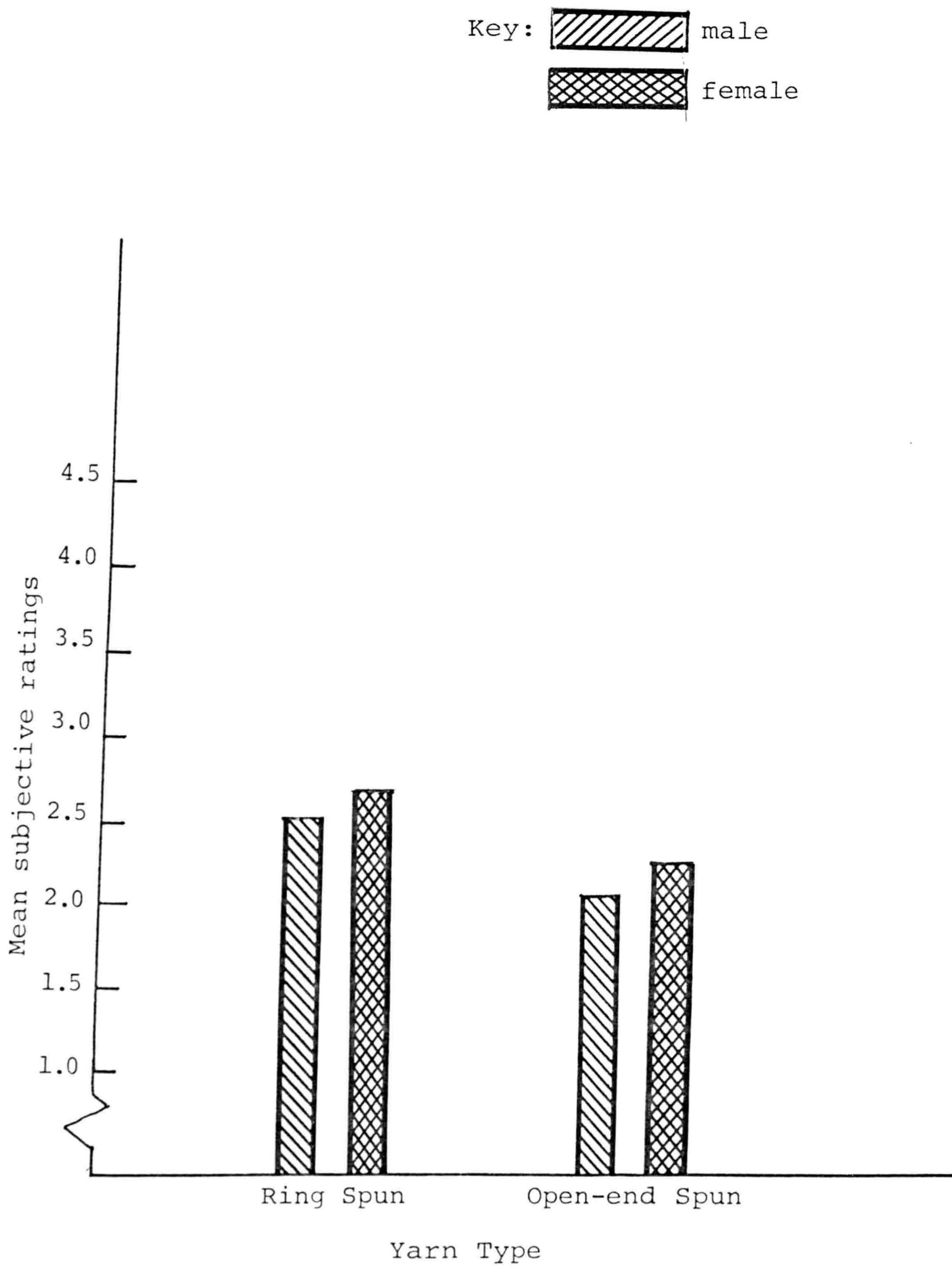

Fig. 28. Means for male and female subjective ratings for type of yarn.

TABLE 28

SUMMARY OF ANALYSIS OF VARIANCE FOR SUBJECTIVE ASSESSMENT FOR TYPE OF YARN

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-Ratio	Probability
Type of yarn	1	9.000	9.000	14.68	.001*
Error	31	19.000	.613		

*Significant at $\alpha = 0.001$ level.

subjective assessment showing acceptability of the type of yarn used in fabrics for shirts is highly significant at the $\alpha = 0.001$ level. This means that when all data for male and female participants were compared for each of the two fabrics representing different types of yarn, the ring spun yarns were significantly more acceptable than the open-end spun yarns.

Correlation of Pupillometric, Skin Conductance, and Subjective Assessments

The Pearson product-moment correlation analysis was performed to determine the degree of association among pupillometric, skin conductance, and subjective assessments. Results of correlation analyses associated with fiber content, fiber length, and type of yarn are located in the Appendix in tables 47, 48, and 49.

When pupillometric, skin conductance, and subjective responses were correlated with regard to fiber content, a signficant positive relationship was found ($\alpha = 0.05$) between the pupillometric and skin conductance measures for both the 55/45 and 40/60 wool-cotton blends when the upper body was used as the stimulus receptor (table 29). There was, however, no significant correlation between pupillometric and skin conductance responses for the 25/75 wool-cotton blend, when fingertips were used as the receptor, or when either pupillometric or

TABLE 29

CORRELATION COEFFICIENTS AMONG PUPILLOMETRIC, SKIN CONDUCTANCE, AND SUBJECTIVE ASSESSMENTS FOR FIBER CONTENT ACCORDING TO BODY AREA STIMULATED

	Upper Body		Fingertips	
	Variables Correlated			
	Pupil-lometric	Skin Conductance	Pupil-lometric	Skin Conductance
55/45 Wool-Cotton				
Skin Conductance	0.3382*		0.2655	
Subjective	0.1877	-0.2179	0.1277	-0.2438
40/60 Wool-Cotton				
Skin Conductance	0.3595*		0.2826	
Subjective	0.2996	0.0138	0.0783	-0.0227
25/75 Wool-Cotton				
Skin Conductance	0.2362		0.1711	
Subjective	0.1517	0.2154	0.1960	0.1937

*Significant at the $\alpha = 0.05$ level of probability.

skin conductance assessment was correlated with subjective assessment.

A correlation between pupillometric and skin conductance measurements, significant at the $\alpha = 0.05$ level, was found for upper body stimulation by the experimental fabrics containing the shorter wool fibers (1.71 inches) as noted in table 30. There were no significant correlations evident for the pupillometric and skin conductance measures of the long wool fibers (3.38) or for pupillometric and subjective ratings. Negative correlations were apparent for both upper body and fingertip responses when skin conductance responses were correlated with subjective assessments.

When pupillometric and skin conductance assessments were compared in regard to type of yarn used in the test fabrics, a significant correlation ($\alpha = 0.05$) was found for ring spun yarns when the upper body was the stimulus receptor but not for open-end spun yarns (table 31). In addition, no significant correlations were found for either pupillometric or skin conductance measurements when correlated with subjective assessment, or for correlations among any of the variables when fingertips were used as the area of the body stimulated.

The significant correlations that occurred indicated that a relationship existed between the two autonomic

TABLE 30

CORRELATION COEFFICIENTS AMONG PUPILLOMETRIC, SKIN CONDUCTANCE, AND SUBJECTIVE ASSESSMENTS FOR FIBER LENGTH ACCORDING TO BODY AREA STIMULATED

	Upper Body		Fingertips	
	Variables Correlated			
	Pupil-lometric	Skin Conductance	Pupil-lometric	Skin Conductance
	1.71 inches (wool)			
Skin Conductance	0.3382*		0.2655	
Subjective	0.1877	-0.2179	0.1277	-0.2438
	3.38 inches (wool)			
Skin Conductance	0.2484		0.1994	
Subjective	0.1717	-0.2395	0.0304	-0.1867

*Significant at the $\alpha = 0.05$ level of probability.

TABLE 31

CORRELATION COEFFICIENTS AMONG PUPILLOMETRIC, SKIN CONDUCTANCE, AND SUBJECTIVE ASSESSMENTS FOR TYPE OF YARN ACCORDING TO BODY AREA STIMULATED

	Upper Body		Fingertips	
	Variables Correlated			
	Pupil-lometric	Skin Conductance	Pupil-lometric	Skin Conductance
	Ring Spun Yarns			
Skin Conductance	0.3595*		0.2826	
Subjective	0.1083	0.0138	0.0783	-0.0227
	Open-end Spun Yarns			
Skin Conductance	0.2819		0.2802	
Subjective	-0.0384	-0.1502	0.0236	-0.1160

*Significant at the $\alpha = 0.05$ level of probability.

variables, pupil and skin, when the upper body was used for stimulation by fabrics of various fiber content, fiber length, and type of yarn. Hess (24) initiated the theory that constriction of the pupil is characteristic of aversive stimuli while dilation of the pupil is related to interesting or pleasant stimuli. This theory has been the subject of much debate. Loewenfeld (38), another historical figure in pupillometric research, has concluded that the pupil is made to dilate by all stimuli, a view that is supported by Woodmansee, Newsome, and Kirby (74) and by Peavler and McLaughlin (57). Similarly, there has been controversy and debate on the use of skin conductance as a useful tool in physiological research. However, Lykken (44) supported the applicability of electrodermal activity to the measurement of physiological and psychological stimulation although he admitted that the technique has been misused. Results of this investigation seem to support the theories that pupillometric and skin conductance responses are the result of different levels of stimulation.

There appears to be no significant correlation, however, between these physiological reactions to the experimental fabrics and the subjective ratings given by the participants according to a scale used to rate the acceptability of the fabrics for shirts. These findings do not agree with those of Olsen (55) who found a relationship between pupillometric and subjective measurements.

Hypotheses Testing Based on Results of this Investigation

The following inferences have been derived from the results based on the hypotheses formulated for this investigation:

Hypothesis 1. Pupillary response in regard to consumer acceptance of wool-cotton blends for shirts is not affected by the following fabric variables:

a. Fiber content
b. Fiber length
c. Yarn type

Results of the analysis of covariance with repeated measures for pupillometric response to fiber content indicated that no significant effect was exerted by body area stimulated and the fiber content of the test specimens, the length of the fiber used in the experimental fabrics, or the type of yarn incorporated into the fabrics upon the change in pupillometric responses. Based on these results, hypothesis 1a, 1b, and 1c were accepted.

<u>Hypothesis 2</u>. Skin conductance response in regard to consumer acceptance of wool-cotton blends for shirts is not affected by the following fabric variables:

a. Fiber content
b. Fiber length
c. Yarn type

Skin conductance responses to the fiber content, fiber length, and type of yarn used in the experimental fabrics indicated no significant effects from these factors when the analysis of covariance with repeated measures was applied to these data. These results implied that neither fiber content, fiber length, nor type of yarn were significant factors in determining acceptance of the fabrics by the participants. Hypothesis 2a, 2b, and 2c were accepted on the basis of these findings.

<u>Hypothesis 3</u>. Subjective response in regard to consumer acceptance of wool-cotton blends for shirts is not affected by the following fabric variables:

a. Fiber content
b. Fiber length
c. Yarn type

Results of the analysis of variance with repeated measures in regard to subjective assessment indicated that, even though fiber content did not significantly affect the acceptability of fabrics for shirts at the $\alpha = 0.05$ level, these results, however, approached significance ($\alpha = 0.09$). An F-value of 5.74 showed significant effects at the $\alpha = 0.02$ level of probability for fiber length. This finding indicated that the shorter wool fibers (1.71 inches) were significantly more acceptable to the participants than were the longer wool fibers (3.38 inches). Results also showed that the acceptability of a fabric for shirts according to the type of yarn used in the fabric was highly significant at the $\alpha = 0.01$ level of probability showing that ring spun yarns were significantly more acceptable to the participants than were the open-end spun yarns. According to these results hypothesis 3a was accepted while 3b and 3c were rejected.

<u>Hypothesis 4</u>. There are no significant differences between male and female responses to:

a. Pupillary assessment
b. Skin conductance assessment
c. Subjective assessment

According to the analysis of covariance with repeated measures, there were no significant differences at the $\alpha = 0.05$ level of probability between male and female pupillary and skin conductance responses to stimulation by the experimental fabrics. However, the results revealed highly significant differences ($\alpha = 0.001$) between the subjective responses of male and female participants. On the basis of these findings hypotheses 4a and 4b were accepted and 4c was rejected.

Hypothesis 5. There are no significant differences among body area responses to:
a. Pupillometric assessment
b. Skin conductance assessment

Results of an anlaysis of covariance with repeated measures indicated no significant differences between the response of the participants as to whether the upper body or the fingertips were used as the body area stimulated when measured by pupillary and skin conductance assessments. These data led to the acceptance of hypotheses 5a and 5b.

Hypothesis 6. There is no relationship among pupillometric, skin conductance, and subjective assessments as means of measuring the effects of the following fabric variables on consumer acceptance:
a. Fiber content
b. Fiber length
c. Yarn type

Results of the Pearson product-moment correlation analysis showed a significant positive relationship at the $\alpha = 0.05$ level between pupillometric and skin conductance measurements for both the 55/45 and 40/60 wool-cotton fabrics. No significant relationship was found between pupillometric and skin conductance responses to the 25/75 wool-cotton fabric or between pupillometric or skin conductance responses when correlated with subjective responses.

A positive correlation significant at the $\alpha = 0.05$ level, was found between the pupillometric and skin conductance assessment of fiber length when the upper body was used as the stimuli receptor by the experimental fabrics containing the shorter wool fibers. No significant correlation, however, was noted between skin conductance and subjective responses or between pupillometric and subjective responses. Negative, non-significant relationships were found when subjective assessments were correlated with skin conductance measurements.

With regard to yarn type, a positive significant correlation at the $\alpha = 0.05$ level of probability was found between the pupillometric and skin conductance responses for ring spun yarns when the upper body was used as the stimuli receptor. No significant relationships were found between any measurement when the fingertips were the area used as the receptor. Non-significant negative relationships were found when subjective tests were correlated with pupillometric and skin conductance measurements. On the basis of these data, hypotheses 6a, 6b, and 6c were accepted.

CHAPTER V

SUMMARY

This study entailed an investigation of the effect of fiber content, fiber length, and yarn type upon the consumer acceptance of shirt-like garments composed of wool-cotton blends. Evaluations of these effects were based on the responses of 17 female and 15 male volunteers by means of pupillometric, skin conductance, and subjective assessments.

Three fabrics were used in determining the effect of fiber content. They were composed of 55/45, 40/60, and 25/75 percentages of wool and cotton intimately blended together. Determinations of the effect of fiber length compared fabrics containing wool fibers of 1.71 inches and 3.38 inches while an examination of yarns produced by two spinning methods explored differences between ring and open-end spun yarns.

The fabrics were constructed into cape-like garments for use in upper body stimulation, and flat fabric swatches measuring 38 x 38 cm. were used for the tactile stimulation of the fingertips of each participant. The participants were selected at random according to predetermined criteria related to age, size, visual acuity, allergenic reactions, use of stimulants, color variability between iris and pupil, and accessibility for testing.

The pupillometric, skin conductance, and subjective assessments involved a selected group of instruments for measuring participant response to the experimental fabrics. The pupillometric recording device consisted of a 16mm-1P camera system with a 28 mm lens and a 5 mm extender. Measurements of the exposed film after processing were made digitally on a Vanguard Motion Analyzer to one-thousandth of an inch. Calculations involved the use of the last 10 control frames before stimulation and the first 10 frames during stimulation.

Skin conductance response and skin conductance level were measured by a R-511 Beckman dynagraph with a type 9844 skin conductance coupler. These measurements were based on the last one-half second before stimulation and the highest peak during the 10 seconds of stimulation by the fabric. The acceptability of the fabrics for shirts by personal opinion was measured by a scale of descriptive terms ranging from most acceptable to least acceptable.

Pupillometric and skin conductance measurements of the acceptance of the experimental garments and swatches were made simultaneously in a test chamber selected to maintain constant light, noise control, temperature, and humidity using a five member research team. Before entering the test chamber, electrodes to be used in the skin conductance test were placed on the palm of the right hand of each participant for conditioning 30 minutes before the test. In order to insure similar thought processes, the techniques involved were explained to each participant who was asked to concentrate during the testing period on the acceptability of the fabrics for a shirt.

Upon entering the test chamber, participants were positioned in a head rest; adjustments were made in the heights of the headrest and camera; the camera was focused on the right eye of each participant; and the electrodes on the palm of the participant's hand were hooked to the dynograph. Photographs were made with the participant at rest for 10 seconds followed by 10 seconds for each of the two body areas stimulated by each of the experimental fabrics. Simultaneously, the dynograph recorded the electrodermal responses of the participants. Following the photographic and skin conductance evaluations, each participant was asked to rate the fabric according to a five point scale ranging from most acceptable to least acceptable.

Data related to pupillometric and skin conductance measurements were evaluated by means of an analysis of covariance with repeated measures while the subjective assessments were evaluated by means of an analysis of variance with repeated measures. Pearson product moment correlation analyses compared responses by the participants according to the pupillometric, skin conductance, and subjective measurements.

According to results of the analysis of covariance there were non-significant statistical effects due to the fiber contents, fiber lengths, yarn types, body area stimulated or sex of the participants when measured by means of pupillometric assessment. This is interpreted to mean that the wool-cotton percentage used in the blends, the length of the fibers used, and the type of yarn exerted no significant effect on the acceptability of the fabric for a shirt. In addition, the use of the upper body or the fingertips as the stimuli receptors or whether the participant was male or female were not significant at the limitations ($\alpha = .05$) set for this investigation.

Pupillary responses showed that upper body stimulation responded to a greater degree to the experimental fabrics containing higher percentages of the short wool fiber blend made from open-end spun yarns. Fingertip stimulation indicated different patterns for fiber content and fiber length, responding more to the 40/60 wool-cotton blend and the longer wool fibers. Response patterns from male and female participants were similar for upper body stimulation relating to fiber length and to fingertip sensitivity for fiber content and type of yarn.

The results of analysis of covariance procedure indicated non-significant effects from all of the fabric variables measured by skin conductance assessment. This indicated that the wool-cotton percentages used in the fibers, the length of the fibers, the method of spinning the yarn, the area of the body stimulated, or the sex of the participant did not significantly affect the acceptability of the fabric for a shirt.

Skin conductance measurements indicated greater amplitude for upper body stimulation by the experimental fabrics containing higher percentages of the short wool fiber blend made from ring spun yarns. Fingertip stimulation, however, showed more reaction to the 40/60 wool-cotton fiber blend, the shorter wool fibers, and ring spun yarns. Male and female participants gave similar responses to upper body stimulation, both having higher amplitudes for the short wool fibers and ring spun yarns. In regard to fiber content, males reacted more to the 55/45 wool-cotton blend while females responded more to the 25/75 wool-cotton. For fingertip stimulation, the only similarities in response between the sexes were the higher responses to ring spun yarns.

Subjective ratings for fiber content were highest for the blend that had the greatest percentage of cotton, the shorter wool fibers, and ring spun yarns. Comparisons between males and females showed that males preferred the blend highest in cotton content while females preferred the high wool percentage blend. Both sex groups gave higher ratings to the shorter fibers and to ring spun yarns. According to the results of the analysis of variance, these findings indicated that the shorter wool fibers and the ring spun yarns were significantly more acceptable to the participants than the longer fibers and the open-end spun yarns. Differences among the three levels of wool-cotton percentage used in the fabrics, according to subjective assessment, were not significant.

Significant correlations according to results of the Pearson's product moment correlation analyses, were noted for fiber content between pupillometric and skin conductance measurements for both the 55/45 and 40/60 wool-cotton fabrics. Additional significant correlations were found between pupillometric and skin conductance responses for upper body stimulation by the shorter wool fibers and the ring spun yarns.

Findings in this study revealed the complexity and diversity involved when evaluating components of textile products. Greater significance was found to be related to subjective assessments of the acceptability of the experimental fabrics for shirts as stated by the participants which proved to be a better measure of consumer acceptance than the physiological and psychological procedures used in the study.

The use of physiological measures, however, has provided new insight into the complex and intricate dimensions of consumer acceptance of textile products. Additional experimentation is needed to establish these tests as objective measures of man's emotions and feelings, and to determine ways to control the immense number of variables that affect the involuntary responses of the body. Sensitive measures such as pupillometric, skin conductance, and/or other autonomic measures could be applied to a myriad of research topics relating to man's physiological and psychological needs and could provide valuable insight in helping man adapt to an ever increasing complicated enrironment. Specifically, textile research is needed to coalesce the consumers' interest and desires with the multitude of new textile products appearing on the market. It is hoped that results of this study will add further impetus to pupillometric and skin conductance assessments as a valuable tool in textile research.

APPENDIX

TABLE 32

MALE AND FEMALE MEAN PUPIL RESPONSES OF THE UPPER BODY RELATIVE TO FIBER CONTENT (inches)*

Subject	55/45 Wool-Cotton		40/60 Wool-Cotton		25/75 Wool-Cotton	
	Pre	During	Pre	During	Pre	During
M-2	.872	1.001	.850	.912	.899	.889
M-3	.967	1.029	1.085	1.144	.951	.881
M-4	.726	.734	.674	.733	.700	.808
M-5	.644	.663	.655	.675	.735	.744
M-6	.588	.652	.662	.696	.781	.831
M-7	1.006	1.112	.975	1.047	.958	1.029
M-8	.981	1.083	.916	1.010	.954	1.099
M-9	.588	.598	.560	.595	.636	.653
M-10	1.038	1.050	1.079	1.107	1.070	1.091
M-13	.787	.814	.765	.851	.781	.801
M-14	.836	.866	.806	.888	.670	.729
M-15	1.195	1.202	1.287	1.264	1.320	1.335
F-1	.972	1.006	.747	.762	.747	.772
F-2	.704	.793	.738	.760	.791	.780
F-3	.773	.807	.806	.897	.722	.763
F-5	1.093	1.007	.965	.961	.888	1.000
F-7	.687	.735	.603	.632	.652	.651
F-8	.691	.739	.958	.939	.605	.643
F-9	.526	.561	.544	.582	.569	.584
F-10	.870	.893	.916	.822	1.107	1.048
F-11	.579	.689	.509	.564	.525	.576
F-12	.977	.890	.936	.954	.894	.929
F-13	1.022	1.031	1.021	1.051	1.036	1.057
F-14	.556	.585	.518	.501	.548	.581
F-15	.419	.411	.458	.481	.501	.553
F-16	.036	.989	.951	1.016	.945	.902
F-17	.875	.938	.861	.818	.835	.853

*Pupil size as indicated by the Vanguard Motion Analyzer.

TABLE 33

MALE AND FEMALE MEAN PUPIL RESPONSES OF THE FINGERTIPS RELATIVE TO FIBER CONTENT (Inches)*

Subject	Fiber Content: 55/45 Wool-Cotton		40/60 Wool-Cotton		25/75 Wool-Cotton	
	Pre	During	Pre	During	Pre	During
M-2	.816	.871	.855	.869	.815	.839
M-3	1.022	.969	1.015	1.056	1.017	1.050
M-4	.703	.713	.689	.718	.730	.800
M-5	.643	.681	.653	.652	.640	.654
M-6	.604	.682	.650	.776	.612	.662
M-7	1.062	1.044	1.087	1.112	1.042	1.052
M-8	.951	1.064	.967	1.069	.909	1.049
M-9	.542	.581	.540	.554	.598	.647
M-10	1.026	1.102	.954	1.079	1.060	1.136
M-14	1.006	1.006	.982	1.049	1.003	1.031
M-15	1.202	1.225	1.235	1.305	1.218	1.224
F-1	.777	.871	.738	.768	.723	.722
F-2	.817	.855	.698	.791	.705	.726
F-3	.786	.802	.712	.778	.755	.771
F-5	.985	1.085	.975	1.042	.986	1.072
F-7	.588	.599	.561	.612	.565	.594
F-8	.612	.632	.630	.754	.601	.607
F-9	.544	.555	.522	.588	.546	.572
F-10	.926	.811	.838	.890	.799	.919
F-11	.525	.634	.519	.601	.556	.610
F-12	.831	.915	.881	.891	.840	.888
F-13	1.122	1.003	1.062	1.186	1.045	1.111
F-14	.513	.494	.510	.515	.514	.559
F-15	.449	.511	.336	.380	.424	.422
F-16	.943	.946	.909	.956	.835	.852
F-17	.873	.893	.858	.882	.908	.876

*Pupil size as indicated by the Vanguard Motion Analyzer.

TABLE 34

MALE AND FEMALE MEAN PUPIL RESPONSES OF THE UPPER BODY RELATIVE TO FIBER LENGTH (inches)*

Subject	Fiber Length			
	1.71 Inches		3.38 Inches	
	Pre	During	Pre	During
M-2	.872	1.001	.881	.943
M-3	.967	1.029	.901	.945
M-4	.726	.734	.686	.778
M-5	.644	.663	.645	.656
M-6	.587	.652	.597	.697
M-7	1.006	1.112	1.150	1.238
M-8	.981	1.083	.986	1.055
M-9	.588	.598	.614	.634
M-10	1.038	1.050	1.049	1.063
M-13	.787	.814	.824	.829
M-14	.836	.866	.802	.856
M-15	1.195	1.202	1.241	1.217
F-1	.972	1.006	.902	.902
F-2	.704	.793	.822	.811
F-3	.773	.807	.723	.766
F-5	1.093	1.007	.912	1.007
F-7	.687	.735	.669	.696
F-8	.691	.739	.646	.656
F-9	.526	.561	.534	.557
F-10	.870	.893	.782	.790
F-11	.579	.689	.540	.581
F-12	.977	.890	1.003	.985
F-13	1.022	1.031	1.000	1.091
F-14	.556	.585	.580	.602
F-15	.419	.411	.306	.326
F-16	.936	.989	1.011	1.009
F-17	.875	.938	.863	.869

*Pupil size as indicated by the Vanguard Motion Analyzer.

TABLE 35

MALE AND FEMALE PUPIL RESPONSES OF THE FINGERTIPS RELATIVE TO FIBER LENGTH (inches)*

Subject	Fiber Length			
	1.71 Inches		3.38 Inches	
	Pre	During	Pre	During
M-2	.816	.871	.888	.918
M-3	1.022	.969	.908	.944
M-4	.703	.713	.711	.738
M-5	.643	.681	.633	.644
M-6	.604	.683	.584	.702
M-7	1.062	1.044	1.095	1.146
M-8	.951	1.064	.923	1.048
M-9	.542	.581	.552	.620
M-10	1.026	1.102	1.077	1.137
M-14	1.006	1.006	.968	1.006
M-15	1.202	1.225	1.188	1.218
F-1	.777	.871	.733	.764
F-2	.817	.855	.780	.800
F-3	.786	.803	.687	.755
F-5	.985	1.085	.981	1.065
F-7	.588	.599	.604	.591
F-8	.612	.632	.594	.618
F-9	.544	.555	.603	.651
F-10	.926	.811	.909	.913
F-11	.525	.634	.565	.601
F-12	.831	.915	.952	.985
F-13	1.122	1.003	1.164	1.153
F-14	.513	.494	.594	.560
F-15	.449	.511	.403	.440
F-16	.943	.946	.831	.829
F-17	.873	.893	.885	.906

*Pupil size as indicated by the Vanguard Motion Analyzer.

TABLE 36

MALE AND FEMALE PUPIL RESPONSES OF THE UPPER BODY RELATIVE TO TYPE OF YARN (inches)*

Subject	Type of Yarn			
	Ring Spun		Open-end Spun	
	Pre	During	Pre	During
M-2	.849	.912	.774	.914
M-3	1.085	1.144	.991	1.033
M-4	.674	.733	.774	.833
M-5	.655	.675	.660	.647
M-6	.662	.696	.636	.664
M-7	.975	1.047	1.014	1.072
M-8	.916	1.010	.966	1.069
M-9	.560	.595	.696	.697
M-10	1.079	1.107	1.064	1.070
M-13	.765	.851	.781	.835
M-14	.806	.888	.951	.946
M-15	1.287	1.264	1.264	1.299
F-1	.747	.762	.753	.762
F-2	.738	.760	.827	.836
F-3	.806	.897	.757	.854
F-5	.965	.961	1.029	1.022
F-7	.603	.632	.574	.589
F-8	.958	.939	.718	.738
F-9	.544	.582	.622	.638
F-10	.916	.822	.815	.848
F-11	.509	.564	.532	.550
F-12	.936	.954	.906	1.011
F-13	1.021	1.051	.994	1.039
F-14	.518	.501	.554	.632
F-15	.458	.481	.368	.402
F-16	.951	1.016	.941	.994
F-17	.861	.818	.858	.866

*Pupil size as indicated by the Vanguard Motion Analyzer.

TABLE 37

MALE AND FEMALE PUPIL RESPONSES OF THE FINGERTIPS RELATIVE TO TYPE OF YARN (inches)*

Subject	Type of Yarn			
	Ring Spun		Open-end Spun	
	Pre	During	Pre	During
M-2	.855	.869	.786	.823
M-3	1.015	1.056	.925	.977
M-4	.689	.717	.716	.721
M-5	.653	.652	.645	.639
M-6	.650	.776	.538	.625
M-7	1.087	1.112	1.045	1.084
M-8	.967	1.069	1.080	1.151
M-9	.540	.554	.546	.592
M-10	.954	1.079	1.122	1.138
M-14	.982	1.049	1.085	1.110
M-15	1.235	1.305	1.178	1.193
F-1	.738	.768	.721	.738
F-2	.698	.791	.768	.825
F-3	.712	.778	.740	.804
F-5	.975	1.042	1.073	1.056
F-7	.561	.612	.532	.591
F-8	.630	.754	.632	.637
F-9	.522	.588	.576	.559
F-10	.838	.890	.823	.893
F-11	.519	.601	.538	.607
F-12	.881	.891	.837	.881
F-13	1.062	1.186	.931	1.068
F-14	.510	.515	.595	.644
F-15	.336	.380	.431	.445
F-16	.909	.956	.840	.831
F-17	.858	.882	.812	.849

*Pupil size as indicated by the Vanguard Motion Analyzer.

TABLE 38

MALE AND FEMALE SKIN CONDUCTANCE RESPONSES OF THE UPPER BODY RELATIVE TO FIBER CONTENT (micromhos)

Subject	55/45 Wool-Cotton		40/60 Wool-Cotton		25/75 Wool-Cotton	
	Pre	During	Pre	During	Pre	During
M-1	17.1	19.2	17.7	19.3	18.8	19.8
M-2	25.6	30.1	25.4	28.1	27.8	25.9
M-3	8.5	8.6	8.4	8.7	8.5	8.7
M-4	2.9	4.3	3.1	4.5	3.1	5.3
M-5	4.2	4.7	4.9	5.4	4.7	5.2
M-6	2.4	2.8	2.2	2.5	2.8	2.7
M-7	13.1	15.3	12.0	12.5	11.5	12.9
M-8	23.6	26.1	24.3	26.6	23.9	25.9
M-9	2.7	2.6	3.0	3.1	2.8	2.8
M-10	8.8	10.1	8.2	9.0	8.0	9.5
M-11	4.6	7.0	4.2	4.9	4.0	5.0
M-12	24.4	28.0	24.4	27.9	25.0	28.3
M-13	23.4	25.1	23.0	24.5	25.7	26.7
M-14	11.9	12.1	11.8	11.7	12.2	12.6
M-15	15.2	17.5	13.8	15.9	13.1	17.7
F-1	4.5	5.5	3.5	4.7	4.0	5.7
F-2	5.4	6.2	6.5	6.5	6.1	6.8
F-3	8.3	10.5	9.8	11.0	8.9	10.8
F-4	9.6	11.6	9.1	9.6	9.1	10.0
F-5	10.2	10.4	9.0	9.8	9.2	10.0
F-6	8.5	9.6	7.3	8.0	8.7	8.9
F-7	9.7	10.5	10.4	10.3	10.0	10.4
F-8	13.5	14.8	13.4	15.7	14.3	15.9
F-9	2.7	3.3	2.7	2.9	2.8	3.9
F-10	4.0	4.0	4.6	5.2	3.7	5.2
F-11	5.5	6.8	5.3	6.5	5.4	6.3
F-12	1.3	1.9	1.7	1.7	1.6	2.0
F-13	8.6	9.5	7.7	9.2	7.4	7.6
F-14	5.4	6.0	5.6	6.5	5.3	6.0
F-15	20.9	21.5	16.1	17.7	16.0	18.5
F-16	20.4	22.4	19.4	21.2	18.7	20.1
F-17	9.1	9.5	9.7	9.9	9.2	9.4

TABLE 39

MALE AND FEMALE SKIN CONDUCTANCE RESPONSES OF THE FINGERTIP RELATIVE TO FIBER CONTENT (micromhos)

Subject	Fiber Content					
	55/45 Wool-Cotton		40/60 Wool-Cotton		25/75 Wool-Cotton	
	Pre	During	Pre	During	Pre	During
M-1	19.5	21.0	20.7	21.8	21.4	23.1
M-2	27.8	30.5	30.2	29.8	28.4	30.8
M-3	9.4	9.4	9.5	9.7	9.6	9.8
M-4	3.7	4.3	3.3	4.5	3.4	4.6
M-5	4.6	5.0	6.1	6.0	4.3	5.1
M-6	2.5	3.1	2.3	2.8	2.3	2.7
M-7	16.9	16.9	17.3	18.3	14.4	18.1
M-8	25.1	29.4	24.1	29.7	26.6	28.4
M-9	3.0	3.4	3.2	3.5	2.7	3.3
M-10	9.4	9.3	9.0	8.8	9.0	8.9
M-11	4.4	7.4	4.8	4.6	5.4	5.5
M-12	26.7	31.4	26.0	31.8	29.2	33.3
M-13	27.7	27.3	26.0	27.8	28.4	29.4
M-14	16.4	16.8	16.8	17.1	16.9	17.3
M-15	16.9	18.4	15.3	16.9	16.3	15.7
F-1	4.5	6.7	4.3	4.8	4.4	5.1
F-2	6.2	6.5	5.9	6.5	6.0	6.6
F-3	9.2	12.0	8.7	12.9	10.1	11.8
F-4	10.1	12.4	10.7	11.7	9.9	11.4
F-5	10.9	11.2	10.3	11.0	10.2	10.7
F-6	9.8	10.8	9.4	11.0	9.7	12.2
F-7	9.7	12.8	9.9	11.2	10.2	11.5
F-8	15.9	17.8	15.8	17.6	15.9	16.5
F-9	3.5	4.6	3.1	3.5	5.2	5.4
F-10	5.7	5.7	5.6	6.2	4.6	6.6
F-11	6.3	9.7	6.5	8.2	7.4	8.4
F-12	2.8	2.8	2.5	2.5	2.6	2.8
F-13	6.8	6.8	7.4	8.8	6.4	6.4
F-14	6.7	6.8	6.4	7.6	6.0	6.2
F-15	20.8	25.9	19.2	22.2	18.8	24.6
F-16	20.7	22.6	21.2	23.6	22.6	22.9
F-17	10.0	10.4	10.7	10.9	10.6	10.6

TABLE 40

MALE AND FEMALE SKIN CONDUCTANCE RESPONSES OF THE UPPER BODY RELATIVE TO FIBER LENGTH (micromhos)

Subject	Fiber Length			
	1.71 Inches		3.38 Inches	
	Pre	During	Pre	During
M-1	17.1	19.2	17.5	18.6
M-2	25.6	30.1	25.4	28.0
M-3	8.5	8.6	8.9	9.0
M-4	2.9	4.3	2.9	4.1
M-5	4.2	4.7	4.3	4.7
M-6	2.4	2.8	2.4	2.6
M-7	13.1	15.3	13.3	16.3
M-8	23.6	26.1	23.7	25.7
M-9	2.7	2.6	2.9	3.0
M-10	8.8	10.1	8.3	9.1
M-11	4.6	7.0	5.0	5.8
M-12	24.4	28.0	25.7	28.5
M-13	23.4	25.1	26.9	28.1
M-14	11.9	12.1	12.1	12.2
M-15	15.2	17.5	15.3	15.8
F-1	4.5	5.5	3.9	5.2
F-2	5.4	6.2	5.6	6.6
F-3	8.3	10.5	8.1	9.9
F-4	9.6	11.6	9.7	10.4
F-5	10.2	10.4	9.7	9.9
F-6	8.5	9.6	7.7	8.5
F-7	9.7	10.5	10.9	11.2
F-8	13.5	14.8	14.7	15.9
F-9	2.7	3.3	2.9	3.1
F-10	4.0	4.0	4.1	4.3
F-11	5.5	6.8	5.6	7.0
F-12	1.3	1.9	1.1	1.4
F-13	8.6	9.5	7.3	7.7
F-14	5.4	6.0	5.3	6.1
F-15	20.9	21.5	18.3	19.7
F-16	20.4	22.4	18.8	20.5
F-17	9.1	9.5	9.0	9.7

TABLE 41

MALE AND FEMALE SKIN CONDUCTANCE RESPONSES OF THE FINGERTIPS RELATIVE TO FIBER LENGTH (micromhos)

	Fiber Length			
Subject	1.71 Inches		3.38 Inches	
	Pre	During	Pre	During
M-1	19.5	21.0	19.5	21.4
M-2	27.8	30.5	26.7	31.9
M-3	9.4	9.4	9.9	10.1
M-4	3.7	4.3	3.0	4.4
M-5	4.6	5.0	4.8	5.3
M-6	2.5	3.1	2.2	2.7
M-7	16.9	16.9	16.7	18.4
M-8	25.1	29.4	27.9	29.5
M-9	3.0	3.4	3.0	3.3
M-10	9.4	9.3	9.3	9.5
M-11	4.4	7.4	4.6	5.6
M-12	26.7	31.4	39.1	45.7
M-13	27.7	27.3	30.1	29.6
M-14	16.4	16.8	16.6	16.8
M-15	16.9	18.4	17.6	18.2
F-1	4.5	5.5	3.9	5.2
F-2	5.4	6.2	5.6	6.6
F-3	8.3	10.5	8.1	9.9
F-4	9.6	11.6	9.7	10.4
F-5	10.2	10.4	9.7	9.9
F-6	8.5	9.6	7.7	8.5
F-7	9.7	10.5	10.9	11.2
F-8	13.5	14.8	14.7	15.9
F-9	2.7	3.3	2.9	3.1
F-10	4.0	4.0	4.1	4.3
F-11	5.5	6.8	5.6	7.0
F-12	1.3	1.9	1.1	1.4
F-13	8.6	9.5	7.3	7.7
F-14	5.4	6.0	5.3	6.1
F-15	20.9	21.5	18.3	19.7
F-16	20.4	22.4	18.8	20.5

TABLE 42

MALE AND FEMALE SKIN CONDUCTANCE RESPONSES OF THE UPPER BODY RELATIVE TO YARN TYPE (micromhos)

Subject	Type of Yarn			
	Ring Spun		Open-end Spun	
	Pre	During	Pre	During
M-1	17.7	19.3	18.3	19.4
M-2	25.4	28.1	25.8	28.0
M-3	8.4	8.7	8.1	8.3
M-4	3.1	4.5	3.8	5.4
M-5	4.9	5.4	4.4	4.8
M-6	2.2	2.5	2.3	2.5
M-7	12.0	12.5	12.1	13.0
M-8	24.3	26.6	24.4	26.5
M-9	3.0	3.1	2.6	3.0
M-10	8.2	9.0	8.1	8.9
M-11	4.2	4.9	4.9	5.1
M-12	24.4	27.9	24.0	27.0
M-13	23.0	24.5	23.4	25.0
M-14	11.8	11.7	12.4	12.8
M-15	13.8	15.9	13.5	15.8
F-1	3.5	4.7	4.4	5.2
F-2	6.5	6.5	6.9	7.1
F-3	9.8	11.0	9.4	11.2
F-4	9.1	9.6	7.7	9.3
F-5	9.0	9.8	9.3	9.7
F-6	7.3	8.0	8.1	8.5
F-7	10.4	10.3	9.7	10.0
F-8	13.4	15.7	13.4	14.4
F-9	2.7	2.9	3.9	4.5
F-10	4.6	5.2	4.2	4.5
F-11	5.3	6.5	7.2	8.1
F-12	1.7	1.7	1.9	2.0
F-13	7.7	9.2	7.5	8.4
F-14	5.6	6.5	5.3	5.9
F-15	16.1	17.7	14.9	16.6
F-16	19.4	21.2	21.2	21.4
F-17	9.7	9.9	10.0	10.5

TABLE 43

MALE AND FEMALE SKIN CONDUCTANCE RESPONSES OF THE FINGERTIPS RELATIVE TO YARN TYPE (micromhos)

Subject	Type of Yarn			
	Ring Spun		Open-end Spun	
	Pre	During	Pre	During
M-1	20.7	21.8	20.7	22.0
M-2	30.2	29.8	30.7	32.0
M-3	9.5	9.7	9.6	9.7
M-4	3.3	4.5	3.2	5.1
M-5	6.1	6.0	5.5	5.9
M-6	2.3	2.8	2.7	2.6
M-7	17.3	18.3	16.2	17.3
M-8	24.1	29.7	29.1	30.8
M-9	3.2	3.5	2.7	3.8
M-10	9.0	8.8	9.3	8.8
M-11	4.8	4.6	5.9	6.0
M-12	26.0	31.8	27.1	32.3
M-13	26.0	27.8	27.6	27.2
M-14	16.8	17.1	17.4	17.9
M-15	15.3	16.9	15.7	18.1
F-1	4.3	4.8	4.5	4.8
F-2	5.9	6.5	6.3	6.5
F-3	8.7	12.9	10.1	12.2
F-4	10.7	11.7	10.8	12.1
F-5	10.3	11.0	10.5	11.3
F-6	9.4	11.0	9.5	11.6
F-7	9.9	11.2	10.5	12.9
F-8	15.8	17.6	15.7	15.9
F-9	3.1	3.5	3.1	7.6
F-10	5.6	6.2	5.1	6.5
F-11	6.5	8.2	7.2	8.6
F-12	2.5	2.5	2.3	2.3
F-13	7.4	8.8	7.7	7.7
F-14	6.4	7.6	6.3	6.5
F-15	19.2	22.2	19.6	22.4
F-16	21.2	23.6	22.1	23.1
F-17	10.7	10.9	10.8	11.3

TABLE 44

SUBJECTIVE QUESTIONING RESPONSES OF MALES AND FEMALES RELATIVE TO FIBER CONTENT

Subject	Fiber Content		
	55/45 Wool-Cotton	40/60 Wool-Cotton	25/75 Wool-Cotton
M-1	2	3	2
M-2	2	3	5
M-3	5	4	4
M-4	5	2	4
M-5	3	2	3
M-6	2	3	3
M-7	4	2	4
M-8	3	2	4
M-9	3	4	4
M-10	5	2	2
M-11	3	3	4
M-12	3	4	4
M-13	4	3	3
M-14	2	3	4
M-15	3	5	5
F-1	4	4	5
F-2	3	2	2
F-3	4	2	4
F-4	3	2	3
F-5	4	4	4
F-6	4	3	4
F-7	3	5	1
F-8	5	4	5
F-9	4	3	4
F-10	3	3	3
F-11	4	2	3
F-12	4	4	2
F-13	4	4	4
F-14	3	4	4
F-15	3	3	3
F-16	4	3	5
F-17	4	3	4

TABLE 45

SUBJECTIVE QUESTIONING RESPONSES OF MALES AND FEMALES RELATIVE TO FIBER LENGTH

Subject	Fiber Length	
	1.71 inches	3.38 inches
M-1	2	2
M-2	2	3
M-3	5	3
M-4	5	4
M-5	3	3
M-6	2	2
M-7	4	3
M-8	3	3
M-9	3	4
M-10	5	4
M-11	3	3
M-12	3	3
M-13	4	2
M-14	2	5
M-15	3	2
F-1	4	3
F-2	3	2
F-3	4	3
F-4	3	3
F-5	4	4
F-6	4	3
F-7	3	4
F-8	5	4
F-9	4	3
F-10	3	3
F-11	4	3
F-12	4	3
F-13	4	4
F-14	3	3
F-15	3	3
F-16	4	1
F-17	4	2

TABLE 46

SUBJECTIVE QUESTIONING RESPONSES OF MALES AND FEMALES RELATIVE TO TYPE OF YARN

Subject	Type of Yarn	
	Ring Spun	Open-end Spun
M-1	3	3
M-2	3	2
M-3	4	2
M-4	2	2
M-5	2	1
M-6	3	2
M-7	2	2
M-8	2	1
M-9	4	3
M-10	2	3
M-11	3	2
M-12	4	3
M-13	3	2
M-14	3	3
M-15	5	1
F-1	4	2
F-2	2	2
F-3	2	3
F-4	2	4
F-5	4	4
F-6	3	3
F-7	5	5
F-8	4	2
F-9	3	2
F-10	3	2
F-11	2	1
F-12	4	3
F-13	4	3
F-14	4	2
F-15	3	2
F-16	3	1
F-17	3	3

TABLE 47

CORRELATIONS AMONG VARIABLES RELATIVE TO FIBER CONTENT

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	Pupillometric Garment A Pre																								
2	Pupillometric Garment A During	[illegible] ***																							
3	Pupillometric Garment C Pre	[illegible] ***	.8818 ***																						
4	Pupillometric Garment C During	[illegible] ***	.8988 ***	.9682 ***																					
5	Pupillometric Garment E Pre	[illegible] ***	.8507 ***	.8760 ***	.8419 ***																				
6	Pupillometric Garment E During	[illegible] ***	.8626 ***	.8617 ***	.8433 ***	.9707 ***																			
7	Pupillometric Swatch A Pre	[illegible] ***	.9214 ***	.8981 ***	.9111 ***	.8773 ***	.8813 ***																		
8	Pupillometric Swatch A During	.9445 ***	.9354 ***	.8669 ***	.9023 ***	.8426 ***	.8821 ***	.9603 ***																	
9	Pupillometric Swatch C Pre	.9351 ***	.9285 ***	.9106 ***	.9277 ***	.8754 ***	.8945 ***	.9806 ***	.9599 ***																
10	Pupillometric Swatch C During	.9193 ***	.9227 ***	.9178 ***	.9388 ***	.8679 ***	.8925 ***	.9726 ***	.9556 ***	.9819 ***															
11	Pupillometric Swatch E Pre	.9186 ***	.9012 ***	.8914 ***	.9090 ***	.8479 ***	.8695 ***	.9674 ***	.9574 ***	.9676 ***	.9607 ***														
12	Pupillometric Swatch E During	.9191 ***	.8983 ***	.8764 ***	.8938 ***	.8604 ***	.8958 ***	.9666 ***	.9520 ***	.9677 ***	.9668 ***	.9833 ***													
13	Skin Conductance Garment A Pre	.2263	.3125	.2522	.3349 *	.1981	.2257	.2755	.3246 *	.3193	.2818	.2356	.2243												
14	Skin Conductance Garment A During	.2446	.3382 *	.2642	.3516 *	.2154	.2453	.2805	.3341 *	.3267 *	.2916	.2436	.2311	.9950 ***											
15	Skin Conductance Garment C Pre	.2412	.3400 *	.2674	.3545 *	.2099	.2342	.2920	.3382 *	.3320 *	.3041	.2479	.2440	.9887 ***	.9882 ***										
16	Skin Conductance Garment C During	.2448	.3428 *	.2764	.3595 *	.2156	.2437	.2822	.3296 *	.3241 *	.2993	.2384	.2367	.9874 ***	.9903 ***	.9969 ***									
17	Skin Conductance Garment E Pre	[illegible]	.3143	.2388	.3296 *	.1755	.1986	.2626	.3157	.3099	.2838	.2255	.2201	.9841 ***	.9842 ***	.9947 ***	.9918 ***								
18	Skin Conductance Garment E During	.2389	.3277 *	.2691	.3554 **	.2032	.2362	.2862	.3421 **	.3290 *	.3030	.2469	.2404	.9865 ***	.9872 ***	.9920 ***	.9941 ***	.9900 ***							
19	Skin Conductance Swatch A Pre	.2347	.3213 *	.2654	.3487 *	.1895	.2206	.3016	.3496 *	.3528 *	.3119	.2678	.2555	.9886 ***	.9830 ***	.9843 ***	.9793 ***	.9844 ***	.9860 ***						
20	Skin Conductance Swatch A During	[illegible]	.2619	.1883	.2776	.1198	.1579	.2028	.2655	.2523	.2151	.1664	.1572	.9881 ***	.9875 ***	.9801 ***	.9797 ***	.9759 ***	.9843 ***	.9869 ***					
21	Skin Conductance Swatch C Pre	.2355	.3338 *	.2626	.3475 *	.1878	.2103	.2978	.3388 *	.3507 *	.3076	.2637	.2487	.9833 ***	.9811 ***	.9844 ***	.9782 ***	.9860 ***	.9773 ***	.9942 ***	.9796 ***				
22	Skin Conductance Swatch C During	.1871	.2732	.2077	.3023	.1426	.1748	.2707	.3149	.3175	.2826	.2258	.2224	.9741 ***	.9688 ***	.9783 ***	.9735 ***	.9819 ***	.9836 ***	.9868 ***	.9725 ***	.9770 ***			
23	Skin Conductance Swatch E Pre	.2223	.3158 *	.2475	.3408 *	.1667	.1938	.2838	.3381 *	.3323 *	.3017	.2493	.2395	.9830 ***	.9810 ***	.9893 ***	.9852 ***	.9901 ***	.9904 ***	.9921 ***	.9850 ***	.9888 ***	.9851 ***		
24	Skin Conductance Swatch E During	.1618	.2570	.1802	.2763	.1190	.1510	.2196	.2706	.2661	.2243	.1785	.1711	.9827 ***	.9807 ***	.9809 ***	.9777 ***	.9810 ***	.9842 ***	.9901 ***	.9920 ***	.9855 ***	.9820 ***	.9906 ***	
25	Subjective A	.2413	.1877	.2896	.2996	.0596	.0627	.1468	.1277	.1125	.1360	.2017	.1658	-.2123	.2179	-.2299	-.2121	-.2326	-.1970	-2183	-.2438	-.2492	-.1897	-.2244	-.2389
26	Subjective C	[illegible]	[illegible]	.2145	.1083	.1150	.0525	.0503	-.0021	.0998	.0783	.0447	.0374	.0270	.0023	.0044	.0138	.0099	.0167	.0076	.0033	-.0105	-.0227	.0066	-.0272
27	Subjective E	.2586	.3052	.3000	.2978	.1308	.1517	.2328	.2118	.2871	.2587	.2077	.1960	.2260	.2426	.2015	.2367	.2008	.2154	.2216	.2194	.2257	.1932	.2206	.1937

*Significant at the α.05 level of probability.
**Significant at the α.01 level of probability.
***Significant at the α.001 level of probability.

TABLE 48

CORRELATIONS AMONG VARIABLES RELATIVE TO FIBER LENGTH

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 Pupillometric Garment A Pre																	
2 Pupillometric Garment A During	.9671 ***																
3 Pupillometric Garment B Pre	.9491 ***	.9533 ***															
4 Pupillometric Garment B During	.9474 ***	.9585 ***	.9850 ***														
5 Pupillometric Swatch A Pre	.9281 ***	.9214 ***	.9119 ***	.9208 ***													
6 Pupillometric Swatch A During	.9445 ***	.9354 ***	.9232 ***	.9305 ***	.9603 ***												
7 Pupillometric Swatch B Pre	.9319 ***	.9130 ***	.9278 ***	.9331 ***	.9561 ***	.9352 ***											
8 Pupillometric Swatch B During	.9193 ***	.9044 ***	.9141 ***	.9361 ***	.9574 ***	.9535 ***	.9797 ***										
9 Skin Conductance Garment A Pre	.2283	.3125	.2405	.2425	.2755	.3246 *	.1938	.2276									
10 Skin Conductance Garment A During	.2446	.3382 *	.2670	.2707	.2805	.3341 *	.2088	.2416	.9950 ***								
11 Skin Conductance Garment B Pre	.2195	.3086	.2419	.2405	.2760	.3248 *	.1943	.2322	.9913 ***	.9877 ***							
12 Skin Conductance Garment B During	.2157	.3144	.2467	.2484	.2632	.3154	.1865	.2231	.9901 ***	.9913 ***	.9969 ***						
13 Skin Conductance Swatch A Pre	.2347	.3213 *	.2591	.2587	.3016	.3496 *	.2230	.2622	.9886 ***	.9830 ***	.9912 ***	.9901 ***					
14 Skin Conductance Swatch A During	.1690	.2619	.1806	.1810	.2028	.2655	.1214	.1622	.9881 ***	.9875 ***	.9847 ***	.9875 ***	.9869 ***				
15 Skin Conductance Swatch B Pre	.2346	.3254 *	.2585	.2551	.3048	.3594 *	.2236	.2692	.9581 ***	.9576 ***	.9732 ***	.9751 ***	.9711 ***	.9700 ***			
16 Skin Conductance Swatch B During	.1891	.2833	.2072	.2080	.2338	.2917	.1574	.1994	.9550 ***	.9585 ***	.9615 ***	.9675 ***	.9586 ***	.9714 ***	.9908 ***		
17 Subjective A	.2419	.1877	.1845	.1717	.1468	.1277	.1659	.1142	-.2123	-.2179	-.2077	-.1943	-.2183	-.2438	-.2101	-.2395	
18 Subjective B	-.0276	-.0993	-.1643	-.0966	-.0434	-.0693	.0415	.0304	-.2363	-.2476	-.2316	-.2395	-.2166	-.2075	-.1969	-.1867	.1560

*Significant at the α.05 level of probability.
**Significant at the α.01 level of probability.
***Significant at the α.001 level of probability.

TABLE 49

CORRELATIONS AMONG VARIABLES RELATIVE TO TYPE OF YARN

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1 Pupillometric Garment C Pre																	
2 Pupillometric Garment C During	.9682***																
3 Pupillometric Garment D Pre	.9179***	.9257***															
4 Pupillometric Garment D During	.9214***	.9401***	.9812***														
5 Pupillometric Swatch C Pre	.9106***	.9277***	.9545***	.9565***													
6 Pupillometric Swatch C During	.9178***	.9388***	.9570***	.9513***	.9819***												
7 Pupillometric Swatch D Pre	.8524***	.8697***	.9453***	.9366***	.9403***	.9357***											
8 Pupillometric Swatch D During	.8498***	.8681***	.9341***	.9349***	.9468***	.9521***	.9862***										
9 Skin Conductance Garment C Pre	.2674	.3545*	.1971	.2756	.3320*	.3041	.3281*	.3132									
10 Skin Conductance Garment C During	.2764	.3595*	.1943	.2760	.3241*	.2993	.3165	.3014	.9969***								
11 Skin Conductance Garment D Pre	.2585	.3526*	.2028	.2808	.3332*	.3102	.3318*	.3127	.9946***	.9923***							
12 Skin Conductance Garment D During	.2564	.3513*	.2005	.2819	.3288*	.3052	.3294*	.3112	.9947***	.9960***	.9970***						
13 Skin Conductance Swatch C Pre	.2626	.3475*	.1962	.2687	.3507*	.3076	.3417*	.3161	.9844***	.9782***	.9815***	.9788***					
14 Skin Conductance Swatch C During	.2077	.3023	.1497	.2244	.3175	.2826	.3186	.3004	.9783***	.9735***	.9748***	.9759***	.9770***				
15 Skin Conductance Swatch D Pre	.2530	.3459*	.1965	.2731	.3450*	.3123	.3502*	.3313*	.9919***	.9861***	.9903***	.9884***	.9940***	.9815***			
16 Skin Conductance Swatch D During	.2064	.3023	.1588	.2358	.2957	.2601	.3042	.2802	.9862***	.9834***	.9836***	.9871***	.9835***	.9730***	.9894***		
17 Subjective C	.2145	.1083	.1109	.0783	.0998	.0783	-.0247	-.0217	.0044	.0138	-.0139	-.0196	-.0105	-.0227	-.0302	-.0156	
18 Subjective D	-.0403	-.0541	-.0108	-.0384	-.0342	-.0240	.0024	.0236	-.1080	-.1360	-.1478	-.1502	-.1161	-.1276	-.1330	-.1160	.2832

*Significant at the α.05 level of probability.
**Significant at the α.01 level of probability.
***Significant at the α.001 level of probability.

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