AN APPLICATION OF ADAPTATION-LEVEL AND GENERALIZATION THEORIES TO ABSOLUTE JUDGMENTS OF LENGTH

By

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An Application of Adaptation-Level and Generalization Theories to Absolute Judgments of Length

Studies designed to investigate the formation and modification of judgment scales indicate that subjects tend to fit their scales to the stimulus series judged. This tendency was first reported by H. L. Hollingsworth (1910) who, while working with the reproduction of hand movements over linear distances, found that within any given stimulus range his subjects developed a system of positive and negative errors, and within this system there was a stimulus value which appeared to be neutral. The values of stimuli above this point were underestimated and the values of stimuli below it were overestimated. Based on this study and others he formulated his Law of Central Tendency in which he states,

> In all estimates of stimuli belonging to a given range or group, we tend to form our judgments around the median value of the series... toward this mean each judgment is shifted by virtue of a mental set corresponding to the particular range in question (Hollingsworth, 1913, p. 45)

If subjects tend to fit their scales to the stimulus series it would be expected that systematic variations in the range of stimuli judged would bring about systematic changes in the characteristics of the judgment scales. Volkmann (1937) has investigated the relationship between the range of stimuli and the number of categories which a subject will use to judge that range. In his study he had subjects judge the inclination of a series of lines by selecting the number of categories best suited to them and found that the number of categories used increased as the range of stimuli increased. He found, further, that this increase is a sigmoidal function of the range of stimuli.

In another study Volkmann (1938) used the same stimuli to

determine what happens to the judgment scale when the range of stimuli is greatly restricted. He found that as the range of stimuli decreased the category widths narrowed. The rate of change in the category widths was relatively constant at first. It then diminished as if the scale was approaching a limit of compression and when this limit was reached the rate of change increased rapidly and the frequency of judgments in the extreme categories rose sharply.

Tresselt and Volkmann (1942) have noted that the findings of Hollingsworth also apply to judgments made on lifted weights. They found that their subjects developed scales which conformed to the stimulus range and that the centers of these scales tended to be the same for all subjects. They also found that during their initial judgments the subjects were extremely variable in their judgments and their scales were quite dissimilar. It was only after they had made several judgments that the subjects developed similar scales.

Parducci (1954) has taken the position that this initial variability noted by Tresselt and Volkmann will be reduced if the subjects are told the number and range of stimuli to be judged. He found that subjects given prior information about the stimulus series were significantly less variable in their judgments than a group which was given no prior information. He had his subjects make several repeated judgments of the stimuli and compared them in terms of their mean shift in judgment. He found that the subjects in the group without prior information had modified their scales more than the subjects in the other group. He interprets this data as supporting his hypothesis that judgment scales are acquired and modified according to the same principles by which other learning is acquired, retained, or modified.

The above mentioned studies all indicate that one variable which must be considered when discussing the formation and modification of judgment scales is the form and range of the stimulus distribution. There are other studies which indicate that the past experiences of the subject must also be considered.

The role of past experience has been studied by Tresselt (1947) who noted during an experiment with lifted weights that two of her subjects had judged all the weights "light". After discovering that one of the two subjects was a weight lifter she conducted an experiment (Tresselt, 1948) comparing a group of professional weight lifters and a group of watchmakers with a group of students. She found the mean weight judged "medium" was not significantly different for the watchmakers and students, but for weight lifters it was significantly higher than either of the other two groups. She points out that the weight lifters did try to adjust to the stimulus series and for a while overcorrected, but later returned to their original scales.

Parducci (1956) has attacked the problem of past experience in a slightly different manner. For this study he used three groups of subjects judging three different distributions of stimuli all of which were drawn from the same stimulus range. One group judged a series in which the five largest stimuli were presented eight times more frequently than the four smallest stimuli. The second group was given a series in which the five smallest stimuli were presented eight times more frequently than were the four largest stimuli. The third group judged a series containing only the five smallest stimuli. He compared these groups by calculating the mean judgment given to the middle stimulus, because this was the only stimulus judged by all three groups,

and found the first group had judged this stimulus "small", the second group had judged it to be slightly above "medium", and the third group had judged it between "large" and "very large".

In the second part of this same experiment (Parducci, 1956) he had all three groups judge the stimulus series originally judged by group three. He had intended to compare groups one and two on the basis of the number of trials it took for their scale values to reach the same scale values used by group three, but neither group ever reached this point. Instead, he compared them on the basis of the mean shift in their judgments and found that for group two the amount of shift decreased as the amount of experience with the first series of stimuli increased, but for group one it first increased and then decreased. He also found that the scales of subjects in group one had shifted less than had the scales of subjects in group two. He conducted several additional studies to account for this difference in shift and came to the conclusion that subjects in a judgmental situation tend to fit their scales to the total range of stimuli, but if either earlier experiences or the experimental instructions lead them to expect stimuli outside the range being judged they will not use all the judgment categories. It should be noted that the findings of Tresselt (1948), cited above, support the conclusions arrived at by Parducci.

Hollingsworth (1910) in his Law of Central Tendency stated that the subjects tend to form their judgments around the median stimulus value. Parducci (1956) in his study with the skewed stimulus series found that the scale centers were not located at the median stimulus value, but were displaced in the direction of skewing. Johnson (1944) found this was also true for scales developed when

judging skewed distributions of lifted weights.

In his study Johnson (1944) was interested in determining whether or not he could predict the location of the center of the scale by calculating some average value from the stimulus series. He presented his subjects with two skewed series of lifted weights and had them judge them on a two category scale. He determined the mean category limen for these scale and compared them with the mean, geometric mean, and median values of the two stimulus series and found that the category limens were more closely approximated by the geometric means than by either of the other two measures. He verified his findings by using ten different, skewed and unskewed stimulus distributions and found that in all cases the category limens very closely approximated the geometric means of the stimulus series.

From the evidence presented it can be concluded that there are at least two variables which must be considered when attempting theoretical explanations for the formation and modification of response scales. These variables are the form and content of the stimulus series being judged and the past experiences which the subjects have had with similar stimuli.

Theories of Judgment

There have been several attempts to develop theoretical systems which would integrate the phenomena noted in this paper. Two of these, Helson's Adaptation-Level Theory (Helson, 1938, 1947, 1948) and Johnson's Generalization Theory (Johnson, 1944, 1945, 1949), have met with some degree of acceptance. These two theories are similar in that they both use an averaging process to determine the middle of the scale, but

they differ somewhat in terms of their basic assumptions.

Helson's concept of adaptation-level (AL) was originally formulated to account for various phenomena associated with color vision (Helson, 1938) and was later extended to include psychophysical phenomena (Helson, 1947). In his theory he assumes there is an AL for every moment of stimulation and he operationally defines it as the stimulus evoking a neutral or indifferent response (Helson, 1959). He states:

> Fundamental to the theory is the assumption that effects of stimulation form a spatio-temporal configuration in which order prevails. For every excitation-response configuration there is assumed a stimulus which represents the pooled effect of all stimuli and to which the organism may be said to be attuned or adapted. Stimuli near this value fail to elicit any response from the organism or bring forth such neutral responses as indifferent, neutral, doubtful, equal, or the like, depending on the context of stimulation (Helson, 1947, p. 2).

Helson (1947) feels that the AL operating in a given situation can be approximated by calculating a weighted geometric mean of the stimulus series. His equation is:

$$\log(AL + K) = \frac{\sum \log x_i}{N} \qquad (1)$$

The constant K is an empirical constant introduced to account for the fact that with some skewed distributions of stimuli the AL is displaced from the geometric mean. For lifted weights he has found the best value for K to be 0.75d with d being the interval between stimuli.

In order to account for the other scale values Helson (1948) starts with the assumption that the judgment assigned to a given stimulus depends upon the distance between that stimulus and AL. This distance is measured in terms of the number of jnd's between the stimulus and AL. By a series of mathematical substitutions he arrives at the following equation.

$$\frac{(K+P)}{(K-P)} = \frac{x_i}{A'} - b \qquad (2)$$

In this equation P is the difference between the average judgmental value assigned to a stimulus and the center of the judgment scale and K is the upper most value in the category scale. The constants A' and b are empirically determined by using a least squares solution for equation (2). The constant A' is an approximation of AL and b represents the Y intercept of the curve described by (2). Their relationship to AL can be seen from the following equation.

$$AL = A' - bA' \qquad (3)$$

Once A' and b have been determined the response scale values can be obtained from:

$$P = \frac{K(xi - A' + bA')}{(xi + A' + bA')} \qquad (4)$$

Equations (3) and (4) can be used to determine the AL from the experimental data, however if one wishes to evaluate all the factors which determine AL the following equation should be used.

$$A_e = A_p^m + A_c^n + \bar{S}_i^e \qquad (5)$$

In equation (5) A_e is the value of AL as determined from equation (3) and the quantities A_p and A_c are adaptation-levels resulting from past experience and contextual stimuli. It is important to note that the weights m, n, and e must be empirically determined and that they must sum to unity. In his formulations Helson assumes that the pooled effect from the stimulus series is always approximated by the geometric mean of the stimulus series. Johnson, on the other hand, assumes that this is true for lifted weights, but in some judgmental situations a better estimate can be obtained by using the arithmetic mean.

In the development of his theory Johnson (1944) started by stat-

ing that every stimulus presented to a subject for judgment has some central effect on that subject and that the central effect is functionally related to the receptor system used when making the judgments. He suggests that the buffer action of receptor mechanisms indicates a logarithmic relationship for many perceived dimensions such as brightness, loudness, and weight, but for judgments of length and numerousness a linear relationship can be assumed. These assumptions lead him to the conclusion that equation (1) gives an adequate approximation of the midpoint of the response scale when the receptor function is assumed to be logarithmic, but if the function is assumed to be linear the equation should be:

$$AL = \frac{\sum xi}{N} \qquad (6)$$

Johnson (1945) accounts for the other scale values by assuming that the form of the scale is linear and uses the general equation for the regression of Y on X. If his equation is put in Helson's symbols it reads:

$$P = a(x_i - \overline{X}_i) + \overline{Y} \qquad (7)$$

in this equation $\overline{X}_i$ and $\overline{Y}$ are the arithmetic means of the stimulus series and the judgments made on this series. The constant a is determined from the correlation between the stimului and judgments and the standard deviations of the two distributions.

His equation for expressing the relationship between past experience and the present judgmental situation is:

$$Ae = \frac{wA_p + n\overline{X}_i}{w + n} \qquad (8)$$

If Helson's equations are compared with Johnson's we find that they are almost identical. Equations (1) and (6) differ only because

the receptor function for (6) is assumed to be linear. Equations (7) and (4) are different in that (4) describes a scale in which the categories are stepped off in unequal units and (7) describes a scale in which the category widths are all equal. In equations (5) and (8) we have a difference in that (8) does not account for the influence of contextual stimuli and it assumes the pooled effect from the stimulus series is best approximated by the arithmetic mean of the series. It would seem that the primary difference between these two theories results from Helson assuming a logarithmic receptor function in all judgmental situations while Johnson assumes that for judgments of length and numerousness this function is linear.

Statement of the Problem

There have been two studies made comparing the theoretical systems of Helson and Johnson. One study (Helson, 1947) compared the two theories using the lifted weight data obtained by Johnson (1949). This comparison indicated that both theories overestimated the category limen for the middle category. Helson corrected for this overestimation by subtracting an empirical constant and Johnson corrected for it by assuming a modified geometric receptor function. The second comparison was made by Johnson (1955) using data obtained by Philip (1947). Johnson found that Helson's theory predicted a curvilinear relationship between the scale values and the stimulus values while his theory predicted a linear relationship. He plotted Philip's obtained values against the stimulus values and found that his, Johnson's predictions fit the obtained scale better than did Helson's. He states:

We must conclude that the simple assumption of linear

correlation and regression accounts for the response scale used by Philip's subjects better than the complex theory of adaptation-level based on Weber's Law.

If the generalization theory for centering the response scale is correct, the shape of the receptor function relating the stimulus variable to its effect on the organism is of primary importance. It is at this point that a nonlinear, e.g., a logaritmic, relationship may operate. Thereafter, if the regression theory for locating the scale values is correct, only simple assumptions and simple computations are necessary. If we picture the judge's task as one of fitting a series of response categories to a series of stimuli, Weber's Law is irrelevent (Johnson, 1955, p. 361).

In the present study an attempt will be made to compare these two theories on the basis of data obtained from a judgmental situation for which Johnson would predict a linear receptor function. The stimuli used in this experiment will be three series of wooden sticks originally developed by Parducci (1957) to study the effect of order of presentation on adaptation-level. Each of these stimulus series will contain the same range of stimuli and the interval between stimuli will be varied. In one series, unskewed, the intervals between stimuli will be equal throughout the series. In the two skewed series the intervals between stimuli will be greater at the low end of the series for the negatively skewed series and for the positively skewed series they will be greater at the high end of the series.

This approach differs somewhat from the studies previously cited in that a shift in the response scale will be obtained by altering the interval between stimuli as opposed to altering the range of stimuli (Volkmann, 1937 and 1938) or frequency of presentation (Johnson, 1944 and Parducci, 1956). The order of presentation will be randomized in order to avoid any systamatic effects due to order of presentation.

Each subject will be given 28 trials with the stimuli. During the first 14 trials he will be asked to judge the unskewed series and

during the second 14 trials he will judge one of the two skewed stimulus distributions. This will be done for two reasons. First, by having each subject judge the same series for several trials it will be possible to bring all subjects to approximately the same adaptation-level prior to judging the skewed series, thus, the two theories can be compared to determine how well they predict the shift in scale values during the second series of judgments. Second, by using this method it will be possible to compare the two theories over several trials to determine which one is most successful in predicting the value of the neutral stimulus. There is a possibility that the value of the neutral stimulus will coincide with the geometric mean during the early trials and move toward the arithmetic mean as the subjects are given additional trials, or the opposite relationship might hold.

In addition to the comparisons mentioned, the two theories will be compared to determine how well they predict the form of the response scale. It is possible that the theories might adequately locate the center of the scale and fail to properly predict the other scale values. There is also the possibility that interval skewing will have an effect on the form of the response scale such that linear scales will be obtained when the subjects judge the unskewed series and curvilinear scales will be obtained when they judge the two skewed series.

CHAPTER II

EXPERIMENTAL PROCEDURE

The subjects used in this experiment were 40 male students who were enrolled in the ROTC Program at Oklahoma State University. They were randomly assigned to one of the two experimental groups.

The stimuli were three sets of wooden sticks, with 15 sticks in each set. The sticks were approximately 5 mm. wide, 10 mm. thick, and varied from 32 to 298 mm. in length. They were painted a medium gray color and mounted on standard three by five note cards; this was done so that they could be presented in a vertical plane against a contrasting background.

The judgments were expressed in terms of a five category scale and recorded on data sheets provided by the experimenter (Appendix A). The subjects judgments were converted to a numerical scale by assigning a value of nine to judgments of Very Long, seven to Long, five to Medium, three to Short, and one to judgments of Very Short. In order to reduce intertrial variability a judgmental trial was defined as consisting of the average judgment given by a subject during two consecutive presentations of the same stimulus series. Thus, even though all subjects made a total of 420 judgments, the tables presented in this paper indicate a total of 210 judgments per subject.

During the experimental sessions the subjects were brought into the room, seated, and read the experimental instructions (Appendix B).

The stimuli were hidden behind a large screen and were removed one at a time by the experimenter and placed on the chalk tray of a freshly painted green chalk-board. They were presented at approximately two second intervals and in random order with a different random order being used during each presentation of a series. The subjects were given 14 trials with the unskewed series of stimuli (preshift series) followed by a five minute break after which they were given 14 trials (postshift series) with one of the skewed series of stimuli. During the break they were requested not to discuss the experiment.

For the first 14 trials both groups judged a stimulus series containing stimuli with values of 32, 51, 70, 89, 108, 127, 146, 165, 184, 203, 222, 241, 260, 279, and 298 mm. During their second 14 trials one group, Group P, judged a stimulus series containing stimulus values of 32, 45, 58, 72, 85, 98, 113, 125, 138, 151, 164, 178, 211, 254.5, and 298 mm. The other group, Group N, received a stimulus series with values of 32, 74.5, 116.8, 149.5, 163, 176.5, 190, 203.5, 217, 230.5, 244, 257.5, 271, 284.5, and 298mm.

The mean stimulus value in each series was, unskewed, 165 mm.; P or positively skewed series, 134.8 mm.; and N or negatively skewed series, 193.0 mm. The geometric mean for these same three series was 139.4, 113.9, and 171.7; respectively.

CHAPTER III

RESULTS

The judgment scales formed by the subjects during this experiment were described in two ways. First, on every trial mean stimulus assigned to each judgmental category was determined for each subject. It should be recalled that the mean stimulus judged medium fits the operational definition of adaptation-level (Helson, 1959, p. 567) as well as Johnson's concept of the midpoint of the judgment scale (Johnson 1955, p. 345). Therefore, it was used as the obtained midpoint of the scale when comparing the predicitions derived from the theories of Helson and Johnson. Second, the median judgment assigned to each stimulus during each trial was determined and these values were used to derive the predicted scale midpoint and also as the obtained scale values for the judgment scales. The median values were used in this case to reduce the effect of skewing in the extreme categories.

The mean stimulus value assigned to each of the five judgmental categories is presented in Table 1. This table contains those values obtained during the last preshift trial and during the first and last postshift trials because these are the points which summarize the modifications in the judgment scale which are most pertinent to the purpose of this investigation. The values from Table 1 for the last preshift and last postshift trials have been plotted in figure 1 to show the relationship between the judgment scale and the stimulus scale.

Table 1

Mean Values (mm) of Stimuli Assigned to Each Judgmental Category On the Last Preshift Trial and The First and Last Postshift Trials

Categories	Last Preshift Trial		First Postshift Trial		Last Postshift Trial	
	Group P	Group N	Group P	Group N	Group P	Group N
Very Small	33.90	36.28	35.58	34.13	33.95	32.00
Small	79.50	84.25	77.04	90.88	74.67	85.75
Medium	151.70	159.30	141.90	171.48	143.25	170.67
Large	233.40	235.30	210.94	242.92	227.39	248.90
Very Large	288.50	290.18	283.86	289.90	292.69	290.58

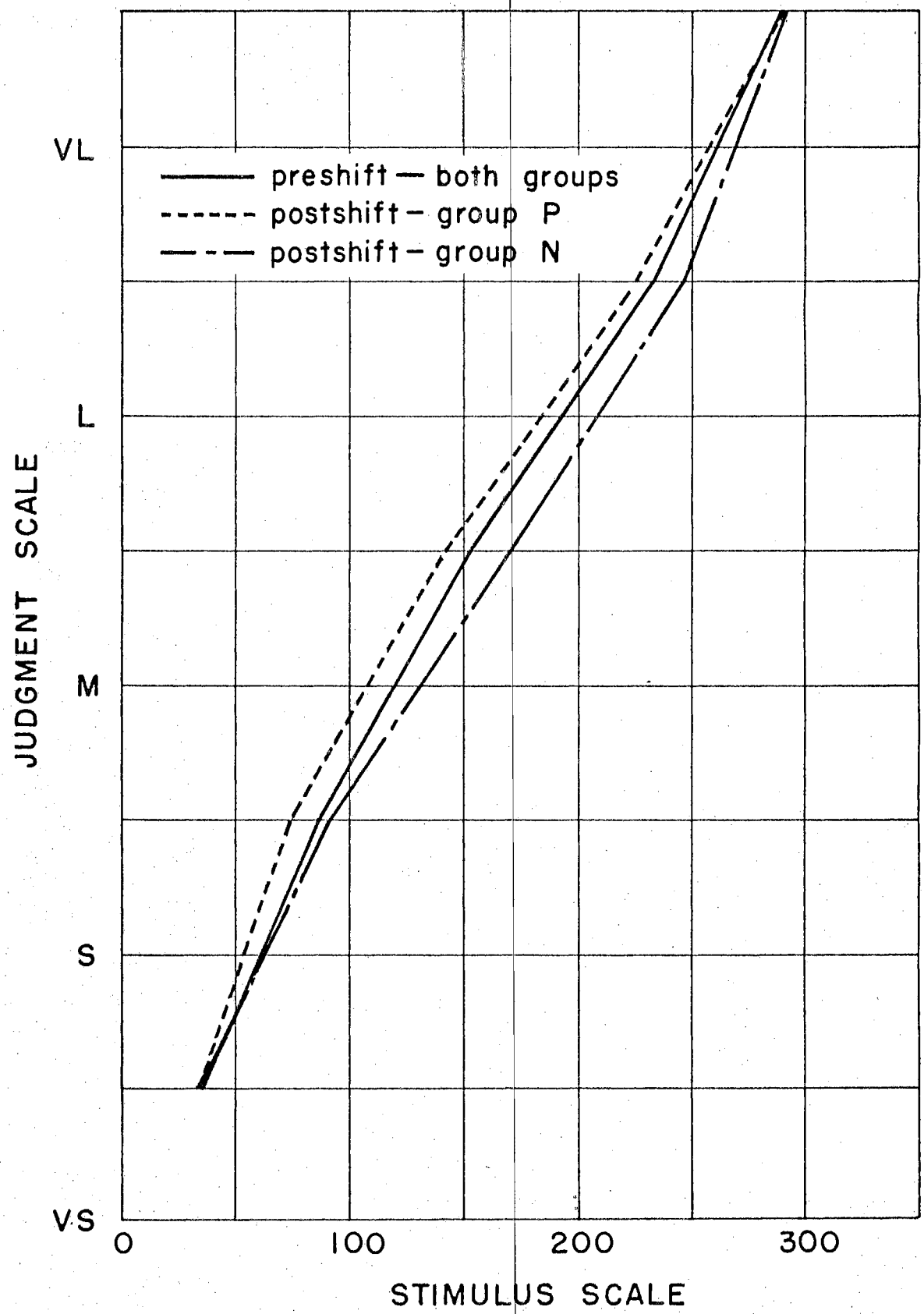

Figure 1. Regression of Stimulus Scale (mm) on the Judgment Scale

In order to determine the amount and direction of the initial shift in the judgment scale, the mean stimulus judged medium on the first postshift trial was subtracted from the mean stimulus judged medium during the last preshift trial for each subject and an average of these differences was calculated. The same procedure was followed to determine the shift between the first and last postshift trials. The measures obtained from these calculations are presented in Table 2. The negative values in Table 2 indicate the shift was to a lower mean value and the positive values indicate a shift to a higher value.

As mentioned earlier, the mean stimulus judged medium was used as the obtained value for the psychological midpoint of the judgment scale. These obtained values were compared with the values predicted from equations (3) and (7) and the results of this comparison are presented in Table 3. Positive values indicate the obtained value was overestimated and the negative values indicate underestimations.

The results of the comparisons made between the obtained judgment scale values and the predicted judgment scale values are presented in Table 4. The obtained values for Table 4 were determined by calculating the median judgment given to each stimulus and the predicted values were derived from equations (4) and (7). The mean squared deviation was determined by subtracting the predicted value from the obtained value, squaring this difference, and averaging these squared differences over all the stimuli judged in a series. The mean squared deviation was used because it gave a better indication of scale fit than did the mean deviation. The mean deviation is sensitive to direction of deviation and indicates a close fit even when values at one end of the scale are over estimated and values at the other end

Table 2

Mean Shift (mm) of the Mean Category Values Observed

After the First and Last Postshift Trials

Categories	After First Postshift Trial		Between First and Last Postshift Trial	
	Group P	Group N	Group P	Group N
Very Small	1.68	- 2.15	- 1.63	- 2.25
Small	- 2.30	5.88	- 2.27	- 5.15
Medium	-10.14	12.18	2.70	- 0.82
Large	-21.21	7.65	16.14	5.93
Very Large	- 5.59	- 0.24	8.83	0.68

Table 3

Mean Deviations (mm) Between the Obtained Mean of "Medium" Category and the Values Predicted From Adaptation-Level Theory and Generalization Theory

Trials	Adaptation-Level Theory		Generalization Theory	
	Group P	Group N	Group P	Group N
Preshift				
1	- 16.18	- 29.49	- 4.69	- 5.01
2	- 22.93	- 17.27	- 2.25	3.05
3	- 20.71	- 23.54	- 0.90	- 0.04
4	- 16.47	- 21.87	6.32	- 0.97
5	- 18.88	- 21.45	4.20	- 0.85
6	- 17.63	- 20.41	4.72	- 0.03
7	- 15.04	- 17.42	6.23	2.77
Postshift				
1	- 15.27	- 20.25	4.17	- 4.65
2	- 12.10	- 19.30	4.80	- 2.66
3	- 12.71	- 14.58	3.08	- 0.92
4	- 15.09	- 21.78	2.58	- 3.11
5	- 10.52	- 21.30	3.70	- 4.23
6	- 13.64	- 24.69	1.48	- 6.50
7	- 8.77	- 21.43	6.00	- 3.86

of the scale are underestimated.

The empirical constants in equation (5) were determined by using equation (3) to determine the value of AL for the last preshift trial and the first and last postshift trials. The value of AL for the last preshift trial was substituted into equation (5) for A_p and the values from the postshift trials substituted for A_e. The equations thus derived, along with an equation expressing the fact that m, n, and e sum to unity, were used to solve for the values of m, n, and e. The equations obtained are listed below.

$$\log A_e = .542 \log A_p + .9419 \qquad (9)$$

$$\log A_e = .666 \log A_p + .7465 \qquad (10)$$

$$\log A_e = .735 \log A_p + .5922 \qquad (11)$$

$$\log A_e = .912 \log A_p + .1810 \qquad (12)$$

Equation (9) was used to predict the mean stimulus judged medium by Group P on the first postshift trial and equation (11) was used for the last postshift trial. Equations (10) and (12) were used for Group N.

The empirical constant w in equation (8) was determined by first solving equation (7) to determine the appropriate values for A_p and A_e. Given these values, the number of times the subjects had judged the skewed series, and the arithmetic means of the skewed series, it was possible to solve for w. The derived equations are presented below. Equations (13) and (15) were used to predicted the mean stimulus judged medium by Group N on the first and last postshift trials and equations (14) and (16) were used for Group P.

$$A_e = \frac{3.81\ A_p + 387.76}{5.81} \qquad (13)$$

Table 4

Mean Squared Deviations Between Obtained Scale Values and Scale Values Predicted from Adaptation-Level Theory and Generalization Theory

Trials	Adaptation-Level Theory		Generalization Theory	
	Group P	Group N	Group P	Group N
Last Preshift	.417	.571	.121	.117
First Postshift	.502	.642	.170	.131
Last Postshift	.236	.312	.170	.134

$$A_e = \frac{23.31\ A_p + 1887.2}{37.31} \tag{14}$$

$$A_e = \frac{28.58\ A_p + 2714.3}{42.58} \tag{15}$$

$$A_e = \frac{1.90\ A_p + 269.6}{3.90} \tag{16}$$

The mean stimulus judged medium by each subject on the last pre-shift trial was substituted into the above equations as A_p and the obtained values for A_e were compared with the obtained mean stimulus judged medium. The differences between the predicted and obtained values were averaged over subjects and the resulting measures are presented in Table 5.

Table 5

Mean Deviation Between the Mean Stimulus Judged Medium and the values Predicted from Equations (5) and (8)

Trials	Adaptation-Level Theory		Generalization Theory	
	Group P	Group N	Group P	Group N
First Postshift	- 9.223	- 6.384	1.120	- 0.282
Last Postshift	4.683	- 8.543	0.186	0.001

CHAPTER IV

DISCUSSION

Inspection of Table 1 indicates that the two groups of subjects did develop similar scales during their judgments of the preshift series of stimuli and that they tended to fit their scales to the range of stimuli. A t test was made to determine whether or not the mean stimulus judged medium during the last preshift trial differed for the two groups and it was found that the means were not significantly different ($t = .987$, $P > .05$). A further inspection of Table 1 shows that the subjects shifted their scales during their judgments of the postshift series of stimuli and t tests were made to test the postshift means. It was found that the two groups were significantly different at the end of the first postshift trial ($t = 4.465$, $P < .01$) and after all seven postshift trials ($t = 3.923$, $P < .01$). It should be noted that the shift obtained in this experiment is similar to the shift found by Parducci (1956) indicating that varying the interval between stimuli has the same effect on the judgment scale as varying the frequency of presentation.

Stevens and Galanter (1957) indicate that the shifts found in this experiment and in Parducci's study can be accounted for if one considers the possibility that the subjects try to use all of the judgmental categories with equal frequency. If stimuli are "bunched" by either differentially varying the frequency of presentation or the

interval between stimuli, the midpoint of the scale will shift toward the bunching. This being the case, it would be expected that in the present study the midpoint for Group P would shift to a lower value and the midpoint for Group N would shift to a higher value. Inspection of Table 2 indicates that the groups did shift in the predicted directions. A t test was made for each of the mean differences shown in Table 2 and it was found that the initial shift for both groups was significant ($t = 2.791$, $P < .05$ for Group P and $t = 4.325$, $P < .01$ for Group N), but the shift between the first and last postshift trials was not significant ($t = .005$, $P > .05$ for Group N and $t = .053$, $P > .05$ for Group P).

If the values from Table 1 for the last preshift and postshift trials are plotted against the values of the stimulus series, Figure 1, we find that the curve appears linear for the middle three categories and that the slope rises sharply at both extreme categories. Actually a family of curves is obtained with the curve for Group P being slightly above the curve for the unskewed judgments and the curve from Group N being slightly below the unskewed curve. All three curves have the same general slope, but the slopes at the extreme categories vary such that for the unskewed curve it is equally sharp at both extremes and for the other two curves the slope for the positive group is sharpest at the lower extreme and for the negative group it is sharpest at the upper extreme. Stevens and Galanter have also predicted these results by pointing out that when the stimuli are closely spaced or appear more frequently the local slope will be steep and when they are widely spaced or presented less frequently the local slope will flatten. They say these results can be explained if one assumes the subjects

seem to resist using the same response category over and indicate that Johnson's Generalization Theory more closely approximated the obtained values than did Helson's Adaptation-Level Theory. Table 2 shows that AL theory underestimated the category limens in every case and that the Generalization theory overestimated the limens for both groups on the preshift trials and for Group P on the postshift trials, but it under estimated the values for Group N on the postshift trials. If a line of best fit is drawn for the curves mentioned above it is found that the midpoint of the scale is overestimated for the unskewed and positive skewed group and underestimated for the negative skewed group. Basically the procedure used by Johnson to determine the midpoint of the scale makes use of a line of best fit.

The data in Table 4 indicates that the Generalization theory very closely approximated the scale values. The deviations which did occur seemed to result from the fact that the curve describing the scale was not completely linear but showed the variations in slope mentioned above. On the other hand, the values from AL theory tended to be too small at the extremes and too big in the middle of the scale. This would indicate that the obtained scale was linear and that its midpoint was located at a higher value than predicted by AL theory.

The direction of change in the midpoint of the scales was accurately predicted by both the Helson and Johnson shift equation, however Johnson's equations appear to be more accurate in predicting the quantitative characteristics of the change.

Conclusions

The results of this experiment indicate that systematic variations in the interval between stimuli will bring about predictable

changes in the judgment scale even though the range and frequency of presentation are held constant. Additional studies are needed, however, to determine how these three variables, stimulus range, interval between stimuli, and frequency of presentation, will interact if two of them or all three are varied at the same time.

The results also indicate that there is factual basis for the assumption made by Johnson that for judgments of length the receptor function is linear and that the subjects making judgments of length will develop a linear scale the midpoint of which approximates the arithmetic mean of the stimulus series being judged.

CHAPTER V

SUMMARY

The types of judgment scales used by subjects when making absolute judgments of length were studied by having two groups of subjects judge the length of three different series of wooden sticks. Initially, both groups judged a rectangular distribution of sticks and then one group judged a negatively skewed distribution and the other group judged a positively skewed distribution. Skewing was obtained by varying the interval between stimuli. It was found that during their initial judgments the subjects developed scales which were linear in form and the centers of these scales approximated the arithmetic mean of the unskewed stimus series. During their judgments of the skewed series, their scales were modified and the midpoints shifted toward the arithmetic mean of the new series. The obtained scales were compared with scales predicted from Adaptation-Level theory and Generalization-theory and it was found that the Generalization theory more accurately predicted the midpoint and form of the obtained scales than did Adaptation-Level theory and that both theories accurately predicted the direction of shift, but Generalization theory appeared to more accurately predict the quantitative characteristics of the change. These results were interpreted as supporting Johnson's assumption that the receptor system used when making the judgments determines the type of mathematical function to be used when predicting the midpoint and form of the response scale.

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APPENDIX A

Sample Data Sheet

Name _____ No. _____

1. _____	1. _____	1. _____	1. _____
2. _____	2. _____	2. _____	2. _____
3. _____	3. _____	3. _____	3. _____
4. _____	4. _____	4. _____	4. _____
5. _____	5. _____	5. _____	5. _____
6. _____	6. _____	6. _____	6. _____
7. _____	7. _____	7. _____	7. _____
8. _____	8. _____	8. _____	8. _____
9. _____	9. _____	9. _____	9. _____
10. _____	10. _____	10. _____	10. _____
11. _____	11. _____	11. _____	11. _____
12. _____	12. _____	12. _____	12. _____
13. _____	13. _____	13. _____	13. _____
14. _____	14. _____	14. _____	14. _____
15. _____	15. _____	15. _____	15. _____

APPENDIX B

Experimental Instructions

EXPERIMENTAL INSTRUCTIONS

Your task in this experiment is to judge the length of different sticks. You will be presented with a series of sticks (hold up the sample stick). As each stick is presented you will make a judgment of how long or short it appears to be to you. You will record your judgment by writing "VS" if it appears to be very short, "S" if it appears to be short, "M" if it appears to be medium, "L" if it appears to be long, and "VL" if it appears to be very long. Your judgments will be recorded on the data sheets which have been placed before each of you. Once you have recorded your judgment, do not go back and change it. Since this experiment is concerned with how the stick appears to you, there can be no right or wrong answers. Please respond to all the sticks; even if at first the decision seems difficult.

APPENDIX C

Obtained Judgment Scale Values

Table 6

Obtained and Predicted Values for the Medium Category

Trials	Obtained Value		Adaptation-Level Theory		Generalization Theory	
	Group P	Group N	Group P	Group N	Group P	Group N
Preshift						
1	171.19	173.63	155.01	144.14	166.50	168.62
2	168.96	164.11	146.03	146.84	166.71	167.16
3	166.90	166.11	146.19	142.57	166.00	166.07
4	157.15	166.71	140.68	144.84	163.47	165.74
5	155.98	161.15	137.10	139.70	160.18	162.00
6	155.41	164.21	137.78	143.80	160.13	164.18
7	151.70	159.30	136.66	141.88	157.93	162.07
Postshift						
1	141.90	171.48	125.63	151.23	146.07	166.83
2	146.48	173.58	134.38	154.28	151.28	170.92
3	144.27	167.12	131.56	152.54	147.35	166.20
4	149.59	172.08	134.50	150.30	152.17	168.97
5	147.63	173.21	137.11	151.91	151.33	168.98
6	150.51	174.34	136.87	149.65	151.99	167.84
7	143.25	170.67	134.48	149.24	149.25	166.81

Table 7

Median Judgment Given to Each Stimulus by Group P

During the Preshift Trials

Stimulus Values	Trials 1	2	3	4	5	6	7
32.0	1.03	1.00	1.00	1.00	1.00	1.00	1.00
51.0	1.21	1.21	1.33	1.88	2.15	2.59	2.73
70.0	2.50	2.56	2.73	2.75	3.00	2.97	3.00
89.0	2.94	2.94	3.00	3.03	3.09	3.06	3.06
108.0	3.21	3.13	3.13	3.41	4.00	3.75	3.70
127.0	4.50	3.93	4.16	4.30	4.30	4.68	4.81
146.0	4.83	4.50	4.90	4.86	4.94	4.92	4.90
165.0	4.88	4.94	5.00	5.00	5.03	5.03	5.09
184.0	5.08	5.08	5.14	5.40	5.33	5.27	5.79
203.0	6.06	6.50	5.41	6.10	6.66	6.50	6.50
222.0	6.93	6.75	6.50	6.50	6.79	6.79	6.83
241.0	7.05	7.00	6.93	7.00	7.00	6.97	6.94
260.0	8.38	7.66	7.41	7.75	7.83	7.50	7.41
279.0	8.59	8.67	8.59	8.73	8.59	8.50	8.78
298.0	8.73	8.88	8.91	8.94	8.88	8.91	9.00

Table 8

Median Judgment Given to Each Stimulus by Group P

During the Postshift Trials

Stimulus Values	Trials						
	1	2	3	4	5	6	7
32.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
45.0	1.90	2.59	2.73	2.67	2.79	2.79	2.83
58.0	2.83	2.83	2.88	2.88	2.91	2.88	2.97
72.0	3.03	3.03	3.11	3.11	3.14	3.09	3.03
85.0	3.06	3.14	3.27	3.27	3.27	3.27	3.21
98.0	3.79	3.41	3.83	3.33	3.33	3.41	3.33
113.0	4.50	4.10	4.60	4.68	4.10	4.00	4.50
125.0	4.86	4.91	4.88	4.88	4.89	4.75	4.93
138.0	4.97	4.94	4.93	4.88	4.93	4.83	4.93
151.0	5.11	4.94	4.97	4.93	5.00	4.97	5.00
164.0	5.50	5.14	5.03	5.00	5.03	5.03	5.03
178.0	6.25	5.33	5.50	5.17	5.23	5.14	5.50
211.0	6.92	6.81	6.83	6.81	6.68	6.75	6.68
254.5	8.67	7.41	7.79	7.17	7.04	7.10	7.14
298.0	9.00	9.00	8.97	8.97	8.97	8.97	8.97

Table 9

Median Judgment Given to Each Stimulus by Group N

During the Preshift Trials

Stimulus Values	Trials						
	1	2	3	4	5	6	7
32.0	1.08	1.03	1.00	1.00	1.00	1.00	1.00
51.0	1.33	1.13	1.21	1.50	2.21	2.50	2.50
70.0	2.10	2.88	2.73	2.91	2.91	2.91	2.91
89.0	3.04	2.96	3.14	3.11	3.19	3.13	3.10
108.0	3.28	3.64	3.19	3.40	3.50	3.41	3.70
127.0	4.00	3.83	4.00	4.59	4.59	4.67	4.67
146.0	4.17	4.59	4.79	4.79	4.79	4.73	4.79
165.0	4.83	5.00	4.91	4.90	5.00	5.06	5.06
184.0	5.07	5.19	5.30	5.14	5.21	5.10	5.21
203.0	6.50	6.21	5.75	5.50	5.93	5.50	5.83
222.0	6.83	6.50	6.59	6.50	6.67	6.59	6.67
241.0	6.83	6.93	6.97	6.99	6.97	6.89	7.03
260.0	8.07	7.79	7.32	7.32	7.64	7.25	7.33
279.0	8.67	8.13	8.73	8.50	8.50	8.17	8.60
298.0	8.79	8.88	8.91	8.88	8.91	8.91	9.00

Table 10

Median Judgment Given to Each Stimulus by Group N

During the Postshift Trials

Stimulus Values	Trials						
	1	2	3	4	5	6	7
32.0	1.00	1.00	1.00	1.00	1.00	1.00	1.00
74.5	2.91	2.97	2.94	2.97	3.00	3.03	2.90
116.8	3.50	3.33	3.83	4.50	4.59	4.16	4.17
149.5	4.88	4.88	4.91	4.94	4.88	4.88	4.94
163.0	4.90	4.91	4.97	4.94	4.97	4.97	5.00
176.5	5.00	4.97	5.00	5.03	5.03	5.00	5.03
190.0	5.17	5.13	5.14	5.25	5.06	5.10	5.14
203.5	5.50	5.41	5.70	5.32	5.32	5.50	5.50
217.0	6.59	6.50	6.59	6.73	6.50	6.79	6.67
230.5	6.86	6.75	6.88	6.86	6.88	6.88	6.90
244.0	6.97	6.86	6.91	6.90	6.88	6.93	6.93
257.5	7.13	7.10	7.06	7.10	7.00	7.00	7.04
271.0	8.50	7.64	7.79	7.70	7.21	7.70	8.00
284.5	8.79	8.21	8.73	8.09	8.33	8.67	8.67
298.0	9.00	8.97	8.94	8.94	8.94	8.94	8.91

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