AN EXPERIMENTAL ANALYSIS OF THE LAW OF EFFECT [1]

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Thorndike has presented a large quantity of evidence "to show that a satisfying after-effect of a connection does in fact strengthen it under conditions equalized in respect of all other forces than the satisfying after-effect." [2] The experiments reported here were performed to determine whether or not it is the satisfying after-effect *alone*, the success of the reaction itself which 'strengthens connections' and thereby brings about repetition of the successful reaction.

The Law of Effect has been tested with human subjects only in situations in which it was the obvious task of the subject to learn the rewarded material. Repetition of rewarded responses has so far been shown to occur only where such repetition was sensible; it has not been demonstrated merely as an automatic effect of reward.

The experiments to be reported in the present paper were designed to present a situation in which repetition of rewarded responses was possible, while no reason for or against such repetition existed for the subject. Only if under these conditions rewarded responses are still repeated more frequently than by chance, such repetition may be attributed exclusively to an effect of the reward.

Such a situation was created by adopting with modifications a procedure of Thorndike's. He had prepared a list consisting of pairs of words and numbers. The numbers were chosen from a limited sequence of numbers and arbitrarily assigned to the words. A word was read to the subject, who was to guess the corresponding number from this sequence. He was immediately told whether his response was correct or incorrect, and the experimenter proceeded to read the next word of the list. When the list was thus completed, the experimenter started again with the first word. Sooner or later in the course of the repeated presentations of the list the subject was bound to make some hits by chance. Once a correct response was found, the subject was to repeat it on subsequent presentations of the list. Correct responses were found to be repeated from presentation to presentation to an extent far exceeding chance expectation. Similar results have been obtained in many previous experiments.

[1] The writers wish to express their gratitude to Professor W. Köhler for his criticism of this paper.

[2] Thorndike, E. L. An experimental study of rewards. *Teach. Coll. Contrib. Educ.*, No. 580. New York: Teachers College Bureau of Publications, 1933. P. 2.

This result was not, however, Thorndike's chief concern in the experiment under discussion. In addition to the repetition of correct responses, Thorndike found that incorrect responses were repeated more frequently than they would have been repeated by chance, and the more so the closer they were in the series to a correct response. It was this gradient of repetition of wrong responses adjacent to a correct one to which Thorndike called attention. He considers it significant because he believes that it "proves that a satisfier or reward can act directly and immediately to strengthen a connection."[3] While 'inner repetitions' or 'expectations' on the part of the subject may complicate the direct action of a satisfier on a rewarded connection, Thorndike believes that in the case of the strengthening of a neighboring punished connnection such complications are absent, and "the satisfier acts upon it unconsciously and directly, much as the sunlight acts upon plants, or an electric current upon a neighboring current, or the earth upon the moon. Presumably it acts upon the connection which is psychologically nearest to it of all, the connection whose after-effect it is felt to be, primarily in this same immediate and direct manner. A satisfying after-effect can strengthen its connection with no paraphernalia to help it. . . ." [4]

This type of experiment, since it is Thorndike's best case for the automatic action of rewards, was chosen for the present analysis. Our experiment duplicated Thorndike's in all important respects except the following: The instructions were framed so that no sensible reason for the repetition of correct responses was given to the subject. Only the satisfying after-effect of these responses could then be responsible if successful reactions should be repeated more frequently than by chance.

Such an experiment, in which the learning motive is to be excluded, and where, therefore, the conscious activity of the subject must be restricted to mere guessing, obviously needs *some* motive. Otherwise the nature of the psychological situation would become entirely undefined. However, this motive may by no means interfere with the purpose of the experiment, which can test a direct influence of the after-effect only if the subject is left entirely free to repeat or not to repeat a given response. These requirements were met by presenting the experiment to the subject as a test of extra-sensory perception.[5]

[3] Thorndike, *op. cit.*, p. 47.

[4] *Ibid.*, p. 48.

[5] No assumption about the existence of extra-sensory perception is made here. This experiment has the character of a test of extra-sensory perception only for the subject. It will appear below from a detailed description of our procedure that actually the results of our experiment could not have been influenced by such an ability should it exist.

This type of procedure appears to be particularly suitable for our purposes also for another reason. If, in a test of extra-sensory perception, the subject tends to assume a conscious attitude of being receptive to the presumably unnoticeable influences of extra-sensory perception, such an attitude should also favor the operation of an automatic effect of reward on the subject's guessing.

The following instructions were read to the subject: "You have perhaps heard that experiments on extra-sensory perception are being performed by Mr. Rhine at Duke University. Subjects are asked to name items which they cannot possibly perceive in any ordinary sense of the word. If they are able to make hits more frequently than they would by chance alone, it mus. be by extra-sensory perception.

"We are dealing with the same problem by a method somewhat different from Mr. Rhine's We have prepared a list of pairs of words and numbers like this." [Here a sample list of word and number combinations was shown to the subject.] "We shall read you the words, and you guess the numbers that go with them. If extra sensory perception exists, you should be able to do this better than chance. If it does not exist, you will merely be guessing the number that goes with each word, and you should not make a score better than chance.

"As numbers we have used the digits from 1 to 10. So you can choose among ten different reactions in each case, and with this large number you will, of course, not make many hits. But neither did Rhine's subjects. After each judgment we shall tell you whether you were right or wrong. To encourage you further, we shall pay you half a cent for each hit you make.

"Thinking about your performance during the experiment will be definitely detrimental in a function as intangible as extra-sensory perception. So try to behave naively and give your responses as quickly as you can. Do not mind if we hurry you through the experiment; it will only help you to make a better score.

"We have a list of 20 words, and this list will be presented a number of times. But the numbers assigned to the words will change in a random fashion from presentation to presentation. Thus a number which is correct on the first presentation will not necessarily be correct on the next."

Two experimenters conducted the experiment, the one reading the words to the subject and informing him of the correctness of his responses, the other recording the responses. The general speed of procedure, as indicated by the average time between successive responses, was comparable to that employed by Thorndike. As subjects, 50 undergraduate or graduate students were used.

We may summarize our procedure as follows: The present experiment duplicated Thorndike's in all important respects except that a learning motive was not present, as in Thorndike's experiment; the experiment was rather, for the subject, a test of extra-sensory perception, in which there existed, therefore, no reason for him to repeat previous correct responses.

The experiment was designed to answer in particular the following questions: How great is the number of repetitions of rewarded responses here as compared with that which Thorndike found in his experiments? How does it differ from the number of repetitions of wrong responses? Does a gradient of repetition of wrong responses around the correct ones exist?

To facilitate computation of such a gradient, we borrowed a procedure first used by Muenzinger and Dove.[6] Instead of using a prearranged list of correct word-number combinations, which would produce a random distribution of hits, we used a prearranged pattern of positions of the responses which were to be called correct no matter

[6] 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, 403–413.

what the subject's reaction was. Thus we were able to get evenly spaced correct responses. Each presentation of the list contained three rewarded responses; any two of these were separated from each other by six incorrect ones. This gave us a list of twenty-one words. The positions of the correct responses were varied in an orderly manner on consecutive presentations of the series. Four series containing no hits were inserted. In all, the list was repeated twenty times. Ten subjects were used in Experiment I.

The results of Experiment I are presented in Table I. Rewarded responses were repeated on the presentation immediately follow-

TABLE I

REPETITION OF REWARDED AND WRONG RESPONSES

	Rewarded Responses			Wrong Responses		
	No. of Responses	No. of Repetitions	Percent of Repetitions	No. of Responses	No. of Repetitions	Percent of Repetitions
Expt. I.....	472	49	10.4	3706	402	10.8
Expt. II.....	823	95	11.5	5262	656	12.5
Total.....	1295	144	11.1	8968	1058	11.8

ing the reward in 10.4 percent of the cases. This result is to be compared with a percentage of repetition of correct responses of 'about 50' in Thorndike's experiment.[7] Wrong responses were repeated in 10.8 percent of the cases under our conditions. The difference between 10.4 percent and 10.8 percent is completely insignificant. Experiment I thus shows no difference of frequency of repetition between rewarded and wrong responses.

Data obtained under exactly comparable conditions in another experiment, which will be described below, are pertinent here, and may be added to the results of Experiment I.[8] Again the difference between rewarded and wrong responses is negligible. The combined results show that rewarded responses were repeated in 11.1 percent of the cases, wrong responses in 11.8 percent. *Rewarded responses were thus not repeated more frequently than wrong ones.*

[7] Thorndike, *op. cit.*, p. 4. It is apparent from the description of the procedure we employed that our experiments are not strictly comparable with the experiment of Thorndike's which has been described above, but with an otherwise similar experiment in which the positions of the correct responses are rotated from trial to trial. Such an experiment has been performed by Muenzinger and Dove, but the results are not numerically comparable to ours since their list of words was twice as long as ours, and should, therefore, give a lower percentage of repetition of correct responses. However, their experiment, as Thorndike's, showed repetitions of correct responses to be high above the level of chance expectation. *Cf.* Muenzinger and Dove, *op. cit.*

[8] The additional data came from experiments with forty subjects. Fewer presentations of the list were given here than in Experiment I.

It will be noted that the percentages of repetition of wrong as well as of rewarded responses (11.8 and 11.1 respectively) are slightly above those which chance alone would have given (10.0). A possible explanation is to be found in the fact that subjects restricted the range of numbers from which they selected their responses to a range smaller than the ten on which calculations of chance probabilities were based. If theoretical probabilities had been based on the range of numbers actually used by the subjects, it is likely that the percentages obtained would not differ from chance. In any case, the important comparison is between the percentages of repetition of rewarded as against wrong responses, and here no significant difference exists.

In yet another respect the results of our experiments differ from Thorndike's. Although our experiment was designed specifically to bring out a gradient of repetition of wrong responses adjacent to rewarded ones, no such gradient appears. The relevant results from the two experiments are presented in Table II. The slight differences

TABLE II

REPETITION OF WRONG RESPONSES AT DIFFERENT DISTANCES FROM THE REWARDED ONES

	Rewarded Responses			Wrong Responses One Place Removed			Wrong Responses Two Places Removed			Wrong Responses Three Places Removed		
	No. of Responses	No. of Repetitions	% of Repetitions	No. of Responses	No. of Repetitions	% of Repetitions	No. of Responses	No. of Repetitions	% of Repetitions	No. of Responses	No. of Repetitions	% of Repetitions
Expt. I.....	472	49	10.4	944	96	10.2	937	93	9.9	934	96	10.3
Expt. II.....	823	95	11.5	1,646	219	13.3	1,646	205	12.5	1,636	198	12.1
Total.....	1,295	144	11.1	2,590	315	12.2	2,583	298	11.5	2,570	294	11.4

in repetition of wrong responses at different positions with respect to rewarded responses are not significant. These results are based on numbers of cases which closely approximate those used in the experiments already referred to in which Thorndike as well as Muenzinger and Dove obtained gradients.

Our failure to obtain a gradient is not astonishing in view of the absence of a high level of repetition of rewarded responses in our experiment. Under conditions where the gross effect of reward on the correct response itself is lacking, we can hardly expect to demonstrate its subtle influence on neighboring responses in the form of a gradient. Since, in Thorndike's view, the gradient is a direct consequence of the reward, just as is the repetition of rewarded responses, and since the latter is by far more conspicuous in Thorndike's results, we shall center our discussion of the effect of reward on the case of repetition of rewarded responses.

Also much more conspicuous than the gradient as such is the general high level of repetition of wrong responses in Thorndike's

experiment. There wrong responses five or more steps removed from a rewarded response (thus far enough away not to be subject to the 'strengthening' influence of the reward) were repeated in about 20 percent of the cases; that is twice as frequently as they would have been repeated by chance, and well above the level of repetition of either rewarded or wrong responses in our experiment. Thorndike considers this to be an effect of the mere occurrence of the response. He writes in this connection: "In such experiments the fact that a person responds to a word by a certain number makes him more likely to respond to that word at the next trial by that same number, even though the response was punished. The connection is strengthened more by being made than it is weakened by being punished." [9] We failed, however, to obtain a level of repetition of wrong responses at all comparable to this. This finding seems to exclude the explanation which Thorndike gives for his results. Even if our subjects reacted under the influence of a tendency to vary their responses, a possibility which will be discussed below, it is not plausible to argue that this tendency was stronger than the tendency of Thorndike's subjects to vary their wrong responses.

Thus our results are entirely different from Thorndike's, although the only important respect in which the two procedures differed was that in Thorndike's experiments the subject was led to expect a right response to be correct on subsequent trials, while in our experiments this was not the case. The high percentage of repetition of correct responses and, to a lesser degree, of wrong responses, and the gradient, which Thorndike obtained, must thus be dependent upon this difference. Of the two variables present in Thorndike's experiment, a possible automatic effect of the reward and the learning motive present in the situation, the latter seems to be the decisive one for his results. If it is eliminated, no automatic effect of reward appears to be demonstrable.[10]

[9] Thorndike, *op. cit.*, p. 4.

[10] It has been suggested to us that our failure to obtain a high level of repetition of rewarded responses is a consequence of a lack of 'belonging' between stimulus and response. Thorndike has shown that another condition of learning, at any rate, namely repetition, does not 'strengthen connections' in the absence of belonging. As Thorndike defines belonging, however, it was certainly present in our experiment. He writes: "The belonging which is always or nearly always necessary in order that the repeated occurrence of a sequence may strengthen the connection between the first term of the sequence and the second need not be more than the least which the word implies. There need be nothing logical, or essential, or inherent, or unifying in it. Any 'this goes with that' will suffice. Each nonsense syllable in a series which is read as a series 'belongs' to the one before it in the series. 1492 belongs to Mr. Jones as his telephone number as truly as to Christopher Columbus as an auspicious year. In an experiment, 1492 may truly belong to 65 or 7843, or sig nop." (*The Fundamentals of Learning*. New York: Teachers College Bureau of Publications, 1932. P. 72.)

Thus, in Thorndike's sense, belonging is just as truly present in our experiment as in his. Our results can only be attributed to a lack of belonging if, in a definition of belonging, one should include some reference to the motivation of the subject.

It might be argued, however, that the results of the present experiments can be explained by a possible tendency against repetition of previous responses on the part of the subject. The low level of repetition of correct responses would, according to this view, be a result of two opposing tendencies: an automatic effect of reward and a tendency of the subject to avoid repetition of rewarded responses. Such a tendency, it might be argued, could be created by the instruction: "The numbers assigned to the words will change in a random fashion from presentation to presentation. . . ."

This interpretation can be subjected to an experimental test. The possibility of the operation of such a tendency presupposes that the subject remembers the preceding correct responses in order to avoid them. Experiment II was set up to determine the subject's memory of correct responses apart from his repetition of them. The procedure of Experiment I was followed without change for six complete presentations of the list. Then a test of recall was introduced with the instructions: "Now will you please repeat the responses you just gave while I read the list of words. I mean try to remember your last responses." After this interruption the series was continued as before, in the case of 20 of our subjects, to obtain more data on repetition of rewarded and wrong responses.[11]

Forty subjects were employed in this experiment. For 10 of them, as in the rest of the experiment, 3 out of 21 responses were made correct in the presentation of the list immediately preceding the test of recall. For the other subjects the number of correct responses on this presentation was increased to four in order to obtain more data on correct responses; here the list was reduced to twenty words to secure even spacing of rewarded responses.

The amount of recall exhibited by the subjects in this test varied considerably. Sixteen subjects were found whose level of recall for all the items of the test was not above chance (0 to 2 hits). On the recall test these subjects reproduced only 6 percent of their previous responses, while chance would have given hits in 10 percent of the cases. Recall of previously rewarded responses alone was likewise not above chance for these subjects. Thus they cannot, on the whole, be assumed to show any memory for their previous responses. With respect to repetition of responses in the other part of the experiment ('extra-sensory perception'), these subjects did not differ from the others, and they can be regarded as representative of the whole group of subjects. To argue, now, that in these subjects an automatic tendency to repeat correct responses was offset by a tendency to avoid

[11] These data on spontaneous repetition of responses, it will be recalled, are presented in Tables I and II as the results of Experiment II. There the results from the two halves of the experiment (before the recall test and after) were combined since they showed no difference.

such repetition is impossible. Both an automatic effect of reward and an intentional variation of response imply memory of the items, and the test has shown no actual basis in the memory of these subjects for either effect. It is thus highly unlikely that the low level of repetition of rewarded responses obtained can be explained by the operation of a tendency to avoid such repetition.

The test of recall has, however, another and much more direct significance for the interpretation of our main experimental result. We have as yet only demonstrated that, under the conditions of our experiments, reward does not bring about the repetition of correct responses. It is, however, conceivable that reward has an influence on memory which, for one reason or another, does not become overt in the behavior elicited by our 'extra-sensory perception' procedure. The test of recall of Experiment II was introduced to demonstrate directly a possible effect of reward on memory as revealed in intentional recall, apart from any effect it may have on responses which are made in the absence of an intention to recall. Such an effect would be demonstrated if, under the instruction to recall, rewarded responses were found to be remembered better than wrong ones. A comparison of recall of responses rewarded on the previous trial with that of responses previously called incorrect revealed no significant difference (Table III). Rewarded responses were recalled in 18 per-

TABLE III

RECALL OF REWARDED AND WRONG RESPONSES IN EXPERIMENT II

	Rewarded Responses	Wrong Responses
No. of responses	150	660
No. recalled	27	124
% recalled	18.0	18.8

cent of the cases, wrong ones in 18.8 percent. This result is too high to be regarded merely as a matter of chance hits. If rewarded and wrong responses show no difference in reproduction on the test of recall, this must therefore be considered as a valid finding regarding their state of memory.

Since subjects differed rather widely in their performance on the test of recall, it seemed advisable to deal separately with the results of subjects who exhibited a large amount of recall. The results of fifteen subjects, each of whom made five or more hits in the test of recall, were considered. These subjects made 100 hits out of a possible 304 on the test of recall.[12] Rewarded responses were remembered in 32 percent of the cases, wrong ones in 33 percent. These results again show no difference in recall between rewarded and wrong

[12] *Cf.* above. Some of these subjects were given lists of 21 words, the others lists of 20 words.

responses. Yet, if Thorndike were correct in assuming an automatic effect of reward on memory, it should have expressed itself in terms of a difference in recall of responses which on the preceding presentation in the 'test of extra-sensory perception' were rewarded or punished. Intentional recall, however, as well as response without the intention to recall, has failed to show a selective effect of reward.

With the demonstration that *reward as such has not the effect of favoring recall*, there appears to remain no possibility of attributing Thorndike's results to an automatic effect of reward. When no learning motivation is introduced, repetition of rewarded responses as well as of wrong ones has been shown to remain on a chance level, although reward is present. In Thorndike's experiments the high level of repetition of rewarded responses must therefore depend upon the presence of this learning motivation.[18]

How, then, can we interpret the chief result of Thorndike's experiment, namely the high level of repetition of rewarded responses? It can perhaps in part be attributed to an intention on the part of the subject to *reproduce* at their proper places as many correct responses as possible on successive trials. Such a tendency was doubtless present under Thorndike's conditions, but was, of course, absent in our 'test of extra-sensory perception,' where the subject merely guessed. That such an intention alone can actually raise the level of reproduction of responses is shown by our experiment in which a test of recall was introduced. In that test the number of reproductions was raised from a level of about 12 percent to about 18 percent when the subject was suddenly asked to repeat responses, which had been made, it will be remembered, in the absence of a motive to learn them. Yet it is clear from a comparison of the latter figure with the number of repetitions of correct responses which occurred in Thorndike's experiment (about 50 percent) that an intention to reproduce particular responses cannot alone account for this number. There was also present in Thorndike's experiment, and absent in ours, the motive to *learn* the correct responses in order to repeat them later. An effort on the part of the subject to commit correct responses to memory probably chiefly accounts for the high level of repetition of correct responses in Thorndike's experiment. As must also be the case with the intention to reproduce correct responses, this effort to learn the correct responses results from a motivation which probably prevails throughout the experiment, and is not created individually each time a reward occurs. What Thorndike and others call reward or success, the reaction of the experimenter to the subject's response

[18] It is clear that here the term motivation does not designate a driving force which brings about action within a given situation, but rather the 'meaning' of the situation itself which directs behavior in the situation in a particular way.

('right' or 'wrong'), seems, then, to be merely a sign which indicates to the subject which responses to commit to memory.

A discussion of the significance of these results for animal learning must be postponed until a better appreciation of the psychological consequences of the learning motive in a situation is possible. If, in the absence of a learning motive, reward shows not the slightest effect on an individual stimulus-response connection in human beings, it seems appropriate to view very critically any supposition of an automatic effect of the reward in animal learning.

Summary

Experiments were performed to determine whether repetition of rewarded responses is, as Thorndike holds, an automatic effect of the reward alone, or whether it is a consequence also of the learning motive present in the situation which Thorndike employed. An experiment was devised which duplicated Thorndike's in all important respects except that it did not possess the character of a learning experiment. Under these conditions, results were obtained which differed from Thorndike's in the following respects: (1) They failed to show the high percentage of repetition of rewarded responses which Thorndike found. Rewarded responses were not repeated more frequently than wrong ones. (2) The general high level of repetition of wrong responses which was conspicuous in Thorndike's experiment was likewise absent here. (3) No gradient of repetition of wrong responses around rewarded ones was found. A control experiment showed that these results cannot be attributed to a tendency of the subject to avoid repetition of previously rewarded responses. This experiment likewise eliminated the possibility that the reward did have an influence on memory which, for one reason or another, could not become overt in the behavior elicited by the procedure in our first experiments. The present experiments may thus be interpreted as demonstrating that reward as such does not have the effect of favoring recall.

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