The Relation of Intelligence and the Spread of Effect

by

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approved

A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of

MASTER OF ARTS

in the Department

of

EDUCATION

The University of British Columbia

August, 1949

ABSTRACT

The problem investigated was the relation of intelligence to the spread of effect. A null hypothesis was set up, that the spread pattern obtained from more intelligent subjects would not differ from that found in the less intelligent.

Data were collected from two groups of thirty subjects each, one composed of "bright" and the other of "dull" students. All were pupils in Grades V, VI, and VII in the same school. The material was of the conventional type (word-stimulus, number-response) used in many "effect" experiments, but the typical procedure of rewarding correct responses with the announcement "right" and punishing wrong responses with the announcement "wrong" was modified by the omission of the announcement "wrong" during the course of the experiment.

Serial position effects were obviated by making successive presentations of the list of stimulus words continuous, and by the length of the list. Favored responses were determined with the help of two presentations free from reward at the beginning of the experiment, and were eliminated from all calculations in order to establish a neutral base-line, which was determined by computing the percentage of total repetitions throughout the five presentations during which rewards were given. Gradients were plotted for each group from the percentages of repetition of rewarded responses and of repetitions one, two, and three steps before

and after rewarded responses.

The results are such that the null hypothesis must be accepted, that is, intelligence as measured by a standard test is not a variable factor in determining the spread of effect. Of the group differences found, none is statistically reliable. In so far as can be judged from a single experiment and within the parameters of that experiment, it is concluded that reward has equal effect on bright and dull students in a serial learning situation.

The relatively low percentage levels of repetition as compared with those of previous studies is attributed to one of two factors, or possibly to a combination of both. In the first place, the method of assembling the data precluded favored responses from contributing to the gradients obtained, and so reduced the number of repetitions calculated. In the second, the word-list was of a length commonly used with subjects at the college level. From these facts, two tentative conclusions are reached. One, that to the extent that favored responses contribute to gradient data, levels of repetition obtained in a number of previous studies and attributed to the effect of reward, are spuriously high, and the influence of reward has been exaggerated. Two, the length of the test (in this case, the word-list), is a factor determining the influence of reward. It is thought that both of these conditions may be responsible, to a degree so far undetermined, for the results obtained in this study.

Similarly to the levels of repetition found in each response category, the height of the established base-line is conspicuously lower than any previously adopted, and is noteworthy in its close approximation to the pure chance figure. It has been accounted for on the basis of elimination of favored responses and serial position effects, and would also have been affected by the factor of length of the word-list if this were an experimental variable.

A summary consideration of the slope of the gradients from these data compared with gradient curves from previous studies where punishment in the form of the announcement "wrong," as well as reward, was administered to the subjects, revealed no consistent trends and added nothing conclusive by way of evidence on the influence of punishment in a learning situation, other than to emphasize the apparently varying roles this type of "punishment" can play, and the inadvisability of generalizing from the evidence thus far available on its modus operandi.

In addition, the fact that unrewarded responses, which were not punished, in seven out of twelve categories were repeated less frequently than consideration of the neutral base-lines would have led one to expect, requires explanation. It has been hypothesized that reward, in emphasizing the correct response, acts as a distraction on neighboring connections and thereby reduces their rate of repetition below the chance level.

Suggestions were made for further research into the relation of intelligence and extent of spread; into the technique for establishing a base-line; into the factor of favored responses as unduly magnifying the effect of reward; and into the falling off of repetitions of unrewarded though unpunished responses below the obtained chance line.

Acknowledgements

In presenting this study, the writer wishes to make the following acknowledgements: to Dr. F. T. Tyler, now of the University of California at Berkeley, for his able introduction into the psychology of learning in general and the spread phenomenon in particular, and for initiating this piece of research; to Mr. Harold F. George, mathematics specialist in the Mission, B. C. School District, whose interest and critical appraisal during the development of the problem were of inestimable value; to Mr. O. J. Thomas, Inspector of Elementary Schools, and to the Principal, Mr. E. V. Caspell, and the staff of Renfrew Elementary School, Vancouver, for their willing cooperation in providing subjects; to Dr. J. R. McIntosh, of the Education Department at the University of British Columbia, for his encouragement and thoughtful criticism throughout; and to Dr. Maxwell A. Cameron, Head of the Education Department, University of British Columbia, whose great kindness and consideration have been never-failing.

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The Relation of Intelligence and the Spread of Effect

Chapter I

Introduction -- The Problem -- Its Background and Development

Background

The purpose of this study was to discover whether there is any relation between the degree of measured intelligence and the spread of effect as demonstrated first by E. L. Thorndike[1] and later by other investigators into the psychology of learning.

Thorndike's "The Fundamentals of Learning," which was published in 1932, contained among other revisions of his original theory of learning, a re-formulated law of effect which minimized the direct weakening influence of punishment. In the following year he published experimental evidence to demonstrate that a reward strengthens not only the connection to which it belongs, but also neighboring connections both preceding and following the rewarded connection, such strengthening gradually diminishing as the distance from the rewarded connection increases. It

1. Thorndike, E. L. "A Proof of the Law of Effect," Science, 1933, 77, pp. 173-175
"An Experimental Study of Rewards," Teachers College, Columbia Univ., Contr. Educ., No. 580. New York: Bureau of Publications, Teachers College, Columbia Univ., 1933.

is this phenomenon to which Thorndike applied the term "spread [of effect],"[2] and which has become the primary article of faith in the Thorndike theory.

In 1947 Postman[3] published an article in which he reviewed the development and the present position of the law of effect. The results of major significant studies were considered and questions not yet satisfactorily answered were put forward. Among these was one which arose in connection with the findings of Muenzinger and Dove,[4] that responses surrounding a rewarded response tend to be repeated while those around a punished response tend to be varied. Postman here makes this comment:

> "This analysis still leaves open the question as to what intervening mechanism the changes in variability should be ascribed." 5

Thorndike himself states that ". . . the extent of spread may vary with the kinds of learning and the learners."[6]

2. Thorndike, E. L., passim

3. Postman, L.,"The History and Present Status of the Law of Effect, Psychol. Bull., 1947, 44, pp. 489-563.

4. Muenzinger, K. F., and Dove, C. C., "Serial Learning: I. Gradients of Uniformity and Variability Produced by Success and Failure of Single Responses," J. Gen. Psychol., 1937, 16, pp. 403-413.

5. Postman, op. cit., p. 518.

6. Thorndike, E. L., Contr. Educ., No. 580, p. 54.

In this regard, Wallach and Henle[7] have demonstrated with college students that the "Thorndike effect" does not appear when motivation to learn is lacking. It appears, then, that the spread of effect may be subject to certain variable factors of which motivation may be one.

Consideration of a mechanistic theory of learning such as Thorndike's leads to the question of cognitive behaviour in relation to behaviour automatically determined by the formation of bonds or connections within the organism. Whether we accept Sandiford's interpretation that these connections ". . . presumably have their physical basis in the nervous system, where the connections between neuron and neuron explain learning"[8], or whether with Gates we regard a connection simply as ". . . a functional relation between a situation and a response . . . . which implies no neurological correlate"[9], the automatic and mechanical element remains and gives rise to speculation concerning the possible operation of cognitive factors in the learning process.

This speculation, coupled particularly with Thorndike's statement regarding variation in extent of spread, and the Wallach and Henle study on motivation and reward, led to the formulation of the present problem -- is intelligence a variable factor in relation to the spread of effect?

7. Wallach, H. and Henle, Mary, "An Experimental Analysis of the Law of Effect, J. Exp. Psychol., 1941, 28, pp. 340 - 349.
"A Further Study of the Function of Reward," J. Exp. Psychol., 1942, 30, pp. 147 - 160.

8. Sandiford, P., "Connectionism: Its Origin and Major Features," Forty-first Yearbook, Nat. Soc. Study Educ., Part II, Bloomington, Public School Publishing Co., 1942, p. 98.

9. Gates, A. I., "Connectionism: Present Concepts and Interpretations, Forty-first Yearbook, Nat. Soc. Study Educ., Part II, Bloomington, Public School Publishing Co., 1942, p. 145.

In reviewing the literature of the field, one is struck rather forcibly by the fact that in the studies so far reported, with one exception where students from Grades 6, 7, and 8 were used,[10] the subjects have been either college students or rats. This observation suggests the practical need, particularly from the viewpoint of general educational application, of investigation in the one instance of a less select, more representative group, and in the other, of subjects more nearly related in kind to the typical school population. Accordingly, it was decided to use in this investigation subjects of a grade level as representative as possible of the average elementary school pupil.

Since intelligence was to be the significant variable, a comparative study was planned around two groups, one composed of pupils who obtained high scores on a standard intelligence test, the other of pupils whose scores on the same test were relatively low.

The specific object of the investigation was to determine whether the spread of effect pattern obtained from a group of subjects of high I.Q. is similar to that manifested by a group of subjects whose I.Q.'s are relatively low. A null hypothesis was set up, to the effect that the spread patterns obtained would not differ significantly from each other.

10. Rock, R. T., Jr., "The Influence Upon Learning of the Quantitative Variation of After-Effects," Teachers College, Columbia Univ., Contr. Educ., No. 650, New York: Bureau of Publications, Teachers College, Columbia Univ., 1935.

Chapter II

The Experiment -- Subjects, Material, Procedure, Calculations

Subjects

Data were collected from two groups, each composed of thirty pupils from Grades V, VI, and VII at Renfrew Elementary School in Vancouver, B. C. The school is located in what might be called an average residential district. Relevant details concerning each group are presented in Table I. For convenience, the group with the higher I.Q. rating will be identified as the high group, and the group with the lower I.Q. rating as the low group.

Table I

COMPOSITION OF EXPERIMENTAL GROUPS

		Grade Placement			Sex		I.Q.		Age (in years)	
	N#	V	VI	VII	M	F	Range	Mean	Range	Mean
High Group	30	11	8	11	12	18	120-154	127.9	10.4-13.4	11.96
Low Group	30	15	8	7	18	12	73-94	87.3	10.8-14.4	12.71

I.Q. ratings were obtained by means of the National Intelligence Test administered by personnel from the Testing Bureau of the city school system. The groups were differentiated by 40.6

In previous studies reviewed N has varied from twenty to seventy-five.

mean I.Q. points, and by 26 points separating the lowest rating in the high group from the highest in the low group. The differences apparent in chronological age were considered not large enough to affect materially the obtained data.

Material

The material used was of the conventional type employed in many experiments designed to test the spread of effect phenomenon, that is, a list of word-stimuli, each word requiring a response in the form of a number from within a designated range. In this case, the word list consisted of 40 simple one-syllable verbs, chosen on the basis of about equal familiarity to all the subjects (Appendix). The range of numbers from which responses were to be made was one to six.[1]

Procedure

In the typical method of procedure, the word-stimuli are presented in fixed order and at a specified rate of speed to each subject. Rewards in the form of the announcement "right", and punishments in the form of the announcement "wrong" are administered by the experimenter according to a

1 In previous studies of similar nature which have been examined the length of the word-series has varied from twenty-five to eighty words, and the range of responses from one to five to one to ten.

key or plan by which right and wrong responses are predetermined. The list is presented to each subject in a number of continuous successive trials and a record is kept, by the examiner, of each response to each stimulus word (Appendix).

This method was followed except for one modification. For the purpose of this study it was decided that the effect of the announcement "wrong" was not of particular moment. Consequently the procedure was modified in this respect, and only reward in the form of the announcement "right" was used in the presentation of the test material.

The total number of trials for each subject was seven. During the first two of these, no rewards were given. Much discussion of the evidence supporting the law and the spread of effect has centred around the determination of a base-line of chance expectation from which to evaluate the actual percentages of repetitions obtained. It is apparent that in the sort of "free association" technique employed in experiments of this kind, some favored word-number combinations are extremely likely to occur and recur. Tilton has stated the problem clearly when he says that what is needed ". . . is the repetition which obtains before the 'rewards' and 'punishments' to be studied are applied."[2] From this premise he plotted a curve of repetitions for 360 observations at each serial point in his experimental material, based on the responses of subjects before they had been informed as to right and wrong responses. The curve proved throughout most of its length to be straight and

2. Tilton, J. W., "Gradients of Effect," J. Genet. Psychol., 1945, 66, p. 8.

horizontal in nature and was adopted as the zero or base-line for his experimental data. In calculating effect gradients, a correction was made for serial position effects which appeared in the base-line data, by omitting from the gradient data items located at the top and bottom of the two pages of learning material, and which showed an extremely high percentage of repetition.

At the same time Tilton found that for such data a similar base-line was arrived at simply by computing the percentage of total repetitions, right and wrong, during the course of the experiment. He points out that in his material the number of rights was about equal to the number of wrongs, and that where this is not the case, the results for rights and wrongs would have to be averaged with equal weights before a similar curve could be obtained by this method.

Martens[3] estimated a base-line by using a control group. The experimental material was presented to the control group in two successive trials without reward or punishment, and the percentage of repetitions which resulted was used as the chance base-line. The number of subjects in the Martens study has not been reported, so that some doubt arises as to the validity of such a technique unless the numbers are very large. For small numbers it would seem preferable to have experimental groups serve as their own controls,

3. Martens, D., "Spread of Effect in Verbal Serial Learning," (Abstract) Amer. Psychologist, 1946, 1, 448-449.

with cognizance taken of the fact that there may be strengthening of a response due simply to its occurrence.

In the present study, the Tilton and Martens procedures were combined and modified to obtain a neutral base-line. The experimental groups served as their own controls in the determination of favored responses. The first two trials of the word series were run through without reward and repetitions were noted as probable favored responses. Only on rare occasions were such responses rewarded throughout the remaining five trials. With six possible responses to each stimulus, and seven presentations of the word-list, two occurrences of the same number-response to a single word-stimulus could be regarded as due to chance. More than two occurrences without the influence of reward could be considered therefore as favored responses.

Thorndike has remarked that the spread appears to stop at some point between the third and sixth step positions removed.[4] With this in mind, it had been decided that gradients plotted to the third step would serve the purpose of the present study. When the problem of determining favored responses arose, the third step was again selected as the point beyond which reward is unlikely to show marked effect. Favored responses, then, were identified as those responses which occurred three times or more before reward could be considered to have influenced them, and were omitted entirely

4. Thorndike, E. L., Contr. Educ., No. 580, p. 54.

from all calculations.

When all the data had been collected, the percentage of total repetitions of rights and wrongs[5] combined, excluding the favored responses, was calculated for each group and used as the neutral base-line. Tilton's proviso concerning equal average weighting where the number of rights is not about equal to the number of wrongs was not considered to hold in this case where only the effect of reward is under observation. However, it should be recognized here that the base-line so obtained may itself have been affected by the influence of reward, with the result that the line obtained is actually higher than pure chance would have dictated. This point will be discussed more fully in the following chapter.

The subject was seated about four feet from the examiner's desk and in a position parallel to the desk. He was given the following directions:

What you are going to do for me now has nothing to do with your school work and won't make any difference to your grades or marks. I'm doing an experiment with boys and girls of your age and Mr. C. [the school principal] says that you will be a good one to help me. This is what we are to do: I have a list of words which I'm going to read to you,

5. It will be recalled that the effect of punishment is not being investigated, and throughout the experiment no announcements of "wrong" were made. For convenience, responses not called right by virtue of reward are termed wrong, but no announcement of "wrong" accompanied them.

one after the other. Each word has a number from one to six belonging to it, and you are to guess that number. We'll practise a bit first, I reading a word and you giving a number from one to six, and then when you have the idea, I'll start telling you when you have guessed the right number. I'll simply say "right" and we'll go straight on to the next word. Remember, any number from one to six. Always say the first number that comes into your head and don't try to follow a pattern of numbers like saying them in a certain order. Ready?

The words were read at a rate of one about every $2\frac{1}{2}$ to 3 seconds, and the presentation was made in as automatic and stereotyped a manner as possible.

Rewards were assigned arbitrarily and only rarely to what seemed to be a favored response. It had been intended originally to keep rewards separated by at least seven or eight unrewarded responses in an effort to obviate interference of backward and forward gradients. With subjects as young as these, and as eager to guess the right number, it was found that a greater number of rewards was necessary to maintain interest and relieve the boredom and apparent fatigue induced by the monotony of the procedure. During the third trial, which marked the beginning of the announcement of "right," rewards were separated varyingly by six, seven, and eight unrewarded responses. Thereafter, repetitions of responses from the immediately preceding trial were rewarded; and additional rewards were given as necessary to insure six or seven rewards per trial. There was thus some "crowding" of right responses, but since the experiment was not designed with the purpose of determining to what extent the backward gradient is a function of a preceding forward one, complete control of this factor was not deemed imperative to the testing of the hypothesis which had been set up.

Calculation of Responses

Repetitions were identified as those responses which duplicated responses made in the immediately preceding presentation of the series, always excluding favored responses. Three step positions before and after a rewarded response were thought to be adequate for the determination of spread patterns, and repetitions beyond these were not calculated in the gradients. Where crowding of right responses was evident, a repetition of a wrong response was credited to the nearest rewarded response which it preceded or followed. Repetitions in an exactly midway position between two rewarded responses were omitted from the calculation of gradients. To the extent that the backward gradient may be a function of a larger forward one, the backward gradients obtained from this data will be spurious, but the original purpose of the study is not thereby affected.

Chapter III

Obtained Data -- Analysis, Findings, Interpretations

Tabulation of Data

The record of each subject was analyzed and responses for the five trials during which rewards were given were classified as illustrated in Table II, which contains composite figures for each group.

Table II

CLASSIFICATION OF SIGNIFICANT RESPONSES

Categories of Responses	Number of Responses	
	High Group	Low Group
Total possible	6000	6000
X - Total calculated#	5725	5764
Y - Total repetitions	850	921
A - Total rewarded responses	783	835
B - Repetitions of rewarded responses	162	201
C - Repetitions one step before	87	113
D - two steps before	103	96
E - three steps before	54	48
F - one step after	103	127
G - two steps after	104	95
H - three steps after	56	54

i.e. omitting favored responses.

Following this basic tabulation, percentages of repetition in each category to be examined were computed to obtain comparable figures. These are reported in Table III. Figure 1 is a graphic description of the same material, and presents for both groups the gradients of effect preceding and following rewarded responses.

Table III

PERCENTAGES OF REPETITIONS IN SIGNIFICANT CATEGORIES

CATEGORIES OF REPETITIONS	Percentages of Repetitions	
	High Group	Low Group
Y/X - Total repetitions: Total responses #	14.85	15.98
E/A - Three steps before	6.89	5.75
D/A - Two steps before	13.15	11.49
C/A - One step before	11.11	13.53
B/A - REWARDED RESPONSES	20.69	24.07
F/A - One step after	13.15	15.21
G/A - Two steps after	13.28	11.38
H/A - Three steps after	7.15	6.47

These ratios represent the chance base-lines used.

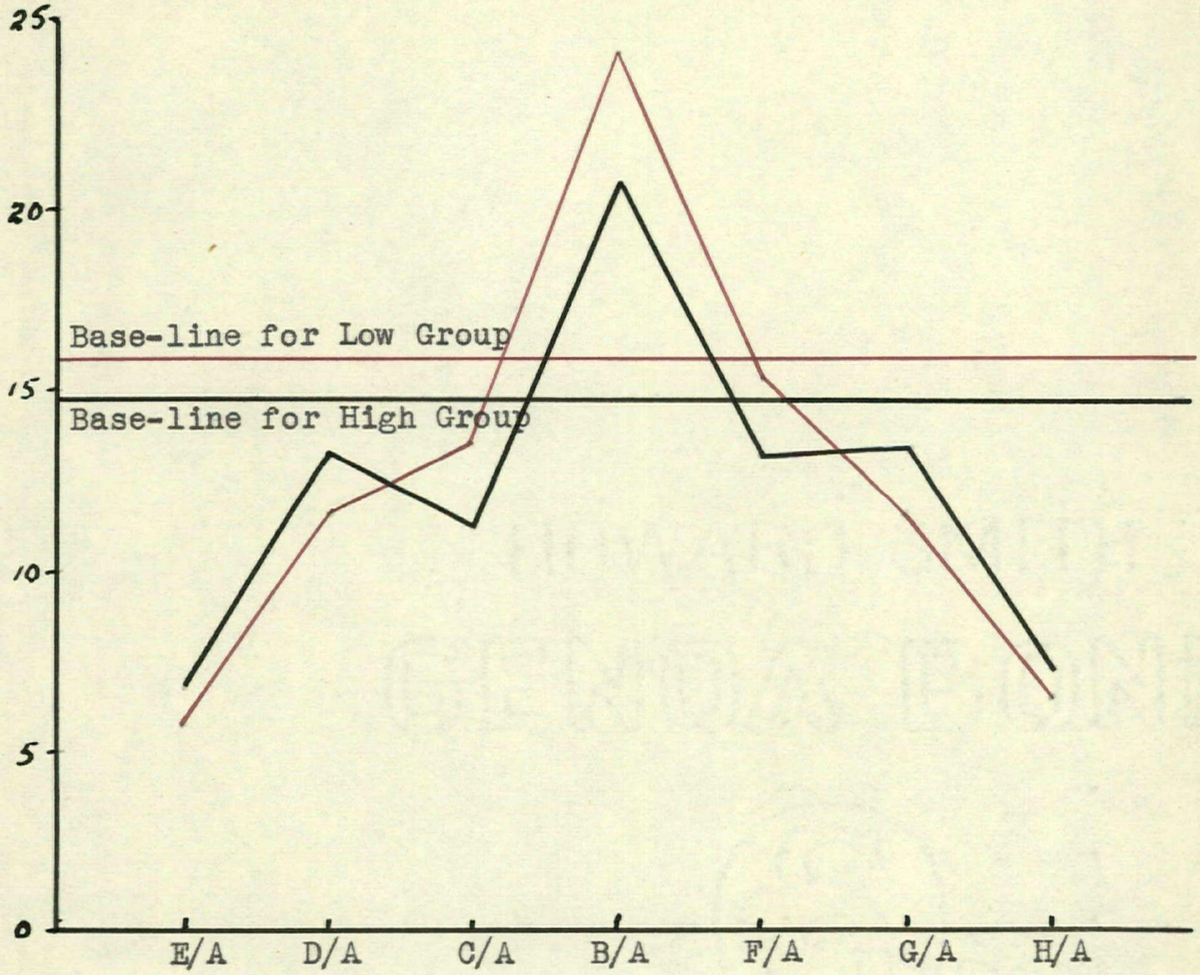

Figure 1. Gradients of Effect Around Rewarded Responses

Analysis and Findings

The percentage of repetitions of rewarded responses for both groups is significantly better than chance. Using the Y/X ratio as the chance base-line, t-ratios of 3.8 and 5.2 were found for the high and low groups respectively.[1]

1. The formulae, $\sigma_P = 100\sqrt{\frac{PQ}{N}}$, $\sigma_D = 100\sqrt{\frac{P_1Q_1}{N_1} + \frac{P_2Q_2}{N_2}}$, and $t = \frac{D}{\sigma_D}$ were used throughout in determining the significance of differences.

The significant values of t at the 5% and 1% levels are 1.96 and 2.576. This finding substantiates the strengthening effect of a reward on the stimulus-response connection to which it belongs.

The t-test was applied to the differences between the groups in each response category and none of these is statistically significant. The largest group difference, 3.38% between percentages of repetition of rewarded responses, has a t-ratio of 1.63. Differences and their t-ratios for each category are presented in Table IV.

Table IV

GROUP DIFFERENCES AND THEIR T-RATIOS

CATEGORIES	DIFFERENCES	T-RATIOS	SIGNIFICANT T VALUES	
			5% level	1% level
Y/X	1.13	1.69	1.96	2.576
E/A	1.14#	1.94	1.96	2.576
D/A	1.66#	1.01	1.96	2.576
C/A	2.42	1.48	1.96	2.576
B/A	3.38	1.63	1.96	2.576
F/A	2.06	1.19	1.96	2.576
G/A	1.90#	1.16	1.96	2.576
H/A	.68#	.54	1.96	2.576

These differences are in favor of the high group.

Interpretations

The similarity, both apparent and statistical, of the effect gradients of both groups supports the hypothesis that the spread patterns obtained from a group of bright subjects and from a group of dull subjects would not differ significantly from each other, and leads to the conclusion that, within the parameters of this study, intelligence as measured by a standard test is not a variable factor in relation to the spread of effect.

The larger over-all percentage of repetitions in the low group, though not reliable, suggests that there may be a greater tendency towards stereotypy among dull students than there is among the bright. This observation seems to be in accord with the recognized use of drill as a teaching method for dull students. However, extreme individual differences apparent in spread patterns and in repetitions of rewarded responses among subjects of both groups make impossible any broad generalizations along this line, and point up Thorndike's acknowledgement of the need for "an enormous body of data" in connection with the possible variation in spread.[2]

At this point, the data might be viewed in the light of an assumption at variance with the original hypothesis. It might be postulated that the more intelligent subjects would tend to a greater extent than the dull to vary their

2. Thorndike, Contr. Educ., No. 580, p. 54.

responses, particularly those responses which had previously not been rewarded. The lower over-all percentage of repetition among the bright lends some support to such a thesis, but again qualifications as to statistical reliability and individual differences must be applied, and no conclusions can be drawn. In addition, differences at the second and third steps both before and after a rewarded response are in favor, though not reliably, of the bright subjects. The slightly steeper nature of the gradients for the low group suggests that the effect of reward might have a wider spread among bright subjects. Further investigation into the questions here raised might prove of value.

Supplementary Considerations

Base-lines

The matter of the determination of a neutral base-line deserves some additional comment. To the writer's knowledge, Stephens,[3] Martens, and Tilton are the only investigators who have systematically attacked the problem.

Although Stephens' assumption, viz., that the base-line is indicated by the percentage of "weak untreated connections" persisting,[4] is basically similar to that adopted here, the nature of his investigation and the precise technique he employed to secure a base-line make comparison with the present study impractical. Likewise, since no

3. Stephens, J. M., "Further Notes on Punishment and Reward," J. Genet. Psychol., 1934, 44, pp. 464-472.

4. Ibid., p. 469.

figures are reported for Martens' experiment, the discussion will centre around Tilton's work.

It is generally accepted that, in learning material of the kind employed here, the probability of occurrence of a single response is not 1/6 (where the denominator equals the number of possible responses per stimulus), but 1/6 plus the factor of favoritism plus the factor of serial position. Favored responses will so vary among individuals that, unless N approaches infinity, to correct only for group predispositions determined by serial position as did Tilton, or to use a control group as did Martens, will not produce an accurate estimate of the true base-line position.

In Tilton's study, the number of responses per stimulus was four. Could we accept pure chance as the determinant, the base-line for his data would fall at the 25% level. As a result of the procedure he used to secure a base-line, it falls at the 38% level.[5] In the light of what has been remarked concerning the probability of occurrence of a single response, 13% of the area which his base-line represents must be attributed to some factor or factors other than chance. Serial position effects as manifested by the group were corrected for, but individual predispositions were not taken into account.

What appears needful in the matter of base-lines and in the collection of gradient data is the elimination of both serial position effects and favored responses. At this

5. Stephens obtained 36% as the base-line for his data. Op. cit., p. 469.

juncture, attention is invited to the technique employed in this study to establish a neutral base-line, and its results. The material was so arranged and presented that serial position effects would be negligible. Favored responses were determined and eliminated from all calculations. When the collection of data was completed, the percentage of total repetitions, excluding favored responses was computed to obtain the neutral base-line. For the high group, it falls at 14.85%; for the low group, at 15.98%. Pure chance, with six possible responses as in this case, would yield 1/6, or 16.66%. The similarity between the obtained base-lines and the chance figure is not a little striking. Differences between the obtained figures and the pure chance figure, with their t-ratios, are shown in Table V. While the figures for the high group and for

Table V

DIFFERENCES BETWEEN OBTAINED BASE-LINES AND THE THEORETICAL CHANCE BASE-LINE

	CHANCE	OBTAINED	DIFFERENCE	T-RATIO	SIGNIFICANT T-VALUES 5% level	1% level
HIGH GROUP	16.66	14.85	1.81	2.701	1.96	2.576
LOW GROUP	16.66	15.98	.68	1.000	1.96	2.576
GROUPS COMBINED	16.66	15.41	1.25	2.604	1.96	2.576

the high and low groups combined differ significantly from the pure chance percentage, the fact remains that the procedure employed has resulted in base-lines which more nearly approximate the theoretical chance line than any previously reported.

As observed in the preceding chapter, involved in this procedure are the factors of reward and occurrence operating to increase the percentage of repetition which represents the base-line. The ideal situation has been remarked by Thorndike when he proposes for a base-line . . . "the % of repetitions there would have been if rewards, punishments, and occurrences had had no strengthening or weakening effect upon any connections."[6] Rewards and punishments, it is true, can be controlled, but how data can be collected without occurrences and the effects thereof is somewhat problematical. Tilton approaches the desideratum in his observation that ". . . in certain cases . . . . collection of data for the base-line would need to parallel the collection for the gradients from trials as well as from positions."[7] In the absence of any conclusive evidence regarding valid base-lines, and in view of those obtained here, the technique used in this study appears to merit further experimentation.

Quantitative Analysis

Consequent to the consideration of neutral base-lines is the question of the quantitative aspects of the gradients obtained in this study. In general it may be stated that the percentages of repetition obtained here are lower than those usually reported from similar experiments. Specific comparison is again limited to the work of Tilton because of the corrective

6. Thorndike, op cit., p. 50.

7. Tilton, J. W., "Gradients of Effect," J. Genet. Psychol., 1945, 66, p. 9 (footnote).

factors used in assembling the data. Gradient figures from Tilton and from an average of the two groups of this study are presented in Table VI. As Tilton has reported only to two step positions, the third step has been omitted.

Table VI

COMPARISON OF GRADIENT FIGURES OBTAINED BY TILTON AND IN THE PRESENT STUDY

	Two Steps Before	One Step Before	Rewarded Responses	One Step After	Two Steps After
TILTON	29.3	30.2	41.35#	35.1	32.4
PRESENT STUDY	12.32	12.32	22.38	14.07	12.33
PRESENT STUDY AS % OF TILTON	.42	.41	.54	.40	.38

With the exception of the rewarded responses, the percentage of repetition at each position in this study is less than half of that reported by Tilton.

How are these consistent differences in degree to be accounted for? In the mind of the writer there are two possible interpretations. First, they may be a manifestation of the variation in extent of spread which Thorndike suggested might occur relative to the kind of learning and the learners. If so, it will be noted that not only the spread has varied, but so has the repetition of rewarded responses themselves. It will be recalled that the mean age of the subjects was approximately 12 years, whereas in previous studies subjects have been college students. The learning material here con-

Tilton reported his backward gradient from one composite rewarded response figure (40.9%), and his forward gradient from another (41.8%). Ibid., p. 12. These were averaged to obtain a single figure for ease of comparison.

sisted of a list of forty words, a length commonly used with college students. Is it possible that the action of reward on learning material of this nature is in some way related to the length of the series and the age or maturational level of the subjects? Is the strengthening effect of reward dissipated in certain subjects by the interference of intervening stimulus-response connections beyond a certain number? Is the time between successive presentations of a single stimulus a factor in determining the influence of its reward? These questions would seem to be of vital importance, both theoretically and practically, and present problems for further study.[8]

The second interpretation derives from the discussion of levels of chance expectation and the securing of a valid base-line. To the writer's knowledge, no previous attempt has been made, with the possible exception of the Martens study, to control as fully as possible the factor of favored responses in relation to an operationally determined base-line and the collection of gradient data. The data of this investigation do not lend themselves to examination in order to discover how the gradients would have appeared had favored responses been

8. Stephens has already presented evidence which suggests that the length of the test may indeed affect the number of repetitions, and has concluded that ". . . the longer the test the less likelihood of persistence [of weak untreated connections]," J. Genet. Psychol., 1934, 44, p. 470.

rewarded and had not been eliminated from all calculations. However, it is submitted that the lower percentages of repetition obtained from these data may be attributed to the elimination of favored responses with a consequent reduction throughout of the levels of repetition and an apparent minimizing of the influence of reward. This interpretation too requires further investigation.

Role of Punishment

Out of the preceding discussion there arises the interesting question as to what effect the omission of punishment in the form of the announcement "wrong" may have had on the repetition of unrewarded responses. No statistical analyses have been made of the gradients obtained here as compared to those reported in other similar studies, but the steepness of these gradients favors the tentative suggestion that the announcement "wrong" in learning material of this kind has a questionable effect on the repetition of wrong responses. Gradients obtained by Muenzinger and Dove[9] are similar in slope; Tilton's[10] are markedly more gradual; Zirkle[11] has reported one similar set and one markedly steeper.

9. Muenzinger, K. F., and Dove, C. C., "Serial Learning: I. Gradients of Uniformity and Variability Produced by Success and Failure of Single Responses," J. Gen. Psychol., 1937, 16, p.406

10. Tilton, op. cit., p. 12.

11. Zirkle, G. A., "Success and Failure in Serial Learning. I. The Thorndike Effect," J. Exp. Psychol., 1946, 36, p. 232.

For convenience of comparison, gradient figures for these several studies are presented in Table VII.

Table VII

GRADIENT FIGURES FROM FIVE STUDIES SHOWING VARIATION IN GRADIENT SLOPES

	PRESENT# STUDY	MUENZINGER AND DOVE	TILTON	ZIRKLE (1)	ZIRKLE (2)
Three Steps Before	6.31	18.3		13.8	13.6
Two Steps Before	12.32	20.9	29.3	14.0	11.8
One Step Before	12.32	22.1	30.2	16.1	11.6
Rewarded Responses	22.38	51.4	41.35	42.5	26.1
One Step After	14.07	22.9	35.1	21.1	19.5
Two Steps After	12.33	19.5	32.4	14.9	16.5
Three Steps After	6.74	17.7		13.6	12.5

Composite figures from gradients of two groups combined.

These instances of variability in obtained gradients seem to indicate that the role of punishment at large and in general in relation to a learning situation is difficult if not impossible to determine on the basis of experimental evidence discovered through the medium of the announcement "wrong." It is realized that this is not a new observation, but the conditions of the present experiment with respect to the omission of specific information regarding wrong responses seemed to the writer to require some comment. The results of this study when viewed in relation to other experiments serve to point up Postman's statement that "The complex ways in which the effects of 'wrong' vary with the parameters of the experimental situation highlight the need for caution in generalizing about the effects of punishment."[12]

A further question arises in this connection. In spite of the fact that no punishment was given to wrong responses throughout this experiment, repetition of unrewarded responses in the second and third steps before and after reward in the low group, and in the first and third steps before and third steps after reward in the high group, are reliably lower than would have been expected having regard for the neutral base-line. Table VIII shows the difference between repetitions at each step position and the obtained level of chance expectation, together with t-ratios. Significant values of t in each case are 1.96 at the 5% level and 2.576 at the 1% level.

12. Postman, L., "The History and Present Status of the Law of Effect," Psychol. Bull., 1947, 44, p. 504.

Table VIII

DIFFERENCES BETWEEN GRADIENT FIGURES AND OBTAINED BASE-LINES

	HIGH GROUP	LOW GROUP
Three steps before - diff.	7.96	10.23
- t	7.80	10.88
Two steps before - diff.	1.70	4.49
- t	1.32	3.74
One step before - diff.	3.74	2.45
- t	3.09	1.91
One step after - diff.	1.70	.77
- t	1.32	.57
Two steps after - diff.	1.57	4.60
- t	1.21	3.83
Three steps after - diff.	7.70	9.51
- t	7.47	9.70

Explanation of this seeming anomaly is difficult. In experiments where punishment was administered, such a drop in repetitions could be attributed to its effect. In this case the cause must be sought elsewhere. The hypothesis is offered that while a reward strengthens the stimulus-response connection to which it belongs, it acts in the nature of a distraction on neighboring connections and thereby reduces their rate of repetition below what could be expected if there were no distraction or interference in their proximity. This interpretation is at variance with the Jenkins and

Sheffield[13] hypothesis that distraction is likely to bring about an increase in the level of repetition of errors remote from reward because under distraction subjects will be less likely to remember and therefore vary wrong responses in subsequent trials. However, accepting for the moment a connectionist theory of learning, the distraction hypothesis is tenable on the grounds that the word-stimuli were presented too quickly during the present study to permit any rehearsal of right or wrong responses. Whatever the interpretation, it seems that further study needs to be made of the effects of both reward and punishment on the learning process.

13. Jenkins, W. O., and Sheffield, F. D., "Rehearsal and Guessing Habits as Sources of the 'spread of effect'," J. Exp. Psychol., 1946, 36, pp. 316-330.

Chapter IV

Summary, Conclusions, Hypotheses

Summary

The problem investigated was the relation of intelligence to the spread of effect. A null hypothesis was set up, that the spread pattern obtained from more intelligent subjects would not differ from that found in the less intelligent.

Data were collected from two groups of thirty subjects each, one composed of "bright" and the other of "dull" students. All were pupils in Grades V, VI, and VII in the same school. The material was of the conventional type (word-stimulus, number-response) used in many "effect" experiments, but the typical procedure of rewarding correct responses with the announcement "right" and punishing wrong responses with the announcement "wrong" was modified by the omission of the announcement "wrong" during the course of the experiment.

Serial position effects were obviated by making successive presentations of the list of stimulus words continuous, and by the length of the list. Favored responses were determined with the help of two presentations free from reward at the beginning of the experiment, and were eliminated from all calculations in order to establish a neutral base-line, which was determined by computing the percentage of total repetitions throughout the five presentations during which rewards were given. Gradients were plotted for each group from the percentages of repetition of rewarded responses and of repetitions one, two, and three steps before and after rewarded responses.

Conclusions

The results are such that the null hypothesis must be accepted, that is, intelligence as measured by a standard test is not a variable factor in determining the spread of effect. Of the group differences found, none is statistically reliable. In so far as can be judged from a single experiment and within the parameters of that experiment, it is concluded that reward has equal effect on bright and dull students in a serial learning situation.

Hypotheses

The relatively low percentage levels of repetition as compared with those of previous studies is attributed to one of two factors, or possibly to a combination of both. In the first place, the method of assembling the data precluded favored responses from contributing to the gradients obtained, and so reduced the number of repetitions calculated. In the second, the word-list was of a length commonly used with subjects at the college level. From these facts, two tentative conclusions are reached. One, that to the extent that favored responses contribute to gradient data, levels of repetition obtained in a number of previous studies and attributed to the effect of reward, are spuriously high, and the influence of reward has been exaggerated. Two, the length of the test (in this case, the word-list), is a factor determining the influence of reward. It is thought that both of these conditions may be responsible, to a degree so far undetermined, for the results obtained in this study.

Similarly to the levels of repetition found in each response category, the height of the established base-line is conspicuously lower than any previously adopted, and is noteworthy in its close approximation to the pure chance figure. It has been accounted for on the basis of elimination of favored responses and serial position effects, and would also have been affected by the factor of length of the word-list if this were an experimental variable.

A summary consideration of the slope of the gradients from these data compared with gradient curves from previous studies where punishment in the form of the announcement "wrong," as well as reward, was administered to the subjects, revealed no consistent trends and added nothing conclusive by way of evidence on the influence of punishment in a learning situation, other than to emphasize the apparently varying roles this type of "punishment" can play, and the inadvisability of generalizing from the evidence thus far available on its modus operandi.

In addition, the fact that unrewarded responses, <u>which were not punished</u>, in seven out of twelve categories were repeated less frequently than consideration of the neutral base-lines would have led one to expect, requires explanation. It has been hypothesized that reward, in emphasizing the correct response, acts as a distraction on neighboring connections and thereby reduces their rate of repetition below the chance level.

Emergent Questions

A critical review of the results of this study discloses certain areas in which further research appears warranted:

1. The last word has not been spoken in regard to the influence of intelligence on the spread of effect. It is true that no statistically significant differences between the bright and the dull were found, but the higher over-all percentage of repetition and the slightly steeper gradients obtained from the dull group suggest that further studies be carried out where intelligence is the experimental variable and where the spread is measured to that step position, before and after a rewarded response, at which the effect of reward is no longer discernible.
2. The approximation of the obtained base-line to the level of pure chance, and the technique by which it was established, require additional investigation.
3. The extent to which favored responses have accounted for repetitions, with the possible consequence of an exaggeration of the effect of reward, calls for systematic inquiry.
4. The falling off of repetitions of unrewarded responses to levels below the neutral base-line cannot in this case be attributed to the effect of punishment, and indicates the need for further research into the effects of both reward and punishment on the learning process.

Bibliography

Gates, A. I. "Connectionism: Present concepts and interpretations." In Forty-first Yearbook Nat. Soc. Study Educ., Pt. II. Bloomington: Public School Publishing Co., 1942.

Jenkins, W. O., & Sheffield, F. D. "Rehearsal and guessing habits as sources of the 'spread of effect'." J. Exp. Psychol., 1946, 36, pp. 316-330.

Martens, D. "Spread of effect in verbal serial learning." (Abstract) Amer. Psychologist, 1946, 1, pp. 448-449.

Muenzinger, K. F., & Dove, C. C. "Serial learning: I. Gradients of uniformity and variability produced by success and failure of single responses." J. Gen. Psychol., 1937, 16, pp. 403-413.

Postman, L. "The history and present status of the law of effect." Psychol. Bull., 1947, 44, pp. 489 - 563.

Rock, R. T., Jr. "The influence upon learning of the quantitative variation of after-effects." Teach. Coll., Columbia Univ., Contr. Educ., No. 650. New York: Bureau of Publications, Teachers College, Columbia Univ., 1935.

Sandiford, P. "Connectionism: Its origin and major features." In Forty-first Yearbook Nat. Soc. Study Educ., Pt. II. Bloomington: Public School Publishing Co., 1942.

Stephens, J. M. "Further notes on punishment and reward." J. Genet. Psychol., 1934, 44, pp. 464-472.

Thorndike, E. L. "The fundamentals of learning." New York: Teachers College, Columbia Univ., 1932.

Thorndike, E. L. "A proof of the law of effect." Science, 1933, 77, pp. 173-175.

Thorndike, E. L. "An experimental study of rewards." Teachers College, Columbia Univ., Contr. Educ., No.580. New York: Bureau of Publications, Teachers College, Columbia Univ., 1933.

Tilton, J. W. "Gradients of effect." J. Genet. Psychol., 1945, 66, pp. 3-19.

Wallach, H., & Henle, Mary. "An experimental analysis of the law of effect." J. Exp. Psychol., 1941, 28, pp.340-349.

Wallach, H. & Henle, Mary. "A further study of the function of reward." J. Exp. Psychol., 1942, 30, pp.147-160.

Zirkle, G. A. "Success and failure in serial learning. I. The Thorndike effect." J. Exp. Psychol., 1946, 36, pp. 230-236.

Zirkle, G. A. "Success and failure in serial learning. II. Isolation and the Thorndike effect." J. Exp. Psychol., 1946, 36, pp. 302-315.

Appendix

WORD-LIST AND RECORD SHEET

CA .... Grade .... SUBJECT....................

IQ .... Sex ....

Test ....

TRIALS

	1	2	3	4	5	6	7
play							
call							
lose							
swim							
run							
cry							
dance							
fall							
sing							
throw							
laugh							
jump							
see							
climb							
sit							
grow							
draw							
look							
move							
drive							
skip							
read							
walk							
build							
cough							
sleep							
catch							
sneeze							
smile							
pull							
burn							
shine							
bite							
find							
give							
hide							
count							
freeze							
break							
drink							