KÜÇÜK UZUNLUK TAHMİNLERİ

ESTIMATION OF SMALL LENGTHS

By

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Yatay düzlemde belirli uzunluklarda uyarıcılarla ilgili tahminlerden elde edilen sonuçlar, farklı metodlarla yeniden iki seri deneyle incelenmektedir. Ortalama hatalar metodunun uygulandığı ilk seri deneylerde 90, 100 ve 110 mm. olan üç standart uzunluk deneklere verilerek, ezberden onar defa bu uzunluklarda çizgiler çizmeleri kendilerinden istenmiş ve hataları incelenmiştir. Sonuç olarak, hatalarda alt-tahminlerin çoğunlukta bulunduğu ve hata miktarının çok ufak bir seviyede olduğu görülmüştür. Sadece parmaklarını kullanarak ve böylece dokunma duyumuna dayanarak yapılan ikinci seri deneylerde sabit tenbihler metodu uygulanmıştır. Hata miktarının bu deneylerde daha arttığı görülmüştür. Kör deneklerin de katıldıkları deneyler sonucunda, görme duyumunun, mesafe tefriklerinin algılanma ve öğrenilmesinde dokunma duyumundan daha üstün olduğu tesbit edilmiştir.

Previous experiments on estimation of small distances yielded some interesting results (Miles 1956, Toğrol 1966). Two sets of experiments were designed to investigate the same problem for different conditions and modalities. Method of average error was employed in the first set of experiments and three standard lengths 90, 100, 110 mm. were used. The Ss were instructed to reproduce lines of these standard distances on paper by relying on their "mental - meter - sticks". Underestimations were prevalent, the magnitude of errors being remarkably low. In the second set of experiments paired comparisons of very small lengths (69 - 111 mm.) were made tactually. Method of constant stimuli was applied, and blind Ss were used as controls. This set of experiments has revealed superiority of vision over touch in the judgments of small lengths.

INTRODUCTION

Errors in the estimation of visual horizontal distances is to be expected. Experiments by Miles (1956) where he used the method of average error with single successively increasing stimuli of limited accidental origin, yielded dominant group tendencies in the direction of underestimations. This constant error, on the average, amounted to about 4 percent of the stimulus lengths. The dependence of these underestimations on the order of presantation of the successive stimuli where each series of experiments started with the smallest horizontal distance, the distances gradually increasing with each new stimulus was questioned. (Toğrol, 1966). Experiments using the same method but introducing successive stimulus series in opposite directions i. e., increasing and diminishing the series of lengths, revealed a direction-bound constant error tendency by the subjects. There were more underestimations in the decreasing sets of stimuli than in the increasing sets with a slight tendency of overestimations in the latter. Yet, the more significant finding was the dependence of the sign of constant errors on stimulus lengths. Lengths of about 80 cm. or longer tended to be overestimated whereas those of 50 cm. or shorter were usually underestimated in both orders of presentation. Within the range of 50 to 80 cm. the sign of the errors were variable. The smallest amount of mean errors were bound to be between 25 to 50 cm. lengths.

In both of these experiments the subjects compared each visually presented length with his own «mental-meter-stick». That the average error was as small as about 4 percent in both instances, exhibits the remarkable accuracy of this human ability. It is natural that there were individual variations in the estimations. But, these findings from such small groups indicate that, if all the meter-sticks (or perhaps inch sticks for that matter) were suddenly lost in the world, it would not be too phantastic to suppose that a larger group of human subjects would easily be able to reproduce them with insignificant errors by using their acquired «mental-meter-sticks» and averaging their results! Whether this same power of estimation for visually presented lengths would still persist under somewhat different conditions or modalities should be worth questioning. One such problem might involve judgments concerning tactually presented distances. Or, the accuracy of reproductions of certain lengths by relying on «mental-standards» might be another.

Two new experiments were designed to study judgments or estimations of small distances. The tasks involved in the new experiments were:

1. Reproductions of small-horizontal-lengths on small papers with pencil, in response to verbally presented stimuli.
2. Judgements concerning the comparison of tactually presented pairs of horizontal distances.

The first problem depended solely on the use of inner-built «mental-meter-sticks» of subjects and their power of equalizing the verbally presented standards on this «mental measures» and reproducing a visual product as a consequence of this judgment. The process involved in this experiment was more complicated than in the previous experiments. In the previous situations a certain distance was presented to the subjects visually. The subjects measured this distance with their acquired «mental-measures», and wrote down their estimates. In this situation, a certain length was presented as a stimulus verbally by the experimenter. The subject had to reproduce a visual image of this length mentally, and then, to respond with a visual outcome by the use of his visuo-motor coordinations; this result being a joint product of visual, kineasthetic and tactual modalities. Since, fortunately, standard metersticks are still in existence, the amount of his success in his reproductions could be easily determined!

In the second problem, two horizontal distances were tactually presented to the subjects and they were required to compare these distances and verbalize their judgments of equality or difference. In this instance the task was simpler, the subjects having to form judgments on two successively presented stimuli. Yet, the situation was complicated by having to use their tactual sense for a task where they normally relied on their vision. Blind subjects were introduced as controls in this part of the experiments. The stimulus lengths were confined to very small distances (a little smaller and larger than 10 cm.) in both experiments. It was expected to find more underestimations in the responses.

EXPERIMENTS

1ST SET

Material and Procedure

The materials consisted of ten ordinary white papers 11×15 cm. in size and a moderately sharp lead pencil for each subject.

The experiments were conducted in the class-room during the Practical hour to serve the joint purposes of training and research, the subjects being randomly divided into three groups of seven each. Method of reproduction was employed in these experiments. After the materials were distributed, the class was instructed to draw carefully about the middle of each paper a straight line of a given standard size, to turn the back of the paper, and then to place it on his left away from his sight repeating the same task until the ten papers provided were exhausted. Three sizes, 90, 100, and 110 mm., were given each as a standard to one of the three groups, the Ss working individually by themselves, at their own pace, relying only on their own «mental-measures» to perform the task. After all of the Ss in the classroom completed this task, they were, then, told to divide each of their reproductions into two equal parts turning the back of their papers, and, placing it on their left as they went along. The subjects' responses, in this instance, were recorded by measuring the distance from the left and and they were informed of this procedure before starting this part of the task. The experiments took about 20 min. Then, each response was read to the nearest millimeter and recorded by the Ss under the supervision of the instructors.

Subjects

Twenty one second-year psychology students took part in these experiments. They were randomly divided into three groups of seven Ss each, corresponding to three standard lengths. Thirteen of the subjects were women and eight were men. None of the subjects were left handed.

Subjects	STANDARDS GROUP I 90 mm.	GROUP II 100 m.m.	GROUP III 110 mm.
1	94.30	98.80	120.10
2	83.30	99.00	104.40
3	81.30	96.20	107.80
4	82.90	92.10	106.90
5	72.60	102.90	108.00
6	94.60	98.10	102.00
7	84.20	99.40	107.50
M	84.74	98.07	108.10
$D(S-R_M)$	-5.26	-1.93	-1.90

TABLE I : Mean lengths reproduced for different standard lengths.

Results

Mean lengths reproduced by three groups of subjects representing different standards is shown in Table I. The average for each group carries a negative sign, indicating a tendency for underestimations. However, the success of the subjects is indeed very great. The first group for the standard 90 mm. was on the average —5 mm. short of the goal, an average error of about 6 percent of the stimulus length. The second group for 100 mm. and the third group for 110 mm. only had about 2 percent mean errors each. Thus, the average of the errors was about 3 percent in this part of the experiments.

In Table II the proportions of differences with positive and negative signs for different standard lengths are given. For each stimulus length, there were 70 (10×7) performances by each group of Ss and the negative signs, i.e., underestimations were dominant in all groups.

Standard Lengths			
Error sign	90 mm.	100 mm.	110 mm.
+	.243	.329	.343
=	.014	.029	.029
—	.743	.642	.628
Between + and – signs CR	7.1	3.9	3.6
P <	.001	.01	01

TABLE II : Proportions of each type of errors for different standards.

Differences between percent + and percent — responses were all significant beyond the .01 level of confidence. Excepting a few instances the majority of all the reproductions of the subjects fell short of the standard. Nevertheless, there were two individuals in the first group (90 mm. standard) that overestimated their performances by 80 percent. There was only one subject who showed this opposite inclination (90 % +) in the second group (100 mm. standard) and again another one (100 % +) in the third group (110 mm. standard). Thus, while 81 percent of the subjects exhibited a tendency for underestimations in their responses only 19 percent revealed an opposite tendency, for overestimations.

When the subjects were asked to divide each of their reproductions into two equal parts, the dominant trend was again largely underestimations read from the left hand side. The smallest mean error, which also carried the only + sign in these experiments, was for 100 mm. Standard. It was only .004 percent of the actual mean half of the reproductions of the subjects in this group.The error for the 90 mm. standard group was about 3 percent and the 110 mm. standard group 4 percent. Thus, the performance in this comparably easier task is as good or even better, the average error in one instance diminishing to a mere .004 percent.

Subjects	STANDARD LENGTHS					
	90 mm.		100 mm.		110 mm.	
	Actual	Performed	Actual	Performed	Actual	Performed
1	47.15	47.30	49.40	50.10	60.50	61.00
2	41.65	40.40	49.50	49.60	52.20	47.90
3	40.65	39.60	48.10	48.40	53.90	50.70
4	41.45	40.40	46.50	45.10	53.45	49.10
5	36.30	38.00	51.45	52.90	54.00	50.90
6	47.30	40.90	49.05	49.90	51.00	50.00
7	42.10	40.20	49.70	49.00	53.75	53.80
M	42.37	41.11	49.10	49.30	54.11	51.91
D $(A_M - P_M)$	−1.26		+0.20		−2.20	

TABLE III : The actual and the performed mean halves for different standards.

2 ND SET

Materials and Procedure

The experimental material consisted of 15 strips of wooden sticks 230 mm. long and 10×10 mm. thick, and a wooden plate with dimensions of 290×130×10 mm. The two smaller sides and one of the larger side of the plate was framed with 10×10 mm. laths, the fourth side was left unframed to push in the comparison strips. One standard and 15 comparison lengths were used in these experiments and they were provided by using 1.5 mm. thick nails which were placed at 20 mm. height, equidistant from the middle of each strip. The standard stimulus was placed on the fixed frame opposite the open end of the plate where the comparison distances were to be inserted. This compact small plate enabled easy handling for the necessary change of positions of the comparison and standard stimuli as required by the predetermined randomization of presentation order. The standard distance was 90 mm. in length, the 15 comparison distances increasing by steps of 3 mm. on either side of this:

69, 72, 75, 78, 81, 84, 87, 90, 93, 96, 99, 102, 105, 108, 111 mm.

The method of constant stimuli was employed in these experiments, each distance judged by the Ss five times providing a total of seventy five responses from one subject. The sequence of the different comparison lengths and the placement of the standard and the comparisons were randomly determined and the same order was applied to all Ss.

The subjects were tested individually in sessions requiring approximately 35 min. During the entire experiment, S sat in a chair in front of a screen placed on a table of normal height (50 cm). E told the Ss that they were to place their dominant hand behind the screen and then their index fingers were to be guided to the middle of a wooden strip. They were instructed to move their fingers to the left and the right till they touched the nails marking the boundaries several times until they had acquired an idea about the distance between these two nails, and then, their fingers would be guided to the middle of another strip, and having explored that distance as well, they were to judge whether this second length was smaller, greater or equal to the first one. A pretest was given to assure that the S understood the task properly. The time taken by each judgment was noted.

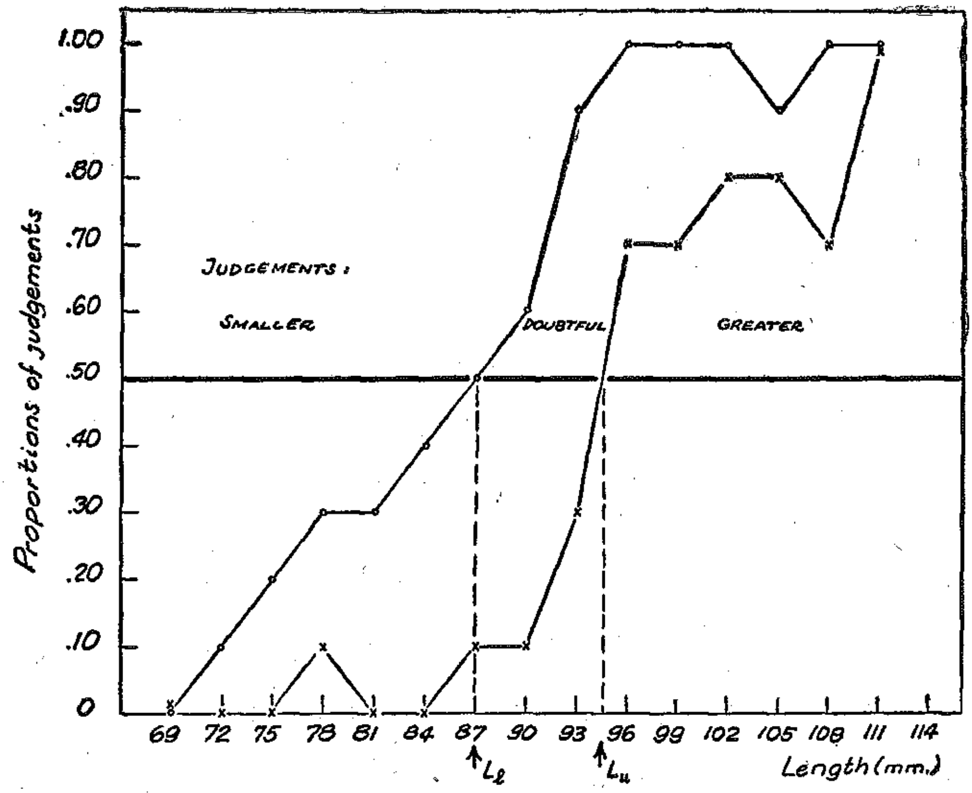

Fig. 1. Psychometric functions showing the upper and lower thresholds L_l and L_u for tactual distances of normal subjects.

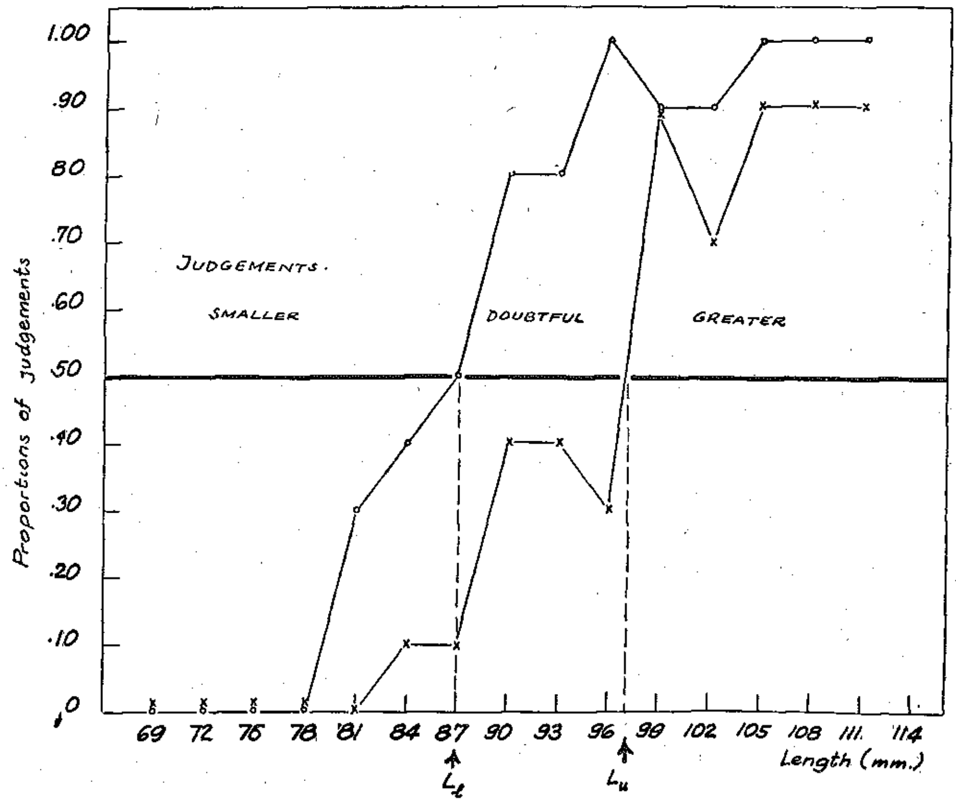

Fig. 2. Psychometric functions showing the upper and lower thresholds L_l and L_u for tactual distances of blind subjects.

Subjects

Four subjects were used in the experiments. They were all men, second year students in the University of Istanbul. Two of these students had congenital blindness, reading psychology and law. They were used as controls in these experiments, but the Ss in the Normal Group had to be matched with them.

Results

Results of the three category paired comparisons of different lengths for the two groups of Ss are shown in Tables IV and V. Though the general tendency of these comparative judgments for the normal subjects and the blinds are similar, yet there are some interesting differences, however small, between the two groups. Comparing the two tables, it is seen that «greater» judgments do not seem to reach a 100 percent certainty for lengths larger than 90 mm. with the Blind Group.

But, the same subjects are more successful in their judgments than the normal group for lengths smaller than the standard (90 mm.). For the «smaller» category of judgments the Blind Group has more number of hits (100 percent correct) at both ends of the comparison lengths. On the other hand, the Blind Group exhibits greater uncertainty than the Normal Group at the «equal» category judgments indicated by the variations throughout this category and the occurrence of as high as 70 percent «equal» judgments for the 96 mm. length.

S_c (mm.)	Greater	Equal	Smaller
111	1.00	0	0
108	.70	.30	0
105	.80	.10	.10
102	.80	.20	0
99	.70	.30	0
96	.70	.30	0
93	.30	.60	.10
90	.10	.50	.40
87	.10	.40	.50
84	0	.10	.90
81	0	.30	.70
78	.10	.20	.70
75	0	.20	.80
72	0	.10	.90
69	0	0	1.00

TABLE IV : Mean proportions for each category of judgements by Normal Group for comparison lengths where standard distance (Sc) = 90 mm.

Table VI summarizes the first occurrence of errors in the comparison series and the differences of these errors from the standard length for both groups of Ss. Errors of the Blind Group for the «Greater» and «Smaller» judgments occur later than the Normal Group in the series, especially, at the shorter end with only —2 mm. difference from the Standard, 90 mm. For judgements of «equal» the Blinds again reveal more number of hits at the shorter end, but they seem to encounter with great difficulty at the longer end of the series for this category of judgments. 114 mm. is added to the Table as a probable longer end for errors, since the last distance of the series 111 mm. still carried some errors by this group.

Psychometric curves of the distributions for judgments «smaller» and «greater» of the two groups are shown in Figures 1 and 2. The descending curves for judgments «smaller» were transformed into ascending curves by deducting proportions of judgments «smaller» from 1.00. Both figures are similar in appearance, and follow the same course as is expected from such three category comparison tasks. The differences between the groups studied from Tables IV and V are better observed

S_c (mm.)	Greater	Equal	Smaller
111	.90	10	0
108	.90	.10	0
105	.90	.10	0
102	.70	.10	.10
99	.90	0	.10
96	.30	.70	0
93	.40	.40	.20
90	.40	.40	.20
87	.10	.40	.50
84	.10	.30	.60
81	0	.30	.70
78	0	0	1.00
75	0	0	1.00
72	0	0	1.00
69	0	0	1.00

TABLE V : Mean proportions for each category of judgements by Blind Group for comparison lengths where standard distance (Sc) = 90 mm.

in these curves. The interval between the «smaller» and the «greater» judgment of the Blind Group is wider at the middle and narrower towards both ends exhibiting a larger segment in the transition zone, hence, greater amount of uncertainty than the normal group.

SUBJECTS	Greater		Equal		Smaller	
	Length (mm.)	Difference from 90 mm.	Length (mm.)	Difference from 90 mm.	Length (mm.)	Difference from 90 mm.
Normals	78	-12	72 108	-18 +18 } 36	105	+15
Blinds	84	-2	81 (114 ?)	-9 +24 } 33	102	+12
Difference between groups	6	-10	9 6	-9 +6	3	+3

TABLE VII : The first occurrence of errors in the comparison series for the three category judgements and their difference from the standard length.

A summary of limens (upper and lower), intervals of uncertainty, difference limens, and points of subjective equality for both groups of subjects is shown in Table VII. The limens are computed by the linear interpolation proces. The distance between them, (L_u - L_l) is the in-

Subjects	L_l	L_u	IU	DL	PSE
Normals	87	94.5	7.5	3.75	90
Blinds	87	97	10	5	94
D	0	3.5	2.5	1.25	4

TABLE VII : Summary of limens, intervals of uncertainty, difference limens and points of subjective equality for tactual discriminations of two groups of subjects.

terval of uncertainty (IU). One half of this interval is taken as the difference limen (DL). The lower threshold of both groups are equal. (at 87 mm.). The upper threshold of the Blinds is 3.5 mm. larger than that of the Normal Group. (97-94.5). The point of subjective equality is also 4 mm. larger than the standard in the Blind Group, whereas, it equals the standard in the Normals. These values indicate the Blind Group as the less sensitive of the two in these experiments. Yet, when the proportions of errors for the three category judgements, and means of errors and corrects for both groups are studied, the overall results are almost the same with even a very slight superiority by the

S_c (mm.)	Greater	Equal	Smaller	Mean error	Mean correct
111	0	0	0	0	1.00
108	.30	.30	0	.20	.80
105	.20	.10	.10	.13	.87
102	.20	.20	0	.13	.87
99	.30	.30	0	.20	.80
96	.30	.30	0	.20	.80
93	.70	.60	.10	.47	.53
90	.10	.50	.60	.40	.60
87	.10	.40	.50	.33	.67
84	0	.10	.10	.07	.93
81	0	.30	.30	.20	.80
78	.10	.20	.30	.20	.80
75	0	.20	.20	.13	.87
72	0	.10	.10	.07	.93
69	0	0	0	0	1.00
Mean error	.15	.24	.15	.18	
Mean Correct	.85	.76	.85		.82

TABLE VIII : Mean proportions of errors for three categories of judgements and the combined averages for comparison distances by Normal Subjects.

S_c (mm.)	Greater	Equal	Smaller	Mean error	Mean correct
111	.10	.10	0	.07	.93
108	.10	.10	0	.07	.93
105	.10	.10	0	.07	93
102	.30	.10	.10	.17	.83
99	.10	0	.10	.07	.93
96	.70	.70	0	.47	53
93	.60	.40	.20	.40	.60
90	.40	.60	.80	.60	.40
87	.10	.40	.50	.33	.67
84	.10	.30	.40	.27	.73
81	0	.30	30	.20	.80
78	0	0	0	0	1.00
75	0	0	0	0	1.00
72	0	0	0	0	1.00
69	0	0	0	0	1.00
Mean error	.17	21	16	.18	
Mean correct	.83	.79	.84		82

TABLE IX : Mean proportions of errors for three categories of judgements and the combined averages for comparison distances by Blind Subjects.

Blind Group. (Tables VIII and IX). So, the greater uncertainty around the middle ranges of this group seem to be compensated by their greater certainty at the ends, and vice versa for the Normals, an interesting difference between the groups. When errors are divided into two types; i.e. overestimations and underestimations as in Table X, the mean proportion of underestimations for comparison lengths other than 90 mm. is greater for both the Normal and the Blind Group, with differences of 4.76 percent and 7.12 percent respectively. Only in the 90 mm. distance the overestimations of the Blind Group has a higher proportion than their underestimations. This deviation at the zero difference from their normal trend is indeed very interesting and needs explanation. It might possibly be typical of the congenitally blind, since both subjects showed this same tendency in the experiments.

S_c (mm)	Normal group		Blind group	
	Overesti-mations	Underesti-mations	Overesti-mations	Underesti-mations
69 - 27, 93 - 111	.14	.19	.11	.19
	$P > .05$		$P > .05$	
Combined overestimations v. underestimations (.14 + .11 v. .19 + .19) $P < .05$				
90	.10	.40	.40	.20
	$P < .05$		$P < .05$	

TABLE X : Mean proportions of errors for the Normal and the Blind group.

DISCUSSION

The two experiments differing widely in their method and their use of sensory modalities have revealed the presence of underestimations for very small distances. This result verifies our previous findings (Toğrol, 1966) and those of Miles (1956) and indicates the presence of constant errors with negative signs in the judgments of small distances. This tendency was significant in all three stimulus groups beyond the .01 level of significance (Table II) for the first set of experiments. For the second set of experiments, though the intragroup differences between overestimations and underestimations did not quite reach the .05 level of significance, combined underestimations of the groups were significantly higher than their combined overestimations ($P < .05$).

The remarkable accuracy of the «mental-measures» encountered in the former experiments where the lengths of visual stimuli were estimated by 4 percent error, is again verified in the first set of these experiments. There was, on the average, 3 percent error in the reproduced lengths of the subjects.

When the task for judging lengths was transferred from the visual to the tactual modality, where paired stimuli were compared successively with the fingers and judged on a three category basis, the magnitude of the errors increased to about 18 percent of the standard lengths. But, the task here was obviously easier than any of the previous ones, since the judgments were simple comparisons of two small distances. The increase in errors may be due to the use of the tactual sense by subjects who normally function with their vision under similar situations. Yet, the congenitally blind Ss who were included as controls in these experiments, exhibited the same amount of errors in these experiments. These findings have revealed superiority of vision over active touch in the judgment of lengths. That the normal subjects rather than the blinds had a smaller differential threshold, and a narrower interval of uncertainty indicates some amount of transfer of learning is possibly taking place from the visual to the tactual modalities in length discriminations. People who have never had a chance to use their vision seem to be somewhat handicapped in judging lengths with small differences from the standards, in spite of their experience in employing the tactual sense in similar instances all their lives. However, the sudden drop from the region of uncertainty to perfect certainty compensates for this impediment equalizing their overall performances with that of the normals.

The superiority of vision over touch has been verified also in form learning through a number of experiments by Lobb (1965). His view that form perception and learning benefit greatly from the faster scanning by vision, is possibly responsible for this phenomenon rather than tactual inexperience, and seem to apply to our findings as well. The inferiority in length discriminations solely by the use of tactual modality, notwithstanding former experience, as was the case with our congentially blind controls, agrees with this point of view.

The various results appear to demonstrate the considerable extent of the acquired «mental - measures» in the judgments of lengths and the amount and quality of the cross modality transfers from vision to touch in such discriminations. Further studies of this phenomenon in clinical cases might prove of great interest.

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