A STUDY OF TACTUALLY PERCIEVED TEXTURES

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INTRODUCTION:

It has long been obvious that the stimulation of one sense organ affects the perceptive end-results accruing from the use of another. There are numerous examples in recent literature in which this seems to be the case. One such case was the investigation of Krekev (3) in which sound and odor stimuli were found to affect critical flicker frequency and the threshold for color. Under some conditions, the use of the sound stimulus raised the c.f.f. and in others it reduced it. The use of an odor as collateral stimulation had a different effect on c.f.f. than it did on color sensitivity. The common explanation of such results as these involves some sort of reduction or enhancement of general excitation.

It is not to be supposed that all connections between the activity of one sense modality and another are to be envisaged on this basis. It is much more likely that certain senses depend for their operation on certain facilities provided by a second sense. This is especially to be expected in the case of certain senses depending on vision. In the first place, sense organs are used to provide the organism with material to solve certain immediate problems. Perception is, basically, a kind of problem solution. If the problem happens to be that of localization in space or that of perceiving the shape and size of an object, it is clear that vision provides the best means of arriving at the solution. Vision stands above all other senses in dealing with space, particularly when remote from the organism. It has well been

given the label of a distance sense. It so happens that by use of certain other senses, such as those of touch and kinesthesis, one often attempts to solve spatial problems. For instance, one may be allowed to feel some solid object while not being allowed to see it, the problem being one of identifying the object or of telling its size and shape. Or it may be one of simply determining whether the object is smooth or rough. Not only are such problems encountered in daily life but, in a few cases, they have been examined in the laboratories. Gutsforth (3), studied the perception of size and shape of blocks when the subject could percieve them only through manual contact. He found that there was a marked discrepancy between visual, and tactually percieved shape and size. The differences however, were not consistent, with the individual and were greater between the trained observers than between naive subjects.

According to unpublished results, Bartley and colleagues (2) found that the size of an object contacted manually was dependent upon the distance of the object from the eyes.

One might well assume that with reference to the sense of touch, texture is a surface property, quite narrowly localized to any one region of the surface area. Hence, the tactual sense may provide a large part, if not all of the material necessary for its perception.

If an individual does succeed in identifying an object or in specifying its size and shape by manual contact, there

is still a question as to whether this is an accomplishment of touch alone. We do know that the usual individual faced with a task such as this, attempts to visualize the object as he manipulates it manually. It seems that the manual manipulation is utilized for the purpose of obtaining information which can be used to fabricate a satisfactory visual image. If we grant this, then it may be said that the tactile information plays a far different role than it would were it used directly to provide the necessary perception. The whole problem of the relation of touch to sight needs considerably more detailed exploration. From what has been said, this exploration might involve two general areas - the one, in which touch might be expected to solve the problem at hand, and the other, in which vision must be somehow involved.

The problem chosen for the present investigation lies in the former area. It is to be assumed that with the proper experimental controls, considerable insight might be gained concerning the inter-relationship of touch and sight. For example, it was assumed in the investigation of Bartley and colleagues (2) that vision played a role in tactile experience involving the perception of object-size. It was supposed that the perception of size was not accomplished without some sort of visualization. On this basis, it was hypothesized that variations in the perception of size mediated by manual contact would follow certain visual laws. For example, it was expected that objects contacted at a distance from the eyes would

appear smaller than those contacted close to them. The rationale for this was that as the object was contacted, the observer visualised the object somewhat in keeping with the distance away from the head. The same object then, whose absolute size was not known, would appear smaller in visualization at a distance than when it was close to the head. Results confirmed this idea. This suggested that touch possessed no outstanding intrinsic means whereby size was percieved but rather had to operate through visualization. Confirmatory to this, congenitally blind subjects were unable to determine the size of an object by touch alone.

STATEMENT OF THE PROBLEM:

As was already pointed out, the area investigated in the present study was that of texture. Although we said that vision probably is only slightly, if at all, involved in the tactual perception of texture, there might be a difference in the outcome with and without vision. Although one might be able to deal with texture without vision, the use of vision simultaneously with touch might result in some differences. The solution of this problem would seem to be one of the early steps in the extensive investigation of the vision-touch relationship. Accordingly, several conditions were set up, some of which involved direct visual observation of the texture of certain surfaces while contact was being made and other conditions involving tactual contact only.

Since texture is primarily a property which can be arranged on a rank-order scale, several degrees of fineness of texture were used with the expectation that if vision influenced the result, it would be in altering the ability to discriminate between textures.

If curves were to be drawn for the responses under the various conditions of using and excluding vision, differences to be found between the several conditions would be just as significant, at least in the light of the conditions used, as if actual differences were found.

Perception of texture by manual contact was studied by Katz (11) some years ago but in his study he made no attempt

to quantify the textures of the stimuli used. He merely chose a series of 14 different surfaces extending from smooth glazed paper through very rough cloth paper, including both soft and hard finishes. It is possible that his scale included qualitative as well as quantitative differences in the stimuli. He made no apparent attempt to determine if an actual scale existed or what stimulus differences could be detected. The essential finding was that conceivable the tactual differences in stimuli were at times too small to be detected. It was our attempt to quantify the problem, at least within the limits of the present availability of different textural surfaces lying on some single continum. For this purpose we chose a series of sandpapers, the nature of which will be indicated in the next section.

METHODOLOGY:

A. Apparatus:

A scale of textures was constructed by using five different grades of commercial sandpaper. The papers used were (from rough to smooth) number 1, 1/2, 1/0, 2/0, and 3/0. The papers were of a uniform color. A microscopic examination of the number 1 paper revealed that the particles varied between 0.2 and 0.5 millimeters in diameter and that those on the 3/0 paper were about one-tenth as large. This size varying as a geometric progression with a common multiple of 2. However, there was a slight shortening of the scale on the smooth end. Paper 1/0, being approximately the center of the continuum, was selected to be the criterion for the judgments. Originally, eight papers were included on the scale but the three roughest (number 2-1/2, 2, and 1-1/2) were eliminated because they were so far from the criterion paper that there was no variability in the judgments .

The papers were cut into 3 in. squares and mounted on 6 in. square blocks of 1/2 in. plywood. These blocks were presented two at a time (one being the standard, 1/0) inside of a box (Figure 1), which had an opening in the front through which the observer could place his hand. This opening was covered by a curtain. The top of the box consisted of two hinged lids so that the observer could be allowed to see either side, both sides, or neither side. The interior of the box was divided into sections by a curtain so that the

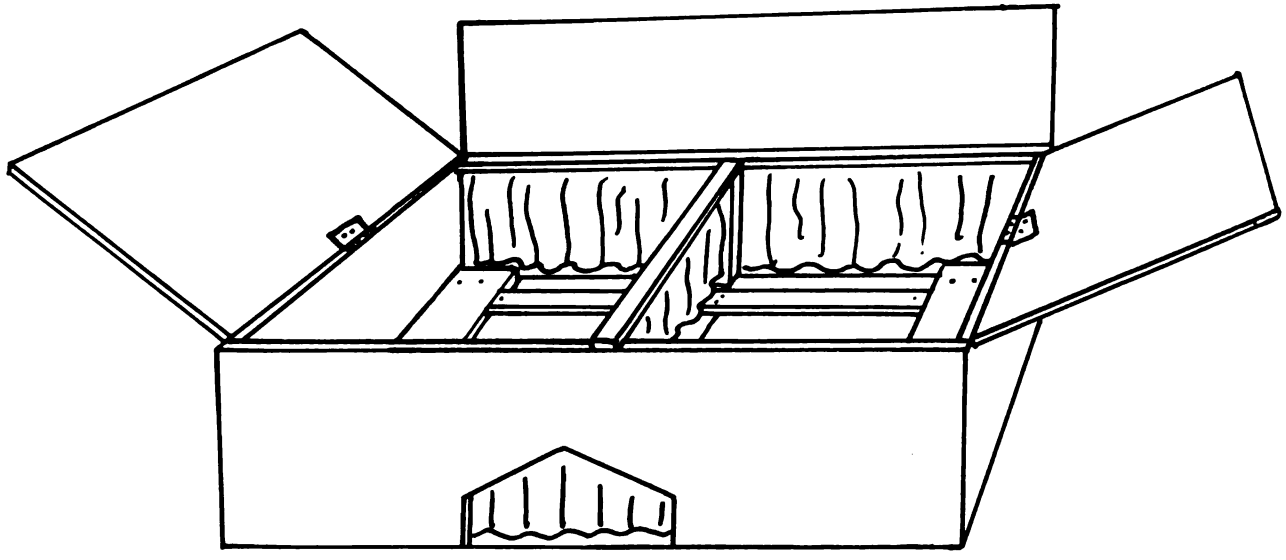


Figure 1

A DIAGRAM OF APPARATUS

observer could pass his hand from one side to the other but could only see a block if the lid on that side were open. On the floor of the box were two slots, each of which held a block while the observer examined it. The rear of the box, which was open to allow the experimenter to insert and remove the blocks, was also covered with a curtain. A screen mounted on the rear of the box prevented vision over the box. This screen, together with the curtain on the rear, prevented the observer from seeing the blocks before or while they were being inserted. Also, this system prevented the observer from seeing the results of his judgments as recorded on the data sheets.

There were 5 blocks with 1/0 sandpaper and one each of the other papers. The various blocks with the 1/0 paper were used in rotation to equalize the wear. A rack was constructed to keep the blocks from rubbing each other and to facilitate their handling. Mimeographed data sheets were used to record the judgments.

B. Population:

One-hundred-and-two right-handed students of Michigan State College were used as observers. Most of them were undergraduates who were recruited from the campus living units - the women from West Mayo Hall and the men from West Shaw Hall. A few were graduate students in the Department of Psychology, but none had had any previous experience as observers in similar situations. There was no attempt to

stratify the sample. Since the data from two of the women observers was discarded for failure to follow instructions, the final population consisted of 30 men and 30 women.

C. Procedure:

The textures were presented two at a time under four different conditions. These were:

I. The observer could see both textures.

II. The observer could see neither texture.

III. The observer could see only the standard texture.

IV. The observer could see only the comparison texture.

Under all conditions, the standard texture (1/0) was presented on the subjects right and examined first. The textures and conditions were randomized by means of Snedecor's Tables (3). The order of presentation is shown in Table 1.

The observers were given the following instructions: "This experiment is concerned with the importance of vision as compared with touch in judging textures. You will be presented with two of these blocks with sandpaper on them, inside of this box. Using your right hand only, you will feel first of the one on your right and then of the one on your left. You are then to judge the one on you left, the last one you feel, as being "rougher than","smoother than", or "the same as" the first. After leaving the first block, you are not to go back to it. You may use three or more fingers but not less than three. When one or both of the covers are open, you are to examine the textures visually as you feel of them. Make your judgments quickly; do not try to "figure it

TABLE 1.

The Order of Presentation of the Comparison texture.

Condition of Vision	Grade of Sandpaper				
	1	1/2	1/o	2/o	3/o
I	1	12	14	18	2
II	10	17	5	7	16
III	6	8	15	13	19
IV	4	3	9	11	20

out". Do you have any questions?

All questions were answered by re-reading the part of the instructions concerned.

After the trials were completed, introspective reports were required on the effect on the different conditions on the perception of the textures.

Microscopic examination of the papers showed that with use, the textures tended to fill up with dirt, thus creating a smoother surface. Also, some of the surface grains were removed from the reported contacts. In order to reduce this variable, two things were done. First, five standard textures (all 1/0) were used in rotation in order to equalize the wear. Second, all the papers were changed after use by every ten subjects. These procedures introduced another variable, that of variation in textures on different pieces of paper of the same grade. However, these procedures did allow each subject to be presented with a closer approximation of the original scale than would have been possible using the same papers throughout.

RESULTS:

The responses of the 100 observers were tabulated and are presented in Table 2. The responses were then tabulated separately for the men and for the women. The responses given by the men are presented in Table 3 and those given by the women in Table 4.

In examining the data, it must be considered that the scale used was a rough one and extended to extremes in either direction with only one point, grade-wise, between the standard texture and either extreme. Thus, the differences between the standard and the comparison texture increased rapidly and as it increased, the percentage of correct judgments increased. This can be seen in Figure 2 where the percentage of correct judgments given under the various conditions are of greater frequency and or smaller range for the end papers (numbers 1 and 3/0) than they are for the three intermediate grades of paper.

To statistically explore the data, the Chi Square technique was used. By this method it was possible to determine whether or not there was a relationship between conditions (considered as one variable) and judgments (considered as the other variable).

If there were a relationship between these two variables, it would follow that, with reference to judgments, we had a heterogeneous set of conditions. In other words, we would have differences in judgments resulting from differences in conditions. We could then conclude that there were differences

TABLE 2.

Summary of Responses: Total Population (N=100)

Condition of Vision.	Judgement given	Grade of Sandpaper 1	1/2	1/0	2/o	3/o	Total
I	R	96	81	18	8	0	203
	=	2	18	64	17	6	107
	S	2	1	18	75	94	190
II	R	100	87	14	5	0	206
	=	0	11	64	37	1	113
	S	0	2	22	58	99	180
III	R	99	82	29	1	1	212
	=	1	16	48	32	3	100
	S	0	2	23	67	96	188
IV	R	95	74	14	1	0	184
	=	4	24	58	22	1	109
	S	1	2	28	77	99	207

TABLE 3.

Summary of Responses: Men (N=50)

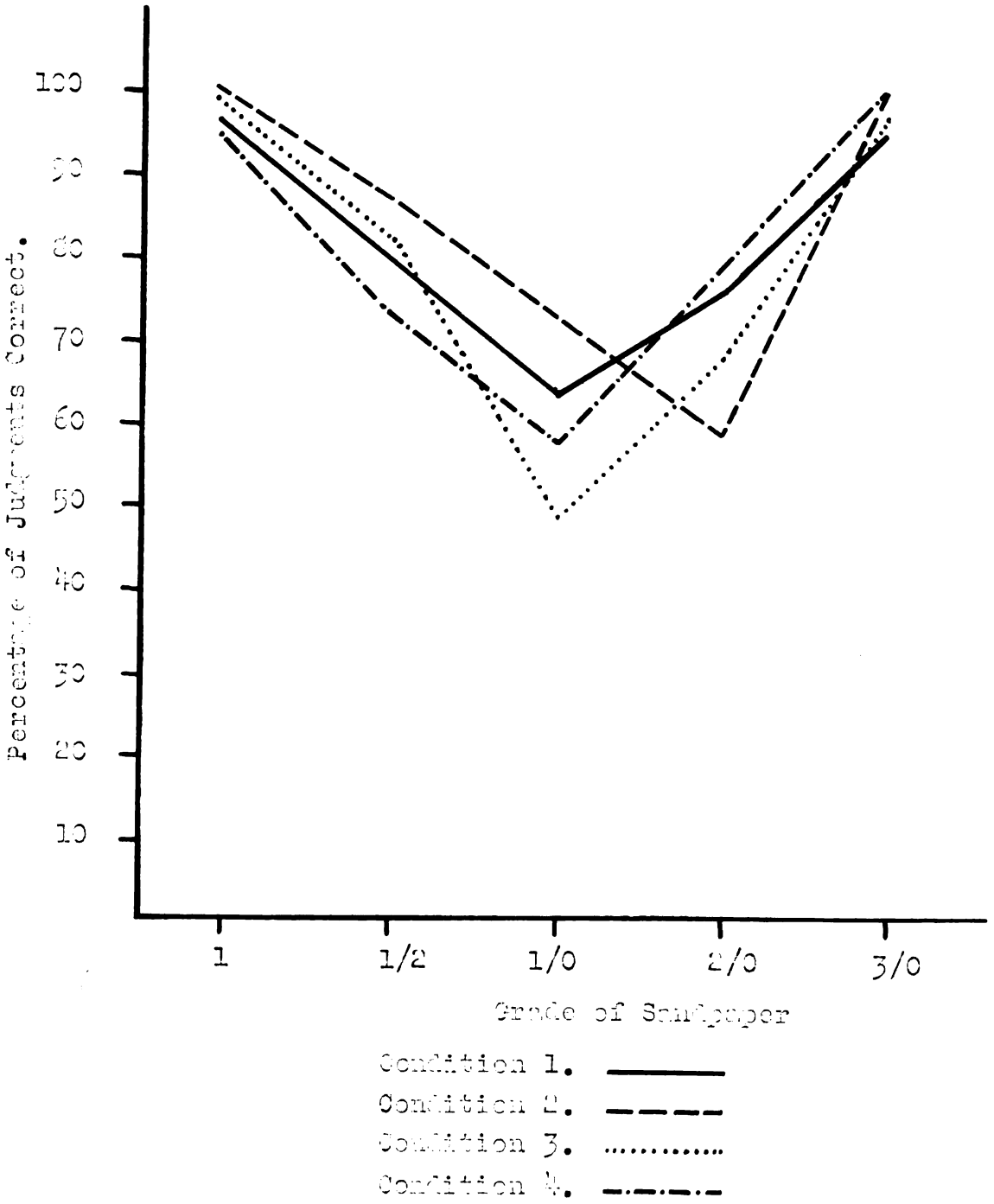
Condition of Vision.	Judgement given	Grade of Sandpaper 1	1/2	1/0	2/0	3/0	Total
I	R	47	37	9	3	0	96
	=	1	12	31	7	0	51
	S	2	1	10	40	50	103
II	R	50	41	7	2	0	100
	=	0	7	33	6	0	46
	S	0	2	10	40	50	102
III	R	50	39	16	0	0	105
	=	0	10	21	14	1	46
	S	0	1	13	36	49	99
IV	R	47	35	5	1	0	88
	=	3	14	28	10	0	55
	S	0	1	17	39	50	107

TABLE 4.

Summary of Responses: Women (N=50)

Condition of Vision.	Judgement given	Grade of Standpoint 1	1/2	1/o	2/o	3/o	Total
I	R	49	44	9	5	0	107
	=	1	6	32	10	6	55
	S	0	0	9	35	43	87
II	R	50	46	7	3	0	106
	=	0	4	31	26	1	62
	S	0	0	12	13	49	79
III	R	49	45	13	1	1	107
	=	1	5	27	13	2	48
	S	0	1	10	31	47	89
IV	R	48	39	9	0	0	96
	=	1	10	30	12	1	54
	S	1	1	11	36	50	100

Figure 2. Percentage of Correct Judgments for Total Population.
(N = 100)



between these four experimental conditions, and that vision did influence the perception of differences in texture (within the limitations of this experiment).

If there were no relationship between conditions and judgments it would follow that with reference to judgments, we had a homogeneous set of conditions. In other words, we could say that so far as any influence upon judgments is concerned, there were no differences between one experimental condition and any other one of the four conditions explored in this study. We could in short conclude that vision did not have any appreciable effect upon the perception of differences in texture (again within the limitations of this experiment).

Since our interest was in the effect of the conditions upon the perception of differences in texture, the Chi Square was used to investigate whether or not there were any relationships between the four experimental conditions and each one of the four classes of judgment ("correct", "rougher than", "equal to", and "smoother than"). This was done for the total population, for the men and the women separately. Similarly, Chi Squares were calculated to determine whether or not the sex of the observer was in any way related to the judgments given.

The results of these breakdowns are presented graphically in Figure 3 for the correct judgments; Figure 4 for the "rougher than" judgments; Figure 5 for the "equal to" judgments and Figure 6 for the "smoother than" judgments.

Figure 3. Correct judgments of men and women under the four experimental conditions.

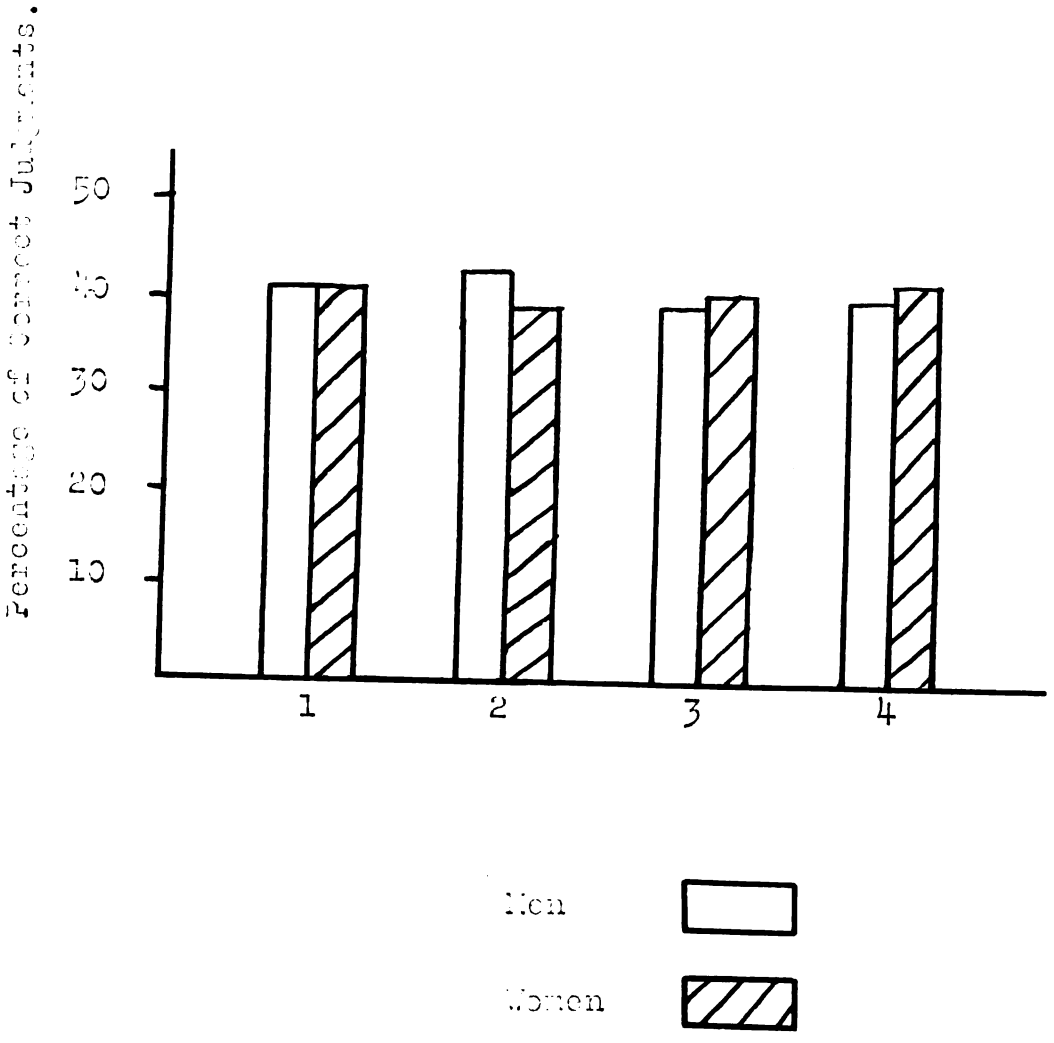


Figure 4. "Longer than" judgments given by men and women under the four conditions of vision.

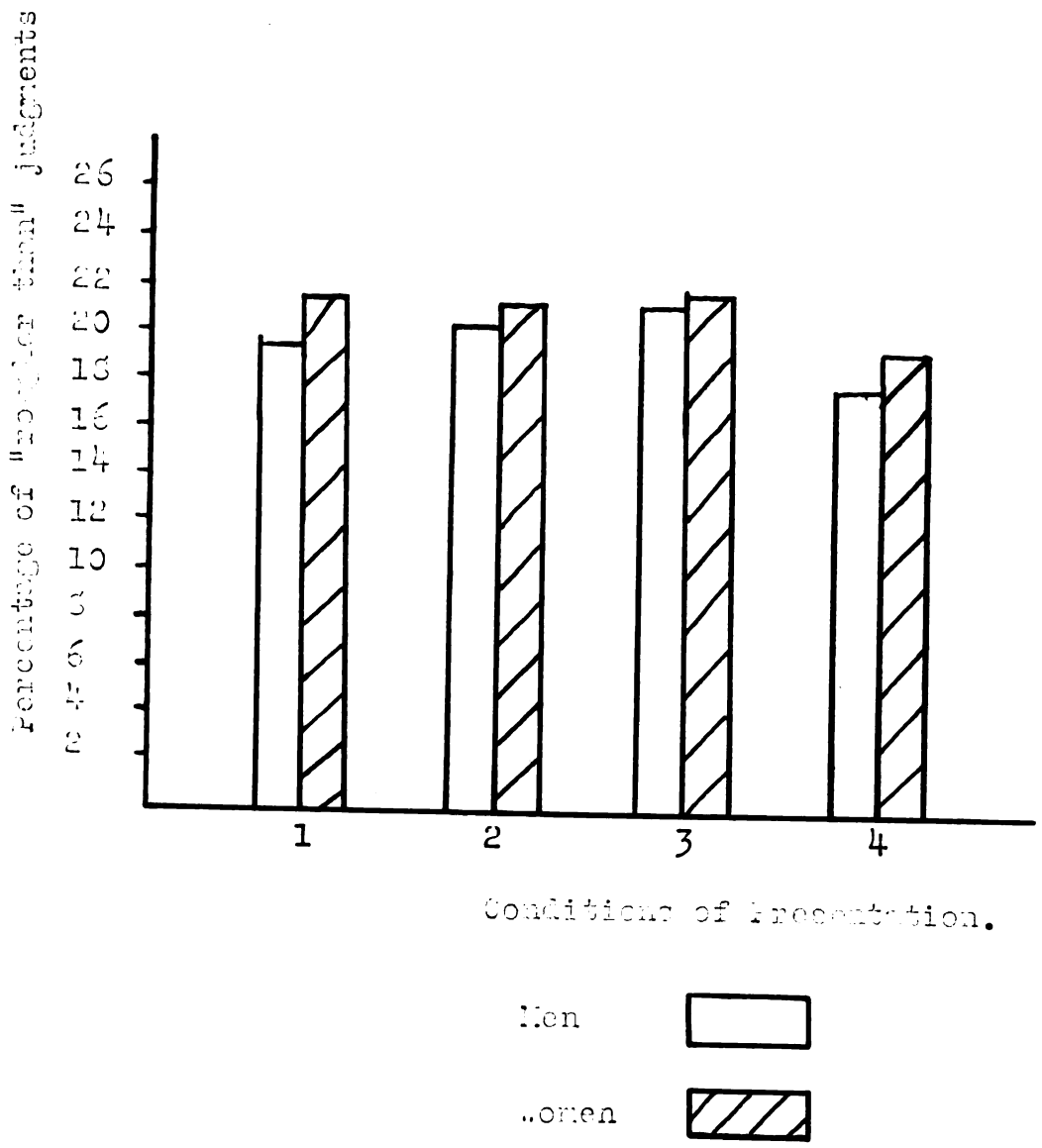


Figure 3. "Equal to" judgments given by the men and women under the four conditions of vision.

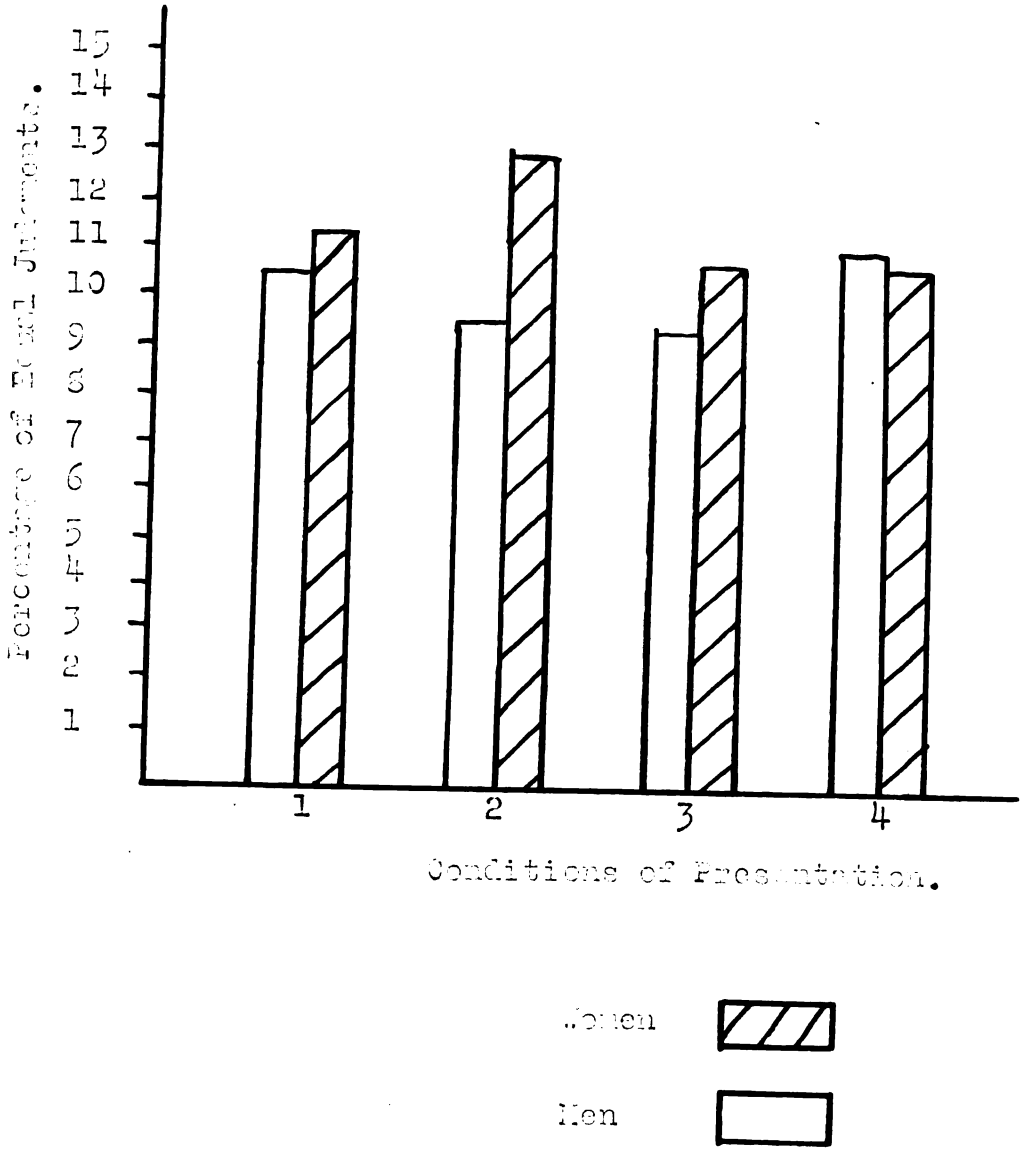
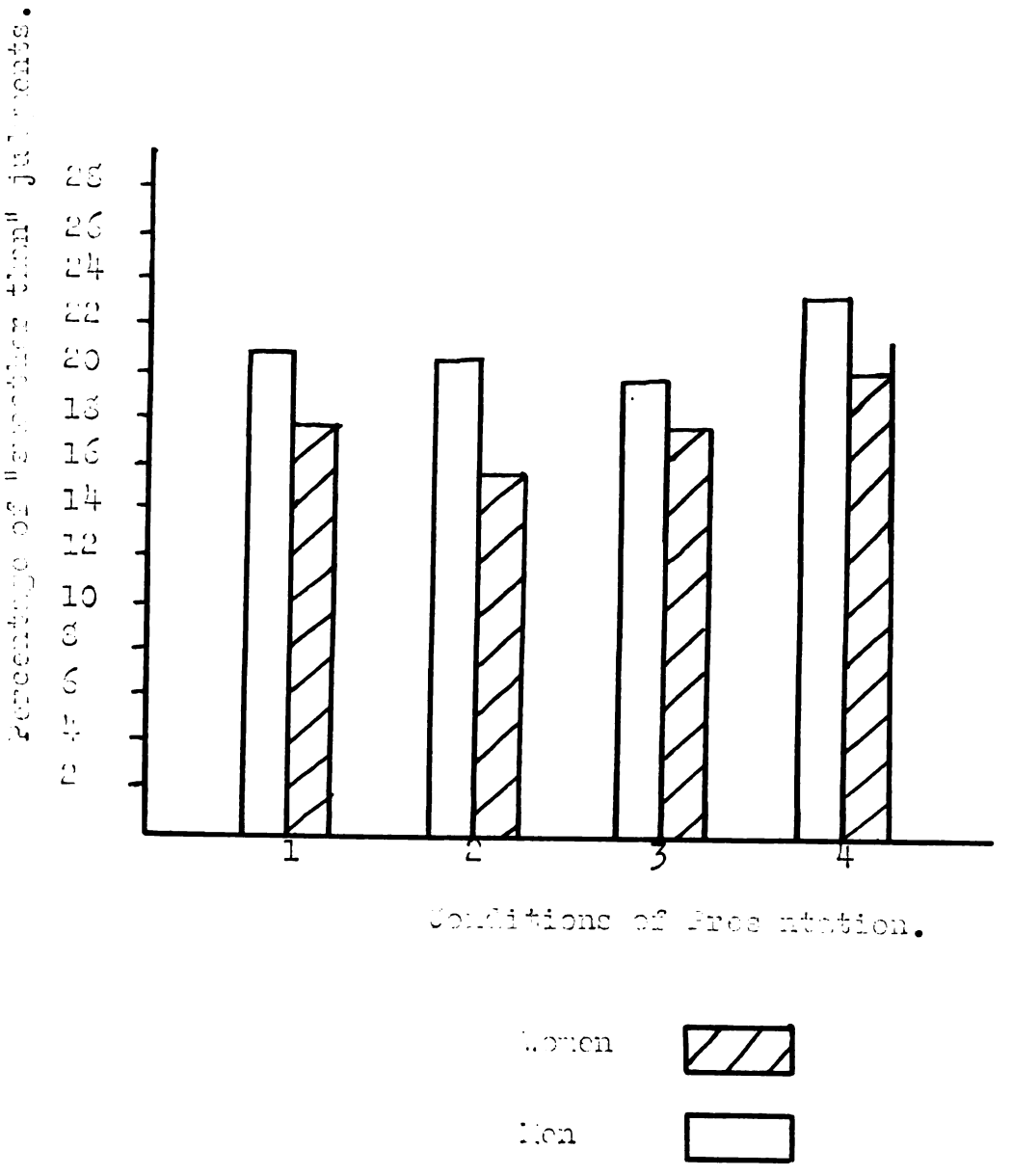


Figure 6. "Smoother than" judgments given by men and women under the four conditions of vision.



Furthermore, the results of the statistical analysis are summarized in Table 5 and the detailed analysis is given in Tables 7 through 29 in the appendix.

None of these results indicate any significant differences either between conditions or between the sexes, with reference to the perception of differences in texture. The values of Chi Square were such as to mean probabilities ranging from 50 chances in 100 to 95 chances in 100 that any apparent differences between the sexes or between conditions were in fact merely chance differences. Within the limits of this study then, vision has no appreciable effect upon the perception of differences in texture.

The results of this experiment agree with those reported by Katz (12) which indicated that vision was not an important variable in judging textures. In evaluating the results of the present investigation, several factors should be considered. The scale used, although a more homogeneous one than that used by Katz was quite rough and was not a strictly equal-interval scale. The points used were quite far apart and the scale was slightly shorter on the smooth side than on the rough. It is barely possible that with the avoidance of these limitations, some differences between the experimental conditions might have appeared.

Although there were no differences in the judgments given under the various conditions, the subjects felt that they were. This can be seen in the verbal report (Table 6).

TABLE 5.

Summary of Statistical Treatment.

Group Considered	χ^2	d.f.	p.[1]
6.1 Correct, rougher, smoother and equal judgments under the four conditions.			
Total population	5.2661	9	80%
Men	3.3552	9	95%
Women	6.8596	9	70%
6.2 Correct judgments given under the four conditions.			
Total population	0.4829	3	90%
Men	1.0674	3	75%
Women	0.4300	3	90%
6.3 Rougher judgments given under the four conditions.			
Total population	2.1301	3	50%
Men	1.5913	3	50%
Women	0.8269	3	80%
6.4 Equal judgments given under the four conditions.			
Total population	0.8275	3	90%
Men	0.1750	3	90%
Women	1.4454	3	70%
6.5 Smoother judgments given under the four conditions.			
Total populations	1.8956	3	60%
Men	0.3137	3	95%
Women	2.5524	3	50%
6.6 Comparison of judgments given by men and women under the four conditions.			
Correct	0.2437	3	95%
Rougher than	0.3245	3	95%
Equal to	1.5422	3	70%
Smoother than	0.1945	3	98%

1. The probability (p) must be 5% or lower before we can conclude that any differences exist. From the probabilities presented in this table, we must conclude that the only differences between conditions, judgment given or sex are due to chance.

TABLE 6.

Tabulation of Introspective Reports.

Report given	Women		Men	
	No.	%	No.	%
No difference	6	12	10	20
Best under Condition 1	5	10	19	38
Best under Condition 2	25	50	5	10
Best under Condition 3	1	2	0	0
Best under Condition 4	2	4	2	4
Best when only one could be seen;	2	4	1	2
Don't know	14	28	5	10

Thirty-six per cent of the men felt that there were no differences and 56% felt that their judgments were most accurate when they could see both textures. The women did not agree with the men. Only 12% felt that there were no differences and 40% asserted their judgments were most accurate when neither texture could be seen. In this connection, it should be noted that only 10 of the 100 observers felt that they did their best when only one texture could be seen.

Although there were no measurable differences between the conditions, it would seem from the verbal reports that there was a phenomenological difference, and this difference was not the same for both sexes.

SUMMARY.

An approximately equal-interval scale of five textures was constructed from different grades of commercial sandpaper. The center paper was selected as the standard. Each paper was compared with the standard under 4 conditions of presentations by 30 men and 30 women. The conditions were:

I. The observers could see both textures.

II. The observers could see neither texture.

III. The observers could see the standard texture only.

IV. The observers could see the comparison texture only.

The results were treated statistically with the Chi Square technique. Only slight differences were found between conditions or between sexes, and hence the conclusion was drawn that vision had no appreciable effect upon the perception of differences in texture. The observers, however, felt that they did better under one condition than under the others with the men favoring condition I (seeing both textures) and the women favoring condition II (seeing neither texture).

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APPENDIX

TABLE 7.

Calculation of Chi Square for the total population under the four experimental conditions for "rougher than", "equal to", "smoother than" and correct responses.

OBSERVED FREQUENCIES (fo)

Condition	Judgment given				
	correct	"rougher than"	"equal to"	"smoother than"	Total
I	410	203	107	190	910
II	408	203	113	191	908
III	392	212	100	188	892
IV	403	184	109	207	903
Total	1613	805	429	766	3613

EXPECTED FREQUENCIES (fe)

Condition	Judgment given			
	c	r	e	s
I	406.22	202.76	106.05	195.45
II	405.33	202.31	107.81	193.02
III	398.19	198.75	105.91	191.58
IV	403.10	201.20	107.22	193.95

(fo-fe)

Condition	c	r	e	s
I	3.78	0.24	1.05	5.45
II	2.67	3.69	5.19	14.02
III	6.19	13.25	5.91	3.33
IV	0.10	17.28	1.78	13.05

$\frac{(fo-fe)^2}{fe}$

Condition	c	r	e	s
I	0.0352	0.0003	0.0102	0.1520
II	0.0176	0.0673	0.2498	1.0079
III	0.0962	0.8833	0.3298	0.0651
IV	0.00002	1.4704	0.0029	0.3721

TABLE 7. (contd.)

This yielded a Chi Square of 5.266, which, allowing 9 degrees of freedom means that there were about 80 chances in 100 that the differences in judgments given under the four conditions are merely chance differences. In other words, this proved to be a homogeneous set of conditions with reference to their influence upon the judgments that were made.

TABLE 8.

Calculation of Chi Square for the men under the four experimental conditions giving correct, "rougher than", "equal to", "smoother than" judgments.

OBSERVED FREQUENCIES (fo)

Condition	Judgment given				
	correct	"rougher than"	"equal to"	"smoother than"	Total
I	203	96	71	103	473
II	214	100	43	102	459
III	195	103	46	99	443
IV	199	88	50	107	443
Total	813	389	200	411	1813

EXPECTED FREQUENCIES (fe)

Condition	Judgment given			
	c	r	e	s
I	204.03	97.63	50.19	103.14
II	203.07	99.56	51.19	105.18
III	199.55	97.43	49.10	100.91
IV	201.34	98.34	49.53	101.78

(fo-fe)

Condition	Judgment given			
	c	r	e	s
I	0.97	1.63	0.81	0.14
II	5.93	0.44	7.19	3.16
III	4.55	5.52	3.10	1.88
IV	2.34	8.34	5.47	5.22

(fo-fe) - Corrected for Continuity

Condition	Judgment given			
	c	r	e	s
I	0.47	1.13	0.31	0.36
II	5.43	0.06	6.69	2.66
III	4.05	5.02	2.60	1.38
IV	1.84	7.84	4.93	4.72

TABLE 8. (cont'd.)

$$\frac{(f_o - f_e)^2}{f_e}$$

Cond.	c	r	e	s
I	0.1417	0.0155	0.0012	0.0013
II	0.1417	0.3600	0.1414	0.0663
III	0.0022	0.0021	0.1377	0.1388
IV	0.0168	0.4900	0.4307	0.2184

This yielded a χ^2 of 3.3559, which allowing for 9 degrees of freedom means that there were 95 chances in 100 that this was "rougher than", "equal to", "smoother than" and correct judgments that were made by men. In other words there were no differences among conditions in terms of their influence upon perceptual differences in texture as observed by the men who participated in this study.

TABLE 3.

Calculation of Chi Square for the words under the four experimental conditions giving correct, "rougher than", "equal to" or "smoother than" judgments.

OBSERVED FREQUENCIES (fo)

Condition	Judgments				
	correct	"rougher than"	"equal to"	"smoother than"	Total
I	295	107	56	67	455
II	194	186	69	74	523
III	197	101	54	89	441
IV	234	96	54	100	454
Total	920	410	229	350	1709

EXPECTED FREQUENCIES (fe)

Condition	Judgments			
	c	r	e	s
I	203.47	104.28	53.24	89.02
II	199.31	100.61	56.12	88.69
III	197.20	101.07	56.45	88.28
IV	203.20	104.05	58.11	88.62

(fo-fe)

Condition	Judgments			
	c	r	e	s
I	1.53	3.72	2.24	2.02
II	2.31	5.39	3.81	11.69
III	0.20	0.07	2.45	2.72
IV	0.98	8.05	4.11	11.13

$$\frac{(fo-fe)^2}{fe}$$

Condition	Judgments			
	c.	r	e	s
I	0.0115	0.1327	0.0036	0.045364
II	0.0272	0.2888	1.3813	1.6460
III	0.0002	0.00004	0.1063	0.0857
IV	0.0047	0.6223	0.2901	1.4073

TABLE 5. (contd.)

This yielded a Chi Square of 6.0596 which, allowing 9 degrees of freedom, means that there were about 70 chances in 100 that the differences in judgment given under the experimental conditions are merely chance differences. In other words, this proved to be a homogeneous set of conditions with reference to their influence upon the judgments that were made.

TABLE 10.

Calculation of Chi Square for the correct judgment given by the total population under the four conditions.

Condition	No. of obtained judgments.	No. of expected judgments.	fo-fe
I	410	403.25	6.75
II	408	403.25	4.75
III	392	403.25	11.25
IV	403	403.25	0.25
Total	1613		

The sum of the squares of the differences between the observed and expected frequencies was found to be 194.75. This yielded a Chi Square of 0.4829 which, allowing 3 degrees of freedom means that there were about 80 chances in 100 that the differences in the judgments given under the experimental conditions are merely chance differences. In other words, this proved to be a homogeneous set of conditions with reference to their influence upon the judgments that were made.

TABLE 19.

Calculation of Chi Square for the "smoother than" judgments given by the total population under the four experimental conditions.

Condition	fo	fe	fo-fe
I	190	191.5	0.5
II	181	191.5	10.5
III	188	191.5	3.5
IV	207	191.5	15.5
Total	766		

The sums of the squares of the differences between the observed and expected frequencies was found to be 363.0. This yielded a Chi Square of 1.8956 which, allowing 3 degrees of freedom would indicate that in 60 chances out of 100 the differences in the number of "smoother than" judgments given by this population under the four conditions, were due to chance. In other words, this proved to be a homogeneous set of conditions with reference to their influence upon the judgments that were made.

TABLE 12.

Calculation of Chi Square for the correct judgments given by the women under the four experimental conditions.

Condition	No. of obtained judgments.	No. of expected judgments.	fo-fe
I	205	200	5
II	194	200	-6
III	197	200	-3
IV	204	200	4
Total	800		

The sum of the squares of the difference between observed and expected frequencies was found to be 86. This yielded a Chi Square of 0.4300 which, allowing 3 degrees of freedom, means that there were about chance in 100 that the differences in the judgments given under the experimental conditions are merely chance differences. In other words, this proved to be a homogeneous set of conditions with reference to their influence upon the judgments that were made.

TABLE 18.

Calculation of Chi Square for the "equal to" judgment given by the women under the four experimental conditions.

Condition	fo	fe	fo-fe
I	56	57.25	1.25
II	65	57.25	7.75
III	54	57.25	3.25
IV	54	57.25	3.25

The sums of the squares of the differences between the observed and expected frequencies was found to be 82.75. This yielded a Chi Square of 1.4454 which, allowing for 3 degrees of freedom means that in 70 chances out of 100 the differences in "equal to" judgments given by the women under the four conditions, were due to chance. In other words, this proved to be a homogeneous set of conditions with reference to their influences upon the judgments that were made.

TABLE 21.

Calculation of Chi Square for the "smoother than" judgment given by the women under the four experimental conditions.

Condition	fo	fe	fo-fe
I	87	88.75	1.75
II	79	88.75	9.75
III	89	88.75	0.25
IV	100	88.75	11.25
Total	355		

The sums of the squares of the differences between the observed and expected frequencies was found to be 224.75. This yielded a Chi Square of 2.5324 which, allowing 3 degrees of freedom means that in 50 chances out of 100, the differences in the number of "smoother than" judgments given by the women under the four conditions, were merely chance differences. In other words, this proved to be a homogeneous set of conditions with reference to their influence upon the judgments that were made.

TABLE 22.

Calculation of Chi S[illegible] comparing the correct judgments given by the men with those given by the women under the four experimental conditions.

OBSERVED FREQUENCIES (fo)

Condition	Men	Women	Total
I	205	205	410
II	214	194	408
III	198	177	375
IV	196	209	405
Total	813	800	1613

EXPECTED FREQUENCIES (fe)

Condition	Men	Women
I	206.65	203.35
II	205.64	202.36
III	189.08	185.92
IV	204.12	200.88

(fo-fe)

Condition	Men	Women
I	1.65	1.65
II	8.36	8.36
III	8.92	8.92
IV	4.12	4.12

$$\frac{(fo-fe)^2}{fe}$$

Condition	Men	Women
I	0.0132	0.0134
II	0.3399	0.3454
III	0.0827	0.0854
IV	0.0830	0.0843

$$X^2 = 0.9483$$

The X^2 of 0.0483, allowing 3 degrees of freedom means that in 85 chances out of 100, the effect of the sex of the

TABLE 22 (contd.)

observer on the number of correct judgments given under the four conditions was homogeneous for both sexes and that the differences observed are merely chance differences.

TABLE 25.

Calculation of Chi Square comparing the "women than men" judgments given by men to those given by women under the four experimental conditions.

OBSERVED FREQUENCIES (fo)

Condition	Men	Women	Total
I	96	107	203
II	100	106	206
III	105	107	212
IV	88	96	184
Total	389	416	805

EXPECTED FREQUENCIES (fe)

Condition	Men	Women
I	98.09	104.91
II	99.55	106.45
III	102.44	109.56
IV	88.91	95.09

(fo-fe)

Condition	Men	Women
I	2.09	2.09
II	0.45	0.45
III	2.56	2.56
IV	0.91	0.91

$$\frac{(fo-fe)^2}{fe}$$

Condition	Men	Women
I	0.0445	0.0416
II	0.0020	0.0019
III	0.0040	0.0036
IV	0.0031	0.0071

$$\chi^2 = 0.0340$$

The χ^2 of 0.0340, allowing 3 degrees of freedom in 99 chances out of 100, the effect of the sex of the observer

TABLE 23 (cont.)

in the number of "rougher than" judgments under the four conditions was homogeneous and the differences observed were merely chance differences.

TABLE 24.

Calculation of Chi Square comparing the "equal to" judgments given by the men to those given by the women, under the four experimental conditions.

OBSERVED FREQUENCIES (fo)

Condition	Men	Women	Total
I	51	56	107
II	48	65	113
III	46	54	100
IV	55	48	103
Total	200	223	423

EXPECTED FREQUENCIES (fe)

Condition	Men	Women
I	49.88	57.12
II	52.68	60.32
III	46.62	53.38
IV	50.82	58.18

(fo-fe)

Condition	Men	Women
I	1.12	1.12
II	4.68	4.68
III	0.62	0.62
IV	4.18	4.18

$$\frac{(fo-fe)^2}{fe}$$

Condition	Men	Women
I	0.0251	0.0220
II	0.4158	0.3631
III	0.0082	0.0072
IV	0.3438	0.3003

$$\chi^2 = 1.5455$$

The χ^2 of 1.5455, allowing 3 degrees of freedom means that in 75 cases out of 100, the differences between the

TABLE 24. (contd.)

sons in respect to the number of "equal to" judgments given under the four conditions were merely chance differences.

TABLE 25.

Calculation of Chi Square comparing the "about as they" judgments given by the male to female ratings by the males under the four experimental conditions.

OBSERVED FREQUENCIES (fo)

Condition	Men	Women	Total
I	103	87	190
II	102	79	181
III	99	89	188
IV	107	100	207
Total	411	355	766

EXPECTED FREQUENCIES (fe)

Condition	Men	Women
I	101.94	88.06
II	97.12	83.88
III	100.87	87.13
IV	111.06	95.93

(fo-fe)

Condition	Men	Women
I	1.06	1.06
II	4.88	4.88
III	1.87	1.87
IV	4.06	4.06

$$\frac{(fo-fe)^2}{fe}$$

Condition	Men	Women
I	0.0110	0.0128
II	0.0245	0.0284
III	0.0347	0.0367
IV	0.0195	0.0226

$$\chi^2 = 0.1343$$

The χ^2 of 0.1343, allowing 3 degrees of freedom, is significant at less than the 99% level of confidence. This

TABLE 25. (contd.)

means that in 95 chances out of 100 the only differences in the number of "smoother than" judgments found between the sexes under the four conditions are merely chance differences.

ABSTRACT

In order to investigate the inter-relationship of the senses of vision and touch in examining textures, the following experiment was performed.

A texture scale was constructed from different grades of commercial sandpaper. A microscopic examination indicated that this scale approximated an equal-interval scale. The center paper was selected as the standard of judgment. This standard was compared with each of the other grades and with itself by 50 men and 50 women who gave judgments concerning the paper on their left being rougher, smoother or the same as the one on their right. These judgments were given under four different conditions with the papers and conditions presented in random order. These conditions were:

I. The observer could see both textures.

II. The observer could see neither texture.

III. The observer could see the standard texture only.

IV. The observer could see the comparison texture only.

The results were examined using the chi square technique. Any differences in judgment as between one condition and another or between the sexes were found to be chance differences. The men were most certain of their judgments under condition I, when they could see both of the textures, while the women felt that they did their best under condition II, when they could see neither texture.