A STUDY OF THE EFFECTIVENESS OF A SEWING METHOD TO REDUCE SEAM PUCKERING IN WASH AND WEAR FABRICS

by

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I. INTRODUCTION

Maintenance of fabrics has evolved from a time consuming process to a minimum expenditure of time and energy. In keeping with this labor saving trend, new methods of garment construction have developed which reduce the meticulous details of sewing to a minimum and enable today's home sewer to produce a satisfactory garment in a comparatively short time.

However, the same elements which account for the convenience of both the new fabrics and the new sewing methods have produced new problems, one of which is the puckering of seams. The manufacturing processes currently involved in the production of wash and wear fabrics--synthetics, blends, and resin treated cottons--make seam puckering an inherent property. Unfortunately, the tendency to pucker is aggravated by some of the short-cut sewing methods now being used, both in the garment industry and in home sewing.

For several years garment manufacturers have attempted to deal with this problem. Careful analyses of styles of garments, sewing threads and needle sizes, sewing machine adjustments, and operators' techniques have enabled the industry to reduce the amount of pucker in ready-to-wear garments though the difficulty has not been entirely eliminated. Little has been done, however, to minimize the problem for the home sewer. With the ever-increasing market of fabrics with wash and wear finishes and the extensive use of man-made fibers, seam pucker is a frequently encountered problem, and until fabric manufac-

turers can successfully eliminate the puckering tendency, sewing methods for these fabrics must be adjusted in order to reduce the problem.

Since the newer, short-cut methods of garment construction are essentially adaptations of the trade methods, it seems reasonable that the techniques used by industry to minimize pucker could also be applied to sewing in the home. It is on this basis that this study has been developed, the overall purpose being to devise a sewing method, based on existing recommendations by leaders in industry, and determine how effectively it can be used by the home sewer to reduce seam pucker.

For purposes of statistical analysis the hypothesis will be stated as a null hypothesis:

Ho: The sewing method adapted from industrial procedures shows no reduction in the amount of pucker in a lengthwise seam when taught to a group of home sewers.

In addition to testing the hypothesis an attempt was made to provide answers to the following questions:

1. Can the home sewers be taught to adjust the lower and upper tensions to the recommended setting?

2. When considered as two separate groups, can adult women and high school girls be expected to achieve different levels of success in reducing seam pucker using the proposed sewing method?

3. Is there any correlation between years and amount of sewing experience and the degree of success which can be attained by using the

method?

4. Does the age or condition of the sewing machine have any bearing on the performance of an individual using the sewing method, particularly in relation to tension adjustment?

5. Is the proposed sewing method equally effective on mercerized cotton and textured nylon sewing threads?

II. REVIEW OF LITERATURE

A recent survey showed that over 42,000,000 women make some or all of their wardrobe, and that money spent by this do-it-yourself couture group in 1964 was a record-breaking $1,000,000,000. (1) The easy fitting styles in fashion today provide a major incentive for the increase in home sewing. Sewing a shift is relatively easy, not too time consuming, and can be a very creative experience.

Accompanying the rise in home sewing is the appearance of more and more new fabrics on the market, most of which have easy-care properties. The characteristics of fabric which contribute to wash and wear properties also cause these fabrics to pucker, especially along lengthwise seams. The problem of seam puckering has been a matter of concern to the garment industry for several years, but the problem has not been as widely recognized in home sewing. Most of the literature is directed at the industry, while the number of articles available which are specifically applicable to sewing in the home is very small.

Edna Bryte Bishop (2), originator of the Bishop Method of garment construction, makes only limited references to special sewing problems of wash and wear and crease resistant fabrics in the 1959 publication of her manual. She cites several disadvantages of synthetic and resin-finished fabrics: (1) that seams will not lie flat after being pressed, (2) that sharp edges will not maintain a crease, (3) and that the new fabrics do not respond well to tailoring. The same resistance to the molding processes of tailoring becomes

apparent when setting in sleeves. The tendency of these fabrics to pucker along lengthwise seams is not included in the list of difficulties to expect when sewing on wash and wear fabrics.

E. I. DuPont de Nemours (3, 4, 5, 6) has published several technical bulletins as guides to the use of some DuPont products in which the problem of seam puckering is discussed. This information includes explanations of the causes of puckering and describes remedies to reduce pucker, which can apply directly to home sewing. These publications and a New Jersey extension bulletin by Florence Minifie (7) provided the only sources of technical information specifically applicable to the home sewer. Consequently, the primary source of information for this study has been literature directed toward the garment industry.

Cause of Seam Pucker

The Cause of Inherent Pucker

There are several explanations for the puckered appearance of seams in wash and wear, but the most basic cause is the resiliency imparted to the fabric by the synthetic fiber or by the resin finish on wash and wear cotton. This is a fundamental property if a fabric is to be expected to achieve wash and wear performance. Resiliency is a natural quality in synthetic fibers, but a resin finish is necessary to produce the same effect in cotton fabrics. Lewis T. Kelly, chief chemist for the Bellman Brook Bleachery Company, Fairview, New Jersey, contributes the following explanation of the role of the

resin:

> "Essentially, what they (the resins) do is to penetrate the cotton fiber and polymerize or lock together when heat is applied at a high temperature in such a way as to resist bending pressures. In other words, a 'spring' or 'bounce' is built into the fiber that it would not ordinarily have. These polymerized resins are insoluble and thus will stay on for the normal life of the fabric, unless improperly heat set" (8).

This "resistance to bending" refers not only to the overall fabric quality of resisting wrinkling and mussing, but to the performance of the individual fabric yarns also. The introduction of the needle and thread when a stitch is made actually forces the yarns in the immediate area of the stitch to move aside. The resiliency of the wash and wear fabric causes the displaced yarns to try to regain their original position, thereby creating opposing forces within the fabric.

The ultimate effect of this action is to shorten the yarns adjacent to the stitching line in relation to the original length of fabric. This phenomenon is most pronounced when the same yarn is displaced many times, as in a lengthwise seam, but it decreases as the seam becomes more and more bias. Dorkin and Chamberlain (9), in an authoritative study of the causes of seam puckering, term this displacement "structural jamming" and further state that there is no machine adjustment which will eliminate it, though there are techniques which help to minimize the effect. It may therefore be considered an inherent property of wash and wear fabrics and is a phase of the problem which the garment industry and the home sewer will have to accept.

The degree of yarn distortion or structural jamming may vary among fabrics depending upon their construction, but it is most likely to occur in fabrics with a high yarn count.

Causes of Seam Puckering Which Can Be Corrected

There are several causes of seam puckering which may be traced to improper sewing machine adjustment, faulty handling by the operator, unsatisfactory sewing thread, or simply poor pattern design. These can be corrected to achieve maximum performance.

Tension

The tension on the sewing threads appears to affect the degree of pucker evidenced in a seam. A tension setting which is too tight results in a drawing together of the yarns and puckers the seam. A resin treated fabric is particularly sensitive to this drawing effect. Curtis E. Bowne (10), vice-president of the American Thread Company, terms this type of pucker "drawing pucker."

Differential Feeding

Another of the most significant causes of seam pucker is termed by DuPont "differential feeding" (6). DuPont's researchers, Dorkin and Chamberlain (9), and Bowne (10) state that the primary cause of this defect is too great a pressure on the fabric plys by the presser foot or improper feed dog adjustment, though faulty handling by the operator may also be a contributing factor. The difficulty is that the feed dog pushes the bottom ply along, while the presser

foot holds the top one back. Consequently, the top ply is stretched and the bottom one eased. The effect is the same as if different lengths of fabric were being fed through the sewing machine, and since the stabilizing resin (or synthetic fiber) prevents distortion of the fabric yarns, seam puckering results.

There is also a tendency on the part of sewing machine operators to overfeed (force the fabric into the feed mechanism faster than it can move through by either pushing the garment through or pulling it from the rear). This is particularly true in industry under the pressures of rapid production. Overfeeding has essentially the same result as too great a presser foot pressure or improper feed dog adjustment (10).

Dorkin and Chamberlain refine this theory and point out that distortion is also introduced as the stitching line is made because the fabric is subjected to "differential stretch" by the feed dog and presser foot and held in this unnatural position along the stitch line. That is, as the needle penetrated the fabric plys and holds them in place, the feed mechanism draws the fabric along. After the seam is removed from the machine the distortion remains; the opposing forces cause the seam to pucker.

Mismatched Patterns

Puckered seams may also result from poorly matched or poorly cut patterns. This is most apparent when close set fabrics of a high yarn count are used, specifically those made up into rainwear. Dorkin

and Chamberlain (9) and a report of the Technical Advisory Committee of the Southern Garment Manufacturers' Association (11) both emphasize that in these cases shaping must be imparted to the garment through differences in the shape of the pattern pieces, not differences in length. The stabilizing action of the finish on these fabrics (or the synthetic fiber in the case of synthetics) makes easing impossible and can result in badly puckered seams.

Suggestions for Reducing Seam Pucker

Minimizing Structural Jamming

The garment industry is putting forth a great deal of effort to develop methods of producing smoother seams, and it is reasonable to assume that many of the industry's improvements may also be put to use in home sewing. The degree of pucker has been shown to vary with the direction of the seam from very noticeable pucker along lengthwise seams of a garment, to less pucker along crosswise seams, and to none at all along bias seams (9). Therefore, one major aim in industry is the selection of patterns whose seams will minimize the limitations of wash and wear and crease resistant fabrics. Most authorities recommend the least possible amount of stitching on these fabrics, so top stitching and flat felled seams and other double constructions are not desirable because they necessitate penetrating the fabric twice, thereby doubling yarn distortion. DuPont Bulletin X-168 (5) and Minifie (7) both recommend avoiding too many seams and eliminating the ease in a seam (such as in a sleeve cap). DuPont

Bulletin D-166 suggests choosing a design with off-grain seams rather than lengthwise seams (6).

Little is said about techniques of cutting and pinning as specifically related to wash and wear, but DuPont suggests that cutting with the grain reduces yarn distortion (5). Several authorities recommend careful selection of smooth, sharp pins of small diameter. Since any penetration of the fabric will cause yarn distortion, pins should be used only when necessary, and then it is best to place them outside the seam line to reduce the danger of distorting the yarns in the immediate area of the seam (11).

As previously discussed, yarn distortion, or structural jamming, is a factor which cannot be eliminated from wash and wear but which can be minimized. The number of times a fabric is penetrated has a direct bearing on the amount of pucker produced. Consequently, the fewer stitches there are per inch, the less pucker there will be. The amount of distortion will also vary with the size of the penetrating object; therefore, needles and sewing threads with small diameters are desirable. It is generally agreed that fine, sharp needles perform best, but there is considerable variation among the authorities as to the specific size needle which achieves the least pucker. Bishop (2) and Minifie (7) both recommend a size 12 to 14 needle for all sewing. The Singer Sewing Machine Company (12) proposes the use of a wide range of needles, from Singer size 9 for the sheerest fabrics to size 18 for the heaviest. The Singer recommendations, however, do not include any special instructions for selecting a needle to be used

for wash and wear fabrics. DuPont Bulletin X-168 (5) specifies a size 11 needle (or its equivalent) for lightweight fabrics containing DuPont fibers and a size 14 needle for heavy fabrics. A good general rule for selection of a needle size is that the needle must be of adequate strength to penetrate the fabric without deflecting, and the eye must be large enough to fit around the thread (13). An article in the New Zealand Textile Journal further explains that a slightly rounded point is best for use on fabrics of synthetic fibers in which the yarns can be pushed aside a little more easily, but that slender, tapered points are desirable for resin treated fabrics since these yarns have an unyielding quality and will not push aside or slide over one another (14).

The sewing thread should be the finest possible type which will still maintain the required strength of the seam, because a smaller thread causes less displacement of the yarns and, therefore, less pucker. The majority of the authorities agree that mercerized cotton should be used on cotton fabrics and that synthetic fabrics should be sewn with synthetic threads. Vandervoort points out, however, that a synthetic thread of fine diameter can provide a strength equal to that of a much heavier cotton thread (15).

Just as the diameter of the sewing thread affects structural jamming, other thread properties cause other types of pucker. The extensibility of the thread and its resistance to shrinkage are two of these properties. If the thread is not well-processed (for example, heat-set if synthetic), it may cause problems. Such a thread may

stretch as it passes through the tension mechanisms of the sewing machine and recover from extension after the stitch is formed, or it may shrink when laundered or even from pressing during construction of the garment. All of these conditions may cause puckering of the seam. Well-processed nylon and polyester threads have been recommended for wash and wear, particularly those fabrics containing synthetic fibers (2, 5, 6, 7, 16). L. D. T. Fleming (17) of J. and P. Coats Ltd., Glasgow, maintains that the sewing thread is too often blamed as the primary cause of seam pucker. He states that ". . . the use of the finest size (thread), and a suitably fine needle, will serve to minimize pucker . . ." He recognizes that the strength of the thread must also enter into the evaluation. Of thread strength and performance he says:

> "Strength should be synonymous with quality and a sewing thread produced from long-staple cotton and spun, twisted and processed to give a smooth, even finish, with a nicely balanced twist, will clearly give not only the resultant seam strength required but also a better sewing performance, with a minimum drag on tensions" (17).

Correcting Mechanical Problems Which Cause Pucker

Tension

As discussed above structural jamming is an inherent property of wash and wear, and though it can be minimized by use of good handling techniques and equipment, it cannot usually be eliminated entirely. Most of the other causes of seam pucker, however, can be corrected if dealt with properly. The most frequently occurring of these problems is improper tension on the sewing threads. The tension is rarely set

too loose for wash and wear, but is more often too tight, resulting in the drawing pucker discussed by Bowne (10). Less tension on both the needle and bobbin threads is generally desirable.

To achieve the best tension setting for wash and wear the bobbin should be adjusted first and then the needle thread adjusted accordingly. The bobbin should be wound with only slight tension (enough to make a firm package and not stretch the thread) and suspended in its case from the thread. When the tension screw is adjusted so that the bobbin case just "rides down" the thread, the bobbin may be said to be in correct adjustment. The top tension is loosened until a poor stitch is formed, then adjusted to correspond with the bobbin setting (5, 6, 14, 15).

The situation often arises in which the bobbin case cannot be removed from the sewing machine. In such a case, the top tension should be loosened one-half turn and the bobbin adjusted accordingly. When a balanced stitch is achieved, the tension may be considered correctly set. To test the accuracy of this adjustment a true bias seam may be made and then jerked hard enough to break the stitching. If a thread breaks, the tension on that thread is too tight for sewing on wash and wear (7).

Nearly all of the authorities stress the importance of proper tension adjustment, and several writers maintain that even more precise adjustment of other mechanisms is necessary to sew successfully on wash and wear. These writers are particularly concerned with the timing of the take-up bar and check spring, which controls the amount

of thread released into the stitch. This action may vary with the thread being used, but if the thread is released too late or too soon, a poor stitch will result which may cause puckering (3, 11, 13, 15).

Operator Handling

Another common cause of pucker is poor handling of the fabric by the operator. This may be the most variable of all the causes of seam puckering. The most generally accepted method of controlling fabric has previously been very light handling with no stress or drag on the fabric as it passes through the feed mechanism; however, industrialists have arrived at several more effective techniques of handling the fabric which are now recommended to combat puckering problems of this nature. The most frequently mentioned is a slight, even pull on the fabric as it is fed through the machine--forward with one hand and back with the other. Some authors advocate slight tension only to the rear, but all who recommend placing tension on the fabric point out that it must still be allowed to progress through the feed mechanism at the normal rate, that the purpose of holding the plys in slight tension is to insure that the edges and notches match and that both plys feed through at the same rate.

Those who recommend holding the fabric in slight tension are supported in a report by V. H. Schrader (16). He tells of significant reductions of pucker obtained by use of a geared, roller presser foot which holds the fabric taut in the immediate area of the needle.

A slower sewing speed is also recommended to improve the

appearance of seams in wash and wear. Minifie (7) expressly warns the operator not to race the sewing machine, and most other authorities cite reduced sewing speeds as a factor in minimizing pucker since it gives the operator greater control. It should be noted, however, that the average revolutions per minute of the power machines used in industry are several times greater than the speeds of home sewing machines. The exact ratio largely depends upon the use for which the industrial machine is designed and the age, model, and condition of the home sewing machine. It is possible that the top speeds of some home sewing machines would not equal the slowest speeds of some industrial machines. Along with warnings against excessive sewing speeds, several authorities state that a minimum of quick, jerky stops and starts can aid in limiting the amount of seam pucker (3, 5, 11, 14).

Pressing

Up to this point only actual sewing techniques and machine adjustments have been considered as elements involved in the puckering of seams. There is some indication, however, that pressing techniques may also have an effect on the amount of pucker evidenced in a seam. Schrader's article on reducing seam pucker in synthetics (16) stated that correct pressing may result in the thread of each stitch being fully utilized in the seam. This was accomplished by pressing the seam flat, i.e., both plys together, before pressing it open. This creates a rectangular rather than an eliptical stitch and

allows for greater utilization of the thread at the ends of the stitch where fabric yarns are most likely to be distorted due to thread tension. Schrader recommends this method for threads and fabrics which can be heat-set, particularly for use on sewing threads of polyester which can still be heat-set at an iron temperature of 350° F.

Seam Puckering Studies in Clothing and Textiles Research

Several masters' theses in recent years have dealt with the problem of reducing seam pucker in home sewing. Kathleen Whiting Lipp of Cornell University (19) developed a method for producing a seam on wash and wear fabric which would not pucker. Her recommendations include the following:

1. Tension as loose as it is possible to retain a balanced stitch. (The top tension was set at one-half for this study and the bobbin adjusted accordingly.)
2. Very small needle diameter (size 9).
3. Six stitches per inch.
4. Exertion of one-half pound pull on the fabric by the operator, both forward and back.
5. Enough pressure on the presser foot to insure that the machine would feed the fabric through while the operator maintained tension on the fabric.

This method was successful in producing seams which did not pucker, but the resultant seams were too loose to be acceptable for any part of a garment which would undergo stress. Lipp found that polyester thread performed best in her study.

Pauline Kubala Gubbels (20),in a study carried out at Purdue University in 1961, was concerned with the puckering present in lengthwise seams on two qualities of polyester and cotton blend. Her research was conducted with several objectives, one of which was to determine the type of seam, stitch length and sewing thread which would produce seams with the least amount of pucker. The threads tested were cotton and textured nylon. Also among the aims of her study was the testing of single construction seams versus double constructions.

Gubbels concluded that a longer stitch (ten and one-half stitches per inch) produced less seam pucker than a shorter stitch (fifteen stitches per inch). She, too, sewed with as loose tension as it was possible to achieve and still maintain a balanced stitch. Her study involved a small diameter needle (size 11) and two threads, cotton and textured nylon. She found no appreciable difference in the amount of puckering between the two threads.

In research conducted at the University of Tennessee, Willie Ruth Nicely (21) tested the effects of several stitching variables on the appearance and the strength of seams in fabrics which contained one or two synthetic fibers. The variables in her study included the following: three types of seams (lengthwise, crosswise, and bias), three sewing threads (cotton, polyester, and textured nylon), needles ranging from size 9 to size 14, and a range of three different stitch lengths.

Nicely's research showed that the polyester thread performed

most effectively in minimizing the amount of seam puckering. The needle with the smallest diameter (size 9) produced less puckered seams than the larger needles. In contrast to nearly all recommendations in other literature, however, she concluded that the shortest stitch length (fourteen or sixteen stitches per inch) yielded seams with fewer puckers than the longer stitch lengths.

This study by Nicely also concludes that yarn distortion, or the "degree of shortening of the finished seam length" was minimized by the use of the best-performing combination described above. She also confirmed that the effect of yarn distortion becomes less as the seam becomes more bias.

PROCEDURE

Fabric Description

The fabric used for this study was a white, plain weave, cotton percale and was selected after comparison with several other similar fabrics because of its tendency to pucker along lengthwise seams. The following tests, conducted according to ASTM Number 1910 specifications, obtained a precise description of the cloth:

1. Yarn count per inch. Warp: 87.1 Filling: 70.9
2. Yarn twist and designation. Warp: Z-22.9 Filling: Z-23.9
3. Weight per square yard: 3.0759 oz.
4. Percent bow and skew: 1.1625% skew

Development of the Sewing Method to Reduce Seam Pucker

Eighteen sewing recommendations suggested in the literature were selected as most adaptable to home sewing and were tested for their effectiveness in reducing pucker. For the preliminary testing lengthwise seams ten inches long were made and evaluated by a panel of judges. Sewing procedures tested and results of the preliminary evaluation are as follows:

Tension

The lower tension was adjusted first by suspending the bobbin in its case from the thread and adjusting the tension screw until the bobbin rode down the thread very slowly. A bobbin "case" refers to the holder, or mechanism, in which the bobbin is placed. There are four types of bobbin mechanisms involved in this study because of the

various types of machines used. The primary distinctions among these mechanisms are enumerated when the equipment is described. The needle thread tension was loosened to the point at which a bad stitch was formed, and then adjusted until a balanced stitch could be made. Since this procedure was widely accepted in the literature, it was held constant throughout the preliminary testing.

Presser Foot Pressure

Pressure on the presser bar was tested by sewing together two eight-inch warp strips of fabric, allowing them to move freely through the feed mechanism. There was no noticeable difference in the amount of pucker in the resulting seams on any of the lower pressure settings, nor was there any difference in the length of the fabric plys after the seam was made. Therefore, the pressure was set at the lowest possible setting and remained constant for the remainder of the preliminary testing.

Needle Size and Throat Plate Hole

The throat plate with the small, round hole was used throughout the study. Two sizes of needles were tested, a Singer size 11 and size 14. The smaller needle, size 11, produced significant reductions in pucker and was selected for use during the subsequent testing.

Stitch Length

The stitch length most commonly recommended for sewing in the home, twelve stitches per inch, was compared with a larger size of

eight stitches per inch. The longer stitch resulted in the least amount of pucker in the seamline and produced satisfactory appearance.

Sewing Thread

Three types of sewing threads were investigated in the preliminary experimentation to determine which one produced the least amount of seam pucker: #50 mercerized cotton, nylon, and polyester. The nylon thread is commercially available as "Taslan" and is produced by Coats and Clark. The polyester thread produced slightly less pucker than the other two threads but is not commercially available to consumers. It was therefore eliminated from the study. There was no clear-cut difference between the cotton and nylon threads, so both were selected for use in the experiment.

Use of Pins

Since it was suggested in the literature that the use of pins may affect seam appearance, preliminary test seams were evaluated for pucker after two treatments: no pinning, and pinning with pins perpendicular to and crossing the seam line. Contrary to expected results as indicated in the literature, less pucker resulted when pins were used.

Sewing Speeds

Sewing speeds ranging from moderately slow to very rapid (i.e., racing the machine) were evaluated for their influence on seam

puckering. The test seams sewn at a very fast speed were better than those sewn slowly. This finding was contrary to recommendations in the literature.

Operator Handling of the Fabric

Test seams which had been fed through the machine naturally without any stress having been placed on them by the operator were compared to those which had been held taut. Those to which tension had been applied showed marked improvement over those which had been allowed to feed through freely.

Pressing

Tests were made to determine whether pressing the plys flat before pressing them open had any bearing on the amount of pucker along the seam. Evaluation of the seams showed that pressing them flat first actually increased the puckering problem. The method which proved best was to press the seam open on the wrong side, then turn it over and press it on the right side.

The results of these preliminary tests were incorporated into the following method for reducing pucker in fabrics which exhibit that tendency:

1. The tension setting must be adequately loose. The bobbin is adjusted first by suspending the bobbin in its case from the thread and adjusting the tension screw until the bobbin slowly "rides down" the thread. The top tension is then adjusted to form a balanced stitch.

When sewing on a machine with a stationary bobbin mechanism another method of obtaining the correct tension setting is required. Two strips of fabric are sewn together on the bias. If either thread breaks when the stitching line is given a quick jerk, the tension on that thread is too tight.

2. Pressure on the presser foot should be the minimum amount which will allow the machine to feed the fabric through naturally with no resultant difference in the lengths of the plys.

3. A small throat plate hole must be used.

4. A small diameter needle performs best. (Size 11 was used for this study.)

5. The stitch regulator should be set at eight stitches per inch.

6. Pins should be perpendicular to and crossing the seam line at intervals of approximately four inches.

7. The operator should sew as fast as it is possible to maintain control of the fabric.

8. The fabric plys should be held taut by the operator as they pass through the feed mechanism.

9. The seam should be pressed open on the wrong side and then top-pressed on the right side.

Testing the Effect of the Method

The second stage of the experiment was conducted to determine if significant improvements would result in seams prepared by home

sewers who used the method. This part of the testing occurred in three stages, hereafter referred to as Phase I, Phase II, and Phase III. Phase I involved the preparation of seams by each individual, who was directed to sew as she normally did at home, without any instructions. The machines had been given the standard adjustments recommended by the Singer Sewing Machine Company plus the specific tension and presser foot adjustments required by the method prior to the testing.

Phase II followed a presentation of the proposed sewing method. The subjects were then asked to prepare seams according to the new procedure without readjusting the machine tensions. Phase III required the subjects to adjust the lower and upper tensions and then, using the new method of sewing, prepare more seams for evaluation.

Subjects

The proposed sewing method was tested on two groups of home sewers, an adult group of sixteen which was tested in the Virginia Polytechnic Institute clothing construction laboratory, and a group of eight high school girls. The high school group performed in the Blacksburg High School laboratory. The size of the two groups was limited by the number of machines in each laboratory.

The participants in the experiment were selected through the use of a questionnaire which furnished the following information:

Name and address

Age (approximate)

Occupation

Education

Years of sewing experience

Method by which subject learned to sew (i.e., self-taught, from parent, sewing classes, college, etc.)

Approximate number of garments made per year

Most frequent sewing problems (e.g., fitting, construction details, seam appearance, pressing, etc.)

It was felt that the number of years one had been sewing and the number of garments made by that person per year would indicate the likelihood of that individual having encountered the problem of seam pucker and might also be related to the skill with which the person could be expected to perform. Therefore, the population was grouped into categories according to the criteria below:

Adult Group

Number of garments made per year	Years of Sewing Experience			
	1 - 10	10 - 20	20 - 30	over 30
10 or less				
10 - 20				
20 - 30				
over 30				

Participants were chosen at random from each of the categories. The high school group was selected in a similar manner, but the categories ranged from one to three years experience and from one to three or more garments per year, providing a much more homogeneous group than the adult group.

Equipment

All of the sewing machines used for the study were made by the Singer Company, though they ranged considerably in age and model. All of the machines used for the adults' testing were slant needle machines, and six of these had the reel type bobbin. The other ten machines all had a "drop-in" bobbin mechanism, but the holder for the bobbin could be removed from the machine for tension adjustments. The cases which held the reels could be removed in the same manner. These machines were professionally adjusted by the Singer representative prior to the testing so that their performance would be as similar as possible.

The sewing machines at the high school were much more varied in both age and adjustment. Two of the eight machines were of the slant needle type, and the rest were older, straight needle models. The two oldest machines had stationary bobbin cases which could not be removed from the sewing machine. Two others had the "drop-in" bobbins in which the entire mechanism, that is, the bobbin and its holder could be removed from the machine if desired. Three of the high school machines had the traditional bobbin case, which must be removed for each rethreading of the bobbin, and one machine had a reel bobbin. The machines for the high school group were not professionally adjusted before the testing. It was felt that some of the differences in the performance of the two groups might be traced to the condition of the sewing machines. Furthermore, if the proposed sewing method were effective using machines of varied type and adjustment, then it would be more likely to be generally effective for all

home sewers, since machines vary in age and condition.

Each subject in both groups was supplied with a size 11 needle, Number 50 cotton and nylon threads. A paper of pins was on hand at each machine, and a small screw driver was provided in order to make tension adjustments.

Preparation of the Test Specimens

Eighteen lengthwise strips were prepared and coded for each subject. Each strip was 4½" by 15" so that when two were seamed together, a 9" x 15" rectangle would result. In addition to the test specimens narrow lengthwise strips were provided as practice strips for use as the subject wished.

Illustrative Material and Instruction Sheets

Large charts were prepared to illustrate the following: adjustment of the stitch regulator, where and how to pin, and tension adjustment. There were three charts on tension adjustment--one to explain what is meant by a balanced stitch, one which covered adjustment of the needle thread tension, and another to explain adjustment of the bobbin thread tension. These were enlargements from the Singer Manual, page 11 (12).

Mimeographed instruction sheets were distributed for Phase II and Phase III of the study. They included a step-by-step description of the method of reducing pucker and were intended to eliminate error which might have arisen from individual note-taking. These instruction sheets are reproduced in the discussion of Phases II and III.

Experimental Procedure

Phase I

Each subject was assigned a sewing machine and a pressing unit and asked to sew and press three 5/8" seams for each of the two types of thread, sewing as she normally would at home. The problem of seam puckering was not mentioned at this point, and no instructions as to special sewing techniques were given. The subjects were asked to adjust the stitch length according to their own judgement, but were cautioned not to change any other machine setting. Seams sewn with cotton thread were completed first, and nylon seams were sewn second to avoid the necessity of rethreading the sewing machine before the next phase.

Phase II

At this point the problem of seam puckering was explained to the experimental group. A mimeographed instruction sheet was distributed, and the methods of reducing pucker which do not apply to tension adjustment were explained. For this phase the group was asked to complete the nylon seams first, and then sew the cotton seams. The following is a reproduction of the instruction sheet by which the method for reducing pucker was taught:

Sewing Method for Wash and Wear

1. Set stitch regulator for eight stitches per inch.
2. Pin edges of fabric together with pins perpendicular to and crossing the seam line. Use about four pins.

3. Sew as fast as you comfortably can. Sew at a steady speed, and make as few jerky stops and starts as possible.

4. Hold fabric taut, with one hand in front of presser foot and one in back. Let fabric feed through naturally at its own speed. Tricks: Pull evenly with both hands. (It may help to sew with elbows raised off table.)

5. Press seam open. Then top press seam on right side.

Phase III

The subjects were presented the theories and methods of gaining proper tension adjustment. In the meantime, those assisting in the testing altered the tension adjustments on each machine. Upon completion of the explanations the subjects were asked to restore their machines to proper adjustment, using the test strips which had been provided to test the accuracy of the adjustment. When the subject felt that her tension was properly set and balanced, she completed another set of three seams, this time using only cotton thread.

The mimeographed sheet which was distributed for reference included the following information, which was supplemented by several large charts on tension adjustments:

Tension Adjustments

I. Adjust bobbin tension

A. Remove bobbin and bobbin case from machine by flipping up black H-shaped holder.

B. Replace bobbin in case and pass thread through slot as if preparing to sew.

C. Let bobbin and bobbin case dangle from thread:

1. If case slowly slides down thread in response to a slight "yo-yo" motion, tension is correctly set.

2. If case will not slide down thread, even with slight urging, tension is too tight:

   a. Turn the larger of the two screws to the left "just a hair" to loosen.

   b. Check for correct adjustment by dangling case from thread as before.

   c. Readjust if necessary, and replace in machine.

3. If case plunges down thread or will not stay suspended from thread, tighten screw very slightly and test again.

Caution: Screw is very sensitive and needs only a very slight turn.

II. Adjust top tension, after replacing bobbin and case in machine.

1. Loosen tension (turn to left) until a bad stitch is formed.

2. Tighten gradually and test until a balanced stitch results.

Collecting and Evaluating the Data

The coded specimens were randomized for presentation to a panel of three judges, all of whom were trained in the evaluation of seam puckering. The method of displaying the seams was adapted from specifications provided in AATCC Method 88B-1964T (23). A paired comparisons method of analysis was used rather than the wash and wear ranking chart specified in the test method. It was felt that this adaptation would be most satisfactory because the primary consideration in this study was individual improvement in the phases of the experiment rather than the specific degree of pucker in each seam. The members of the

adult group, whose machines had been adjusted prior to the testing, were expected to improve during Phase II and reproduce the original tension adjustment (or improve it) during Phase II, so that their performance during Phase III would at least equal that in Phase II. The high school group, sewing on unadjusted machines, was expected to show progressive improvement during the experiment. For this group Phase III was expected to be significantly better than Phase II, and Phase II should have been significantly improved over Phase I.

Each individual's performance was evaluated separately, and cotton seams were considered separately from the nylon seams within each set. The study was not intended to compare the individual's work with another's. The seams were paired (with the nylon and cotton seams in two different groups) so that the first seams done in each of the three phases were compared; the second seams done in each phase were compared; and then the third seams done in each phase were compared.[1]

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[1]The coding system, explained as follows, will further illustrate the method of pairing the seams:

Example 1. 1 - Subject Number 1

I - Phase I (no instruction)

a - first seam sewn in Phase I (The lower case letter indicates that cotton thread was used. A capital letter would have indicated the use of nylon thread.)

Example 2. 12 - Subject Number 12

Seam 1Ia was therefore compared with Seam 1IIa and Seam 1IIIa. These three seams were paired so that all their possible combinations would be seen by the judges (i.e., the pairs would be as follows: 1Ia and 1IIa, 1Ia and 1IIIa, 1IIa, and 1IIIa, 1Ib and 1IIb, etc.) To insure adequate replication for purposes of statistical analysis, each combination (pair) was viewed three different times, making a total of thirty-six comparisons to be made in random order for each subject's set of seams.

The pairs of seams in each set were randomized separately for each of the judges. To insure complete randomization, they were placed on the viewing board one pair at a time so that it was possible for the same pair to appear twice in succession without the judges' being aware that they were viewing the same two seams they had previously rated. In addition, the individual seams in each pair did not necessarily appear on the viewing board in the same position, that is, either on the left or on the right.

Each of the judges had been instructed to give a rating of "1" to the seam preferred in each pair, "2" for the other seam, and "0" if they could perceive no difference between the two seams being presented. This evaluation took place in standard atmosphere under lighting

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II - Phase II (after instruction)

B - Second seam in Phase II
- (Seam was made with nylon thread)

The preceding example would appear on a seam in 1Ia and 12IIA.

conditions specified in AATCC Standard Test Method 88B-1964T. Each judge viewed the seams from a distance of approximately ten feet.

Statistical Analysis

For the sets of cotton seams the responses of the judges were tabulated, totalled, and the results were analyzed by computer. The computer program was devised on the basis of a paper by Otto Dykstra, Jr., of the General Foods Research Center, Tarrytown, New York--"Rank Analysis of Incomplete Block Designs. Method of Paired Comparisons Employing Unequal Repetitions on Pairs" (24). The program provided for refinement of the individual probabilities associated with the responses and grouped the results according to a modification of Duncan's Multiple Range Test at a significance level of .05.

Since there were only two phases of the experiment which involved nylon thread, the binomial method of analysis was used on that data.

IV. RESULTS AND DISCUSSION

Statistical Analysis

The primary statistical tools used in the evaluation of the data from this study were the computer program based on Dykstra's paper (24) and the binomial test. For cotton thread there were three sets of paired comparisons data for the three phases of the experiment. The computer program, which had been developed for analyses of the results of paired comparisons evaluations was used for this data. It yielded the probabilities of preference associated with each phase of the study for each subject and grouped these probabilities for significance at the .05 level according to Duncan's Multiple Range Test. The higher the number for a particular phase, the greater the probability of that phase being preferred. Close examination of the probability values can also indicate some trends and implications of the results, though these generalizations are not necessarily significant.

For nylon thread there were only two phases and, consequently, only two sets of data. This was a binomial situation and lent itself to application of the binomial test. Since the sample size (n) remained the same for all of the subjects it was possible to solve the equation in reverse to determine what x would have to be in order to be significant at the .05 level. It was found that the number of preferences must be 18.596 or greater for the judges' preference to be considered significant.

The results of these analyses are presented in the paired comparisons format (i.e., the preferences for Phase I are evaluated against preferences for Phase II, Phase I is compared to Phase III, and Phase II is compared to Phase III for each subject individually). The following discussion deals with each of the comparisons but is limited only to those results which are significant according to the previously determined standards.

Comparison of Each of the Phases of the Experiment

Adult Group

In general the members of the adult group responded well throughout the testing, but several individuals had difficulty sewing with the nylon thread; that is, their machines repeatedly jammed after a few inches of stitching. Five of the women reported this difficulty. Those assisting with the testing confirmed that the machines had been threaded correctly and could find no mechanical faults, but one subject, Number 12, had to change machines for the remainder of the experiment.

In addition the set of nylon seams was sewn after the cotton seams in Phase I, but before the cotton seams in Phase II. The women made practice seams before beginning the stitching in each phase, but they gained experience on the nylon seams in Phase II which possibly helped them when they sewed the cotton seams. This may partly account for the fact that there was a slightly stronger improvement made with the cotton seams in Phases I and II than with the nylon seams.

Cotton Thread - Comparison of Phases I and II

Comparison of the results of seams made with no instruction (Phase I) and seams made after the method was explained to the group (Phase II) showed that Phase II was significantly improved over Phase I in twelve of the sixteen cases (75%). In two of these cases both Phases II and III were better than Phase I, but there was no difference between Phase II and Phase III. (Phase III involved tension adjustment as well as use of the method.) In the remaining four cases there was no significant difference between Phase I and Phase II.

In only one case (Subject 7) is the number of preferences for Phase I greater than the number of preferences for Phase II. The results of the computer analysis (see Table 9) show that there was no change in this individual's performance during the entire experiment. Table 1 illustrates the results of the judges' evaluation.

Cotton Thread - Comparison of Phases I and III

Differences between Phase I and Phase III are apparent in seven individuals' work. In five of these cases Phase III shows improvement over both Phases I and II. In the other two cases there is no difference between Phase II and Phase III, but they are both better than Phase I. Table 2 further illustrates the results of the judges' comparison.

Cotton Thread - Comparison of Phases II and III

The results of comparing Phase II (use of the method with no further sewing machine adjustment) with Phase II (use of the method

TABLE 1

COMPARISON OF PHASES I AND II

	Number of Judges' Preferences		
Subject	Phase I	Phase II	No Differences
1	2	24*	1
2	3	19*	5
3	2	21*	4
4	7	20	0
5	3	23	1
6	0	26*	1
7	14	13	0
8	2	25*	0
9	6	20	1
10	4	20*	3
11	1	26*	0
12	0	27*	0
13	1	26*	0
14	6	21*	0
15	6	21*	0
16	0	25*	2

*Significant at the .05 level

TABLE 2

COMPARISON OF PHASES I AND III

	Number of Judges' Preferences**		
Subject	Phase I	Phase III	No Difference
1	26	0	1
2	4	16	7
3	16	7	4
4	4	23*	0
5	1	26*	0
6	7	13	7
7	11	12	4
8	6	16	5
9	1	26*	0
10	10	17*	0
11	20	4	3
12	0	27	0
13	18	8	1
14	1	25*	1
15	1	26*	0
16	2	25*	0

*Significant at the .05 level

**More complete information is presented in Table 9. (The significance of these preferences is dependent on the results of comparison of Phases I and II and Phases II and III. For instance, Subject 12: The judges unanimously preferred Phase III over Phase I, yet this is not a significant result. The reason for this apparent discrepancy is the strength of the judges' preference for Phase II in the other two comparisons; it outweighed the preference for Phase III in this comparison.)

after the subject had completed her own tension adjustments) showed that Phase II was slightly better than Phase III. The judges preferred Phase II in nine out of the sixteen cases and chose Phase III at the seams with less pucker in four of the remaining seven cases.

As noted in Table 3, there are only three individuals for which there is no statistical difference between Phases II and III. Out of these three cases, two showed that both Phases II and III were improved over Phase I. The other case, Subject 7, showed no change in performance during any of the three phases.

TABLE 3

COMPARISON OF PHASES II AND III

	Number of Judges' Preferences		
Subject	Phase II	Phase III	No Difference
1	27*	0	0
2	20*	0	7
3	25*	1	1
4	6	18*	3
5	3	24*	0
6	22*	3	2
7	13	12	2
8	23*	3	1
9	7	16*	4
10	11	16	0
11	27*	0	0
12	23*	4	0
13	26*	1	0
14	12	15*	0
15	12	13	2
16	15*	10	2

*Significant at the .05 level

Nylon Thread - Comparison of Phases I and II

When nylon thread was used, there was significant improvement in ten of the sixteen cases. For the other six individuals no

difference could be determined between their performance in Phase I and their performance during Phase II. Table 4 shows the results of the judges' evaluation.

TABLE 4

COMPARISON OF PHASE I AND II - NYLON THREAD

	Number of Judges' Preferences		
Subject	Phase I	Phase II	No Difference
1	3	19*	5
2	0	25*	2
3	11	15	1
4	5	22*	0
5	12	3	12
6	4	22*	1
7	9	14	4
8	2	25*	0
9	13	11	3
10	3	24*	0
11	3	21*	3
12	1	26*	0
13	18	9	0
14	1	26*	0
15	0	27*	0
16	16	9	2

*Significant at the .05 level

High School Girls

The performance of the high school girls was generally good, but Subjects 1 and 2 of the high school group produced seams in which Phase I (no instruction) was significantly better. In these two cases there was no difference between Phase I and Phase II, but they were

both better than Phase III. As discussed in "Procedure" the sewing machines at the high school varied considerably in age, though they were all made by the Singer Company. Subjects 1 and 2 were sewing on the oldest of these machines. The bobbin cases were not removable, so the adjustment of the tensions in Phase III had to be completed by the bias strip method. The rest of the sewing machines were comparatively up-to-date. Since these two girls' age and experience levels were comparable to some of the others in the group who did well, the age of the sewing machine on which they were sewing may have had a causal relationship to their performance.

Some difficulty was also encountered by this group when sewing on nylon thread. Those assisting with the testing found two individuals whose machines were threaded improperly and corrected the threading, but some stitch jamming and tightening was still in evidence.

Cotton Thread - Comparison of Phases I and II

There were three cases out of the total eight in which Phase II was significantly better than both Phases I and II. For the other five subjects there was no statistical difference between Phases I and II. Table 5 shows a breakdown of the judges' preferences.

It should be noted that a distinction exists among the five cases for which there was no statistical difference between Phase I and Phase II. For two of these individuals, Phases I and II were the best seams in the set, that is, they exhibited less pucker than the third phase. For the other three participants, however, Phases I and

TABLE 5

COMPARISON OF PHASES I AND II - COTTON THREAD

	Number of Judges' Preferences		
Subject	Phase I	Phase II	No Difference
1	13	12	2
2	12	11	4
3	20	6	1
4	3	23*	1
5	14	13	0
6	0	26*	1
7	5	19	3
8	0	27*	0

*Significant at the .05 level

II both received a much lower preference rating than Phase III (i.e., they had more pucker).

Cotton Thread - Comparison of Phases I and III.

The performance of five of the high school girls shows a significant difference between Phase I and Phase III; however, in two of these cases Phase III is definitely worse than Phase I. For the three girls who improved, the judges' preferences were quite significant. Table 6 presents these results.

Cotton Thread - Comparison of Phases II and III

Phase II (seams sewn using the method) is significantly different from Phase III (seams sewn using the method after the subject had adjusted the tension) in every instance among the high schools. Three

TABLE 6

COMPARISON OF PHASES I AND III - COTTON THREAD

	Number of Judges' Preferences**		
Subject	Phase I	Phase III	No Difference
1	26*	1	0
2	27*	0	0
3	2	25*	0
4	7	18	2
5	3	23*	1
6	1	26	0
7	1	26*	0
8	0	27	0

*Significant at the .05 level

**The apparent preference for Phase III in this comparison for Subjects 6 and 8 is outweighed by a stronger preference for Phase II in the other two pairs. See Table 9 for the complete relationship of the pairs.

of these eight cases show an improvement for Phase III; the other five show that Phase II was preferred over Phase III, and three of these five were also better than Phase I. The judges' evaluation of Phase II and Phase III appears in Table 7.

Nylon Thread - Comparison of Phases I and II

Six of the high school girls showed significant improvement when they employed the method using nylon sewing thread. Of the other two, one showed no difference between Phases I and II, and the other performed decidedly worse using the method (Phase II). Table 8 illus-

TABLE 7

COMPARISON OF PHASES II AND III - COTTON THREAD

	Number of Judges' Preferences		
Subject	Phase II	Phase III	No Difference
1	26*	0	1
2	26*	1	0
3	0	27*	0
4	18*	8	1
5	4	23*	0
6	22*	5	0
7	1	26*	0
8	20*	2	5

*Significant at the .05 level

TABLE 8

COMPARISON OF PHASES I AND II - NYLON THREAD

	Number of Judges' Preferences		
Subject	Phase I	Phase II	No Difference
1	24*	3	0
2	2	24*	1
3	10	16	1
4	2	25*	0
5	7	20*	0
6	0	27*	0
7	3	23*	1
8	6	19*	2

*Significant at the .05 level

trates these results in terms of the number of preferences the judges recorded for each phase.

Overall Performance -Phases I, II, and III

In general both the adult women and the high school girls were able to sew smoother seams after they had been taught the method. For the adult group, using cotton thread, instruction (i.e, either Phase II or Phase III or both) always produced smoother seams, with one exception. As noted previously the excepted case was unaffected by the method; her performance remained the same throughout the testing.

The judges' choices for the adult group indicated that nine of the subjects performed best (i.e., produced the smoothest seams) during Phase II, using the method alone. Only four of the women showed their best work after adjusting the tension (Phase III). For two members of the adult group both Phases II and III were preferred over Phase I, but the judges could distinguish no difference in the performance of these two individuals when they used the method alone (Phase II) and when they employed the method after making tension adjustments. For these two cases we may state that the sewing method reduced the amount of pucker in the test seams, and adjustment of the tension had no increased effect on the amount of pucker. The method of reducing pucker, therefore, never worsened the appearance of the seams sewn with cotton thread, but resulted in a smoother seam line for fifteen of the sixteen adults who participated, or 93.75%.

For nylon thread the judges' preferences were not so pronounced.

as for cotton thread. Ten of the subjects could use the method successfully with nylon thread, but the other six adults showed no significant change in performance from Phase I to Phase II using nylon thread. This amounts to a level of improvement of 62.5% for nylon thread.

The high school girls showed slightly less improvement for cotton thread and slightly more for nylon than the adults. Three of the girls performed best during Phase II and three others produced their smoothest seams during Phase III (after tension adjustment). The performance of the other two girls showed that the method had no effect for them (i.e., there was no statistical difference between Phase I and Phase II). The appearance of the seams done by these two girls actually deteriorated after they adjusted the tension on their machines. These results indicate that 75% of the girls responded favorably to the use of the method, using cotton thread.

When nylon thread was used, the high school girls had a slightly higher percentage of success than did the adults. Six of them performed better using the method with nylon thread. One of the two girls who performed poorly using cotton thread had a high degree of success with the method using nylon thread. The performance of the other girls deteriorated as before. The total percentage of improvement among the high school group using nylon thread was 75%.

The histograms on pages 55 & 56 illustrate the significance of the preferences of Phases II and III over Phase I. Out of the total group of twenty-four subjects, the method had a detrimental effect on only two individuals. In twelve of the total cases the judges preferred

Phase II as the seams with the least pucker. Seven subjects performed best during Phase III, while two others did well in both Phases II and III (i.e., there was no statistical difference between these two phases). Only one subject remained absolutely unaffected by any of the instructions during the testing. When considering the groups as a whole, it is seen that the method of reducing pucker had a positive effect on 87.5% of the subjects when using cotton thread.

Data from the testing of nylon thread is somewhat less convincing. Sixteen of the total group of twenty-four improved during Phase II for a total effectiveness of 66.7%.

Explanations and Implications of the Results

The Experimental Groups

It was expected that some differences in the performance of the two groups would be encountered and that these could be traced to several factors. One of these factors was the age and condition of the sewing machines used for the study. As previously discussed, the machines used for the adult group were all late-model machines which were pre-adjusted by the Singer representative to the specifications recommended by the Singer Company, with specific modifications required by this study. Thus all machines used for the adult portion of the experiment were kept as similar as possible.

The sewing machines used for the high school group were quite different in age and model. They had not been pre-adjusted for the study, and no effort was made to maintain strict controls for the

TABLE 9

SUMMARY OF JUDGES' PREFERENCES AND STATISTICAL ANALYSIS FOR COTTON THREAD

	Subject	I	II	ND	I	III	ND	II	III	ND	Probabilities of Preference*		
											Phase I	Phase II	Phase III
Adult Group	1	2	24	1	26	0	1	27	0	0	0.1037 (b)	0.9060 (a)	0.0000 (b)
	2	3	19	5	4	16	7	20	0	7	0.0414 (b)	0.8639 (a)	0.0966 (b)
	3	2	21	4	16	7	4	25	1	1	0.1726 (b)	0.7683 (a)	0.0619 (b)
	4	7	20	0	4	23	0	6	18	3	0.0970 (b)	0.2495 (b)	0.6631 (a)
	5	3	23	1	1	26	0	3	24	0	0.0231 (b)	0.1432 (b)	0.8361 (a)
	6	0	26	1	7	13	7	22	3	2	0.0344 (b)	0.8893 (a)	0.0795 (b)
	7	14	13	0	11	12	4	13	12	2	0.3333 (a)	0.3333 (a)	0.3333 (a)
	8	2	25	0	6	16	5	23	3	1	0.0517 (b)	0.8270 (a)	0.1255 (b)
	9	6	20	1	1	26	0	7	16	4	0.0571 (b)	0.2428 (b)	0.6951 (a)
	10	4	20	3	10	17	0	11	16	0	0.1599 (b)	0.4246 (a)	0.4208 (a)
	11	1	26	0	20	4	3	27	0	0	0.0378 (b)	0.9627 (a)	0.0072 (b)
	12	0	27	0	0	27	0	23	4	0	0.0000 (b)	0.8550 (a)	0.0241 (b)
	13	1	26	0	18	8	1	26	1	0	0.0509 (b)	0.9312 (a)	0.0241 (b)
	14	6	21	0	1	25	1	12	15	0	0.0674 (c)	0.3570 (b)	0.5793 (a)
	15	6	21	0	1	26	0	12	13	2	0.0675 (b)	0.3782 (a)	0.5584 (a)
	16	0	25	2	2	25	0	15	10	2	0.0184 (c)	0.6231 (a)	0.3684 (b)
High School Girls	1	13	12	2	26	1	0	26	0	1	0.4962 (a)	0.4933 (a)	0.0095 (b)
	2	12	11	4	27	0	0	26	1	0	0.5273 (a)	0.4647 (a)	0.0093 (b)
	3	20	6	1	2	25	0	0	27	0	0.0660 (b)	0.0183 (b)	0.9183 (a)
	4	3	23	1	7	18	2	18	8	1	0.0961 (b)	0.6431 (a)	0.2670 (b)
	5	14	13	0	3	23	1	4	23	0	0.1167 (b)	0.1157 (b)	0.7630 (a)
	6	0	26	1	1	26	0	22	5	0	0.0056 (b)	0.8216 (a)	0.1794 (b)
	7	5	19	3	1	26	0	1	26	0	0.0257 (b)	0.0815 (b)	0.8953 (a)
	8	0	27	0	0	27	0	20	2	5	0.0000 (b)	0.9147 (a)	0.0930 (b)

*The grouping of these probabilities according to Duncan's test is indicated by (a), (b), or (c), with (a) indicating the highest preference. Probabilities with the same letter are not significantly different. Each subject is treated as a separate entity.

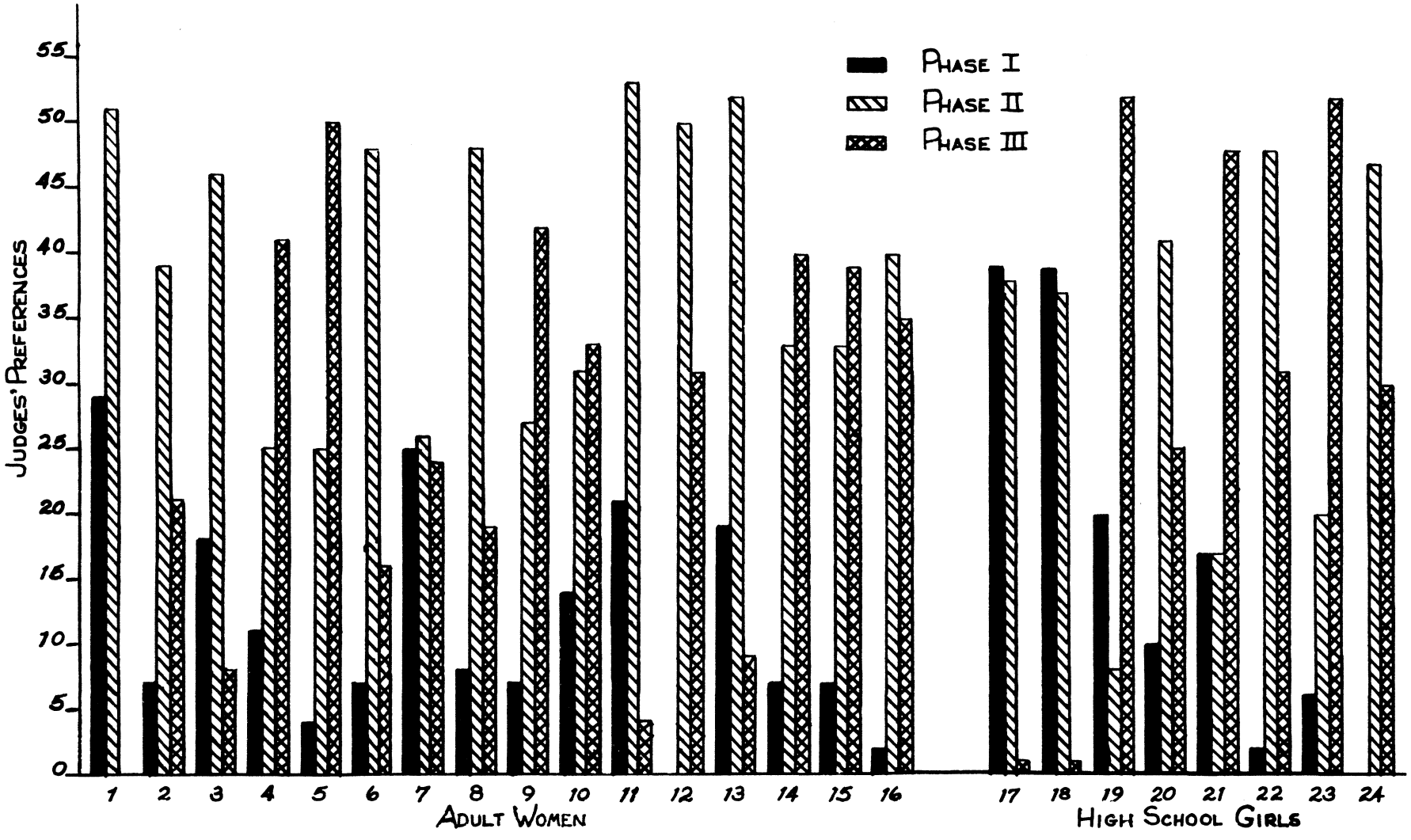

Figure 1 — Cotton Thread: Each Subject's Performance As Indicated by Total Number of Judges' Preferences for Each Phase.

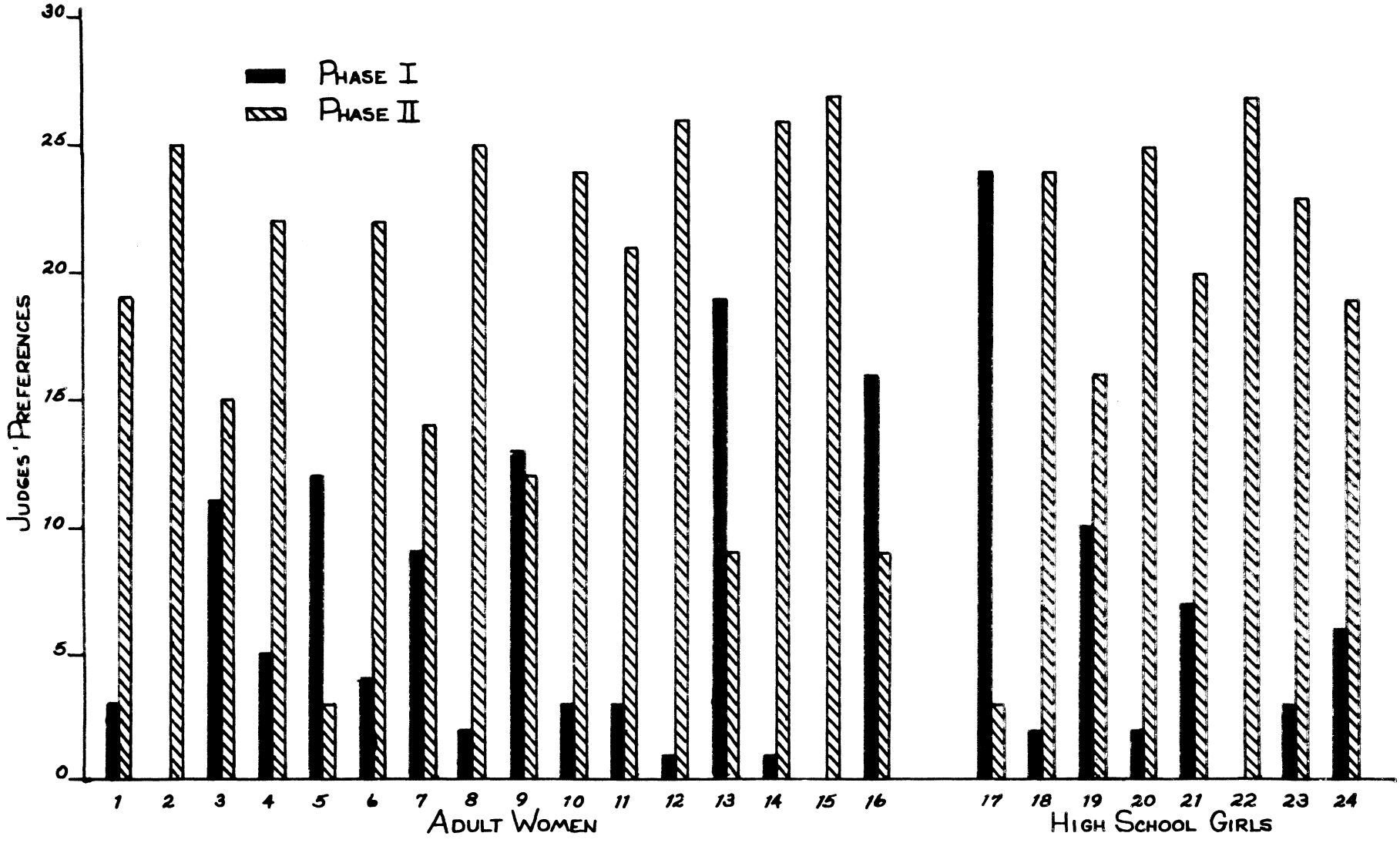

FIGURE 2 — NYLON THREAD: EACH SUBJECT'S PERFORMANCE AS INDICATED BY TOTAL NUMBER OF JUDGES' PREFERENCES FOR EACH PHASE.

the machines as was the policy for those used by the adults. One of the purposes of the study was to determine whether or not the method could be successfully used on widely differing machines.

With only two exceptions, the method succeeded in reducing pucker. As previously discussed, the exceptions occurred in the high school group and were the seams sewn on the oldest of the sewing machines used. Both machines were alike and had bobbin cases which could not be removed. Since these two machines produced the only seams which appeared to be worse after application of the sewing method, it is possible that this effect was caused by the machine and not the operator.

Another factor which was expected to produce some differences in performance was the probable receptivity of each group. It was expected that the high school girls would more readily follow the directions, since they were more conditioned to formal learning processes. The adult women, who were not as accustomed to listening to instructions and then carrying them out, were expected to have more difficulty. To some extent the expectations were true. The high school group did perform the experiment more smoothly with few interruptions and questions and with less confusion than the adult group, but this difference was not evident in the actual results of the judges' evaluation of the amounts of pucker. If the sample size had been larger, some differences might have been detected and traced to this factor.

Correlation of Years of Experience and Garments Made Per Year

Of the seven adults who had any degree of success during Phase III, five were in the category of twenty years of sewing experience or more. It appears from Table 10 that the more extensive a person's experience was, the greater were the chances of that individual having adjusted the sewing machine tensions satisfactorily. Perhaps those with more experience had a greater knowledge of the sewing machine, to the extent that they were more acquainted with the principles of the tension mechanism and had more previous experience with tension adjustment.

The fact that Subject 7, the individual whose performance remains unchanged throughout the study, is in one of the middle experience levels is worthy of note. It is not, therefore, possible to assume that she was so inexperienced in home sewing that the methods being explained would have meant nothing to her.

As shown in Table 10, there seems to be an indication that even those with the least experience can make significant reductions in pucker by using the sewing method alone. Nine adults performed best during Phase II, and six of these subjects fall into the experience category of less than twenty years of sewing. The probabilities associated with their performance reflect a very strong probability of preference by the judges (above .8). It is possible that with more practice these subjects could have developed more skill in tension adjustment and achieved greater success in Phase III.

The distribution of these probabilities over the various

TABLE 10

ADULT GROUP: YEARS OF SEWING EXPERIENCE VERSUS THE NUMBER OF GARMENTS MADE PER YEAR

Garments Made Per Year	Years of Sewing Experience: 1 - 10	10 - 20	20 - 30	Over 30
1 - 10	Subject 1 I 0.1037 (b) II 0.9060 (a) III 0.0000 (b)	Subject 2 I 0.0414 (b) II 0.8639 (a) III 0.0966 (b)	Subject 3 I 0.1726 (b) II 0.7683 (a) III 0.0619 (b)	Subject 4 I 0.0970 (b) II 0.2495 (b) III 0.6631 (a)
10 - 20	Subject 5 I 0.0231 (b) II 0.1432 (b) III 0.8361 (a)	Subject 6 I 0.0344 (b) II 0.8893 (a) III 0.0795 (b)	Subject 7 I 0.3333 (a) II 0.3333 (a) III 0.3333 (a)	*
20 - 30	Subject 8 I 0.0517 (b) II 0.8270 (a) III 0.1255 (b)	Subject 9 I 0.0571 (b) II 0.2428 (b) III 0.6951 (a)	Subject 10 I 0.1599 (b) II 0.4246 (a) III 0.0408 (a)	Subject 11 I 0.0378 (b) II 0.9627 (a) III 0.0072 (b)
Over 30	Subject 12 I 0.0000 (b) II 0.8550 (a) III 0.1495 (b)	Subject 13 I 0.0509 (b) II 0.9312 (a) III 0.0241 (b)	Subject 14 I 0.0674 (c) II 0.3570 (b) III 0.5793 (a)	Subject 15 I 0.0675 (b) II 0.3782 (a) III 0.5584 (a)
				Subject 16 I 0.0184 (c) II 0.6231 (a) III 0.3684 (b)

Results are indicated in terms of the probability values associated with each phase.

*No subject who would agree to participate had the qualifications to fill this category. Subject 16 was selected as the alternate and falls into the same category as Subject 15.

experience levels does seem to indicate that one's previous sewing experience may influence the success with which this sewing method can be employed, particularly the tension adjustments in Phase III.

The high school group was too homogeneous and too small to show any correlation between the amount of sewing experience and the number of garments made per year. All of the girls had less experience than the least experienced subject in the adult group, however. The fact that 75% of these girls had success with either Phase II or Phase III seems to support the assumption that this method can be taught to even very inexperienced home sewers, using machines which vary in age and condition.

The Progression of Performance Over the Three Phases

Adult Group

For the adult group, whose machines were adjusted prior to the testing, Phase II was expected to produce better seams than Phase I, and the performance in Phase III was expected to be at least equal to the performance in Phase II. The probabilities shown by Duncan's Test (Table 9) indicate that this progression is true in only four of the cases. Three more adults, however, show a trend toward this ideal progression, but did not attain statistically significant results, making a total of seven adults who showed some promise toward the anticipated performance.

High School Group

Evaluation of the high school group's performance involved a slight adaptation in the ideal progression. Since their machines had not been adjusted before the testing, it was expected that the girls would improve some using the method alone in Phase II and improve even more in Phase III after adjusting the tension to the recommended setting. However, no one in this group performed in this pattern. Three of the girls did do their best work in Phase III, but the probabilities of preference in Phases I and II are so close that they do not show even a trend toward the anticipated improvement in Phase II.

Therefore, it is not possible to accurately distinguish which factor really accounted for the strong preference for Phase III, the sewing method alone or the tension adjustment. It may have been that these individuals actually made no improvement in the tension adjustment but had just "caught on" to the sewing method during Phase III. It is also possible that these subjects had been using the correct techniques of the method during Phase II and that the tension was so far from the correct wash and wear adjustment that it completely cancelled the effects of the method. This area of the study could be explored again with more attention being given to distinguishing between the two main factors which comprise the total method (the method itself and the tension adjustment).

Performances of Cotton Thread and Nylon Thread

As previously mentioned, this study was not designed to test

the differences in the performance of nylon and cotton threads. However, the fact that the effect of the method on seams sewn with cotton thread seemed stronger than on seams sewn with nylon thread deserves some discussion. The exact reasons for this cannot be pinpointed, but three possible explanations are in order.

First, the nylon seams may have been better than the cotton ones in Phase I and consequently there would be less difference between Phases I and II for nylon thread. Preliminary testing did not indicate that either thread would be more sensitive to the method than the other. Since no comparisons were made of one thread against the other, no conclusive statements can be made about this point.

Second, the data may have been influenced to some extent because the sewing of the seams with the two different threads did not occur in random order. A random order would have been inpractical because it would have involved numerous rethreadings of the sewing machines with the possibility of introducing even more error. As it was, nylon seams were sewn last in Phase I and first in Phase II, giving each subject a little more experience with the method before beginning the cotton seams. This additional experience may partially account for the greater percentage of women who achieved success with cotton thread.

The third explanation lies in the apparent difficulty in sewing with the nylon thread. Some of the seams had minor defects due to these problems, which might have clouded the effect of the individual's performance with nylon thread, though there is no significant pattern

of defects in the data to establish this theory.

When the seams were examined, six sets in the adult group had the type of defect that the five women who reported the sewing problem were producing in their nylon seams, a jammed area of stitching or a few skipped stitches. Two sets of seams in the high school group had these defects, but they were not as severe as those from the adult group. The logical assumption would have been that the older machines which had not been pre-adjusted would have accentuated this problem, but the slant needle machines in the college laboratory were the ones on which the majority of these defects occurred. No explanation has been discovered, but it is possible that the bobbin tension setting on the college machines was more sensitive to the change in threads, and that the nylon thread, being a little more slippery than the cotton, needed a tighter tension on the college machines. More research would be necessary to find the causes of these problems.

SUMMARY AND CONCLUSIONS

The purpose of this study was to develop a method of reducing seam puckering in wash and wear fabrics and determine how effectively it could be used by home sewers. The null hypothesis was that the method would show no reduction in pucker when taught to a group of home sewers.

The test population consisted of sixteen adult women and eight high school girls, and the testing occurred in three phases. In Phase I the subjects received no special instructions about seam puckering and were asked to sew seams as they normally did at home. Phase II followed an explanation of the problem of seam pucker, and instructions were given for the sewing method which was expected to reduce the amount of pucker. The subjects were then asked to sew seams using this method. The third phase required each subject to adjust the upper and lower tensions on her sewing machine to the recommended setting, in accordance with the instructions, and then sew more seams also using the method taught in Phase II.

It was desired to see if the method was effective on more than one thread. Therefore, both cotton and nylon threads were used during Phases I and II.

These seams were then presented to a panel of judges for a paired comparisons analysis of the amount of pucker. The judges' responses were analyzed through use of a computer program for the cotton thread data and by the binomial test for the data from the

nylon seams. Data for each individual was treated as an entity.

In general both the adult women and the high school girls were able to sew smoother seams after being taught the method. For cotton thread the method proved highly significant. It was possible to reject the hypothesis for 93.75% of the adult subjects and 75% of the high school girls. When considering the total group of twenty-four, the hypothessis was rejected in 87.5% of the cases.

The percentages of rejection for nylon thread were slightly lower. In the adult group 62.5% succeeded in using the method, and 75% of the high school girls showed improvement. The percentage of rejection for the total group for nylon seams was 66.7%.

There were several observations made during the study which, due to the design of the experiment, cannot be supported statistically but shed some light on the patterns reflected in the data. They may be of use in further research of this nature.

1. There is some indication that the experience levels of the individuals who participated had an effect on their performance. Indications produced by the data showed that the women who had had more years of sewing experience and also made a large quantity of garments per year were more able to succeed with the tension adjustments in Phase III. The fact that even the least experienced subjects could successfully employ the method in Phase II implies that one could expect a reasonable degree of improvement in seam appearance when teaching this method to almost any group of home sewers.

2. Since the more experienced women did well adjusting the

tension, those with less experience may have improved their techniques with more practice in tension adjustment and would have more easily recognized a balanced stitch when it was attained. It is also reasonable to expect, therefore, that with more practice, and perhaps intensified instruction, a greater percentage of participants could correctly adjust the tension for sewing on wash and wear.

3. It was not possible to ascertain definite differences in the performance patterns of the two groups. The only difference was the way the actual performances of the groups related to their expected performances. No one in the high school group followed the anticipated progression of improvement for sewing on unadjusted machines, whereas, seven adults performed as expected for those using preadjusted machines.

4. There was a slight indication from the data received that the very oldest machines used may have had a detrimental effect when the method was used, especially during Phase III (the tension adjustment). The only two cases in which instruction significantly worsened the appearance of the seams occurred in sets of seams sewn on very old machines which did not have a removable bobbin case. These were the only machines of this type used for the study.

5. The difficulties encountered by the participants when sewing with nylon thread give rise to some questions which cannot be answered by this study. One such problem is why more adults had problems with this thread, when the machines they were using were all preadjusted and all similar, up-to-date models, and the machines used by

the high school girls were much more variable in both age and condition.

It would also be desirable to ascertain why the method did not show as strong an effect for nylon thread as it did for cotton thread. Sewing the nylon seams before the cotton ones in Phase II may have accounted for its slightly lower percentage of success, by giving the individual additional learning opportunity, but this may have been a result of differences in thread characteristics. Perhaps the nylon seams were better than the cotton seams for Phase I and therefore showed less change in Phase II. Further study is needed on this specific problem to determine its causes.

6. Another factor which has been included in several different aspects of the results is the human element involved in an experiment of this type. The results of this study would be much more clear if, for instance, some way of standardizing the sewing skills of the participants existed. Some mechanical ability was necessarily involved in tension adjustment, and a measurement of each subject's aptitude in this area would also have been helpful in understanding some of the differences in individual performance. However, the results indicate that, with further testing, the method of reducing seam pucker may be proved generally effective for all home sewers.

Seam pucker can be reduced using the following procedure.

1. Have the machine set for minimum pressure on the presser foot and use a small diameter needle (Singer size 11 or its equivalent).

2. Adjust the tension to the correct wash and wear setting.

3. Set the stitch regulator for eight stitches per inch.

4. Pin the edges of the fabric together with the pins perpendicular to and crossing the seam line. Use about four pins.

5. Sew as fast as you comfortably can. Sew at a steady speed, and make as few jerky stops and starts as possible.

6. Hold the fabric taut with one hand in front of the presser foot and one in back. Let the fabric feed through naturally at its own speed. Trick: Pull evenly with both hands. (It may help to sew with the elbows raised off of the table.)

7. Press the seam open. Then top press the seam on the right side.

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ABSTRACT

The purpose of this study was to develop a sewing method which could be used in home sewing to reduce seam puckering and to see how well a group of home sewers could use the method to reduce pucker. The hypothesis tested was that use of the method by home sewers would produce no reduction in the amount of pucker in a lengthwise seam.

The sewing method included the following factors: controlling the upper and lower tensions, needle size, stitch length, pinning, holding the fabric plys as they passed through the machine, and pressing. Each subject (home sewer) first sewed seams without using the sewing method, and then used the method to complete more seams. The sets of seams were presented to a panel of judges for comparison, and their responses were statistically analyzed through use of a computer program. Duncan's multiple range test was used to group the results.

The analysis indicated that it was possible to reject the hypothesis for nearly all of the subjects. It was observed that subjects who had the greatest amount of sewing experience apparently were able to use the method with more success than those with less experience. It was not possible to ascertain definite differences in the performance patterns of the high school girls who participated in the experiment and the adult women. The method did not show as strong an effect on seams sewn with nylon thread as it did on those sewn with cotton thread. It is possible that the age and condition of some of the sewing machines also affected the amount of pucker in the seam.