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INFLUENCE OF VISION IN ACQUIRING SKILL

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In an article in a recent number of this JOURNAL, one of the writers¹ reported the results of an experiment on the value of vision in maze learning. A certain amount of vision was found to be extremely effective in reducing the number of trials and errors required to master the problem so that the maze could finally be traversed without the aid of vision. Under the conditions of this experiment, the subjects could see not only the movements of the arm, hand and stylus, but also the pattern of the maze. Vision, however, did not enable the subjects to distinguish the true pathway from the cul de sacs. The motion of the hand and stylus was thus perceived in relation to the fixed pattern of the maze, and presumably this condition materially aided the subjects in identifying and remembering the correct pathway in visual terms. The conditions were somewhat analogous to those involved in learning to write, for in this case the motions of the hand and pen are perceived in relation to the permanent record of those movements.

The experimental procedure, however, failed to duplicate the conditions which obtain during the acquisition of most types of skill, such as walking, dancing, swimming, ball tossing, and typewriting by the touch method, for obviously in these cases the movements are not perceived in relation to some objective system of coördinates.

It was the purpose of the present experiment to create a situation more similar to those under which most acts of

¹ Harvey Carr, 'Influence of Visual Guidance in Maze Learning,' JOUR. EXPER. PSYCHOL., IV.

skill are acquired. As a consequence our experimental procedure was arranged with a view to excluding the sight of the maze pattern while permitting the subjects to see the movements of the arm and stylus. An ordinary form of stylus maze was employed, differing in size and pattern from that previously used. The particular device used to exclude the sight of the maze pattern was a circular disc of thin aluminum plate, firmly attached to the stylus so as just to clear the surface of the maze when the stylus was in position. This disc was sufficiently large to cover completely the maze pattern for all possible positions of the stylus in the maze. Thus when vision was permitted, the subjects could see only the motion of the hand and the stylus with its attached disc, while any perception of this motion in relation to the objective pattern of the maze was prevented.

Five groups of subjects were tested. All subjects were without previous maze experience. All members of group I. learned the maze entirely without the aid of vision. This group is termed the 'standard.' Vision was excluded in the customary manner by the use of a cloth screen. To make the conditions comparable, the members of this group were also required to use the stylus with the attached disc. Groups II., III., and IV. were permitted the use of vision during the initial three, five and seven trials respectively and were then required to complete the mastery of the maze with vision excluded by means of the screen. The members of group V. were permitted the use of vision until each individual was able to run three perfect trials in succession, and then were required to complete the mastery of the problem with vision excluded. The average number of trials in which vision was permitted (not counting the three perfect runs) was 14.9.

The comparative data are given in Tables I. and II. In Table I. are given the visual conditions of learning, the number of individuals in each group, the average number of trials and errors required to learn, and the percentages of saving in trials and errors due to vision. In Table II. the error data are further analyzed into the two classes of

TABLE I

GROSS RECORDS AND PERCENTAGES OF SAVING DUE TO VISION

Groups	Number of Subjects	Trials	Errors	Percentages of Saving	
				Trials	Errors
I. Standard.....	15	22.1	181.4	—	—
II. 3 trials.....	15	16.7	87.4	24.4	51.8
III. 5 trials.....	15	18.9	95.4	14.4	47.4
IV. 7 trials.....	15	17.2	79.7	22.1	56.0
V. 14.9 trials.....	17	17.7	61.4	19.9	66.1

TABLE II

FORWARD AND BACKWARD ERRORS

Groups	Number of Subjects	Forward Errors	Backward Errors	Percentages of Saving	
				For.	Back.
I. Standard... ..	15	58.6	122.8	—	—
II. 3 trials.....	15	30.7	56.7	47.5	53.8
III. 5 trials.....	15	32.6	62.8	44.2	48.9
IV. 7 trials.....	15	33.6	46.1	42.6	62.4
V. 14.9 trials	17	28.5	32.9	51.3	73.2

forward and backward errors. The forward errors consist of all entrances into cul de sacs while the subject is moving forward in the direction of the goal. All sections of the true path retraced and all cul de sacs entered while the subject is moving back toward the entrance of the maze are counted as backward errors. These data justify the following conclusions:

1. Vision, when permitted, is always effective in reducing the number of trials and errors involved in acquiring the ability to run the maze without the aid of vision.

2. Vision is much more effective in reducing the number of errors than of trials.

3. As the amount of vision is increased, its influence upon errors at first decreases and then increases. This statement applies to both types of error.

4. No definite relationship apparently obtains between the amount of vision and its effect upon the number of trials necessary for learning.

5. Vision is more effective in the elimination of the backward errors than in the elimination of the forward ones.

Vision is effective in reducing the number of errors not only during the time when vision is permitted but also during the subsequent period of mastery in which the use of vision is excluded. These two stages in the learning process may be termed the visual and the post-visual periods respectively. Obviously the way in which vision operates will differ in the two cases, and hence any explanation of the effect of vision upon learning must consider these two periods separately.

The error data for the two periods of learning are given in Table III. The first column states the length of the visual

TABLE III
ERROR RECORDS FOR VISUAL AND POST-VISUAL PERIODS

Groups	Visual Period				Post-Visual Period			
	Length	Total	Ave.	Per Cent.	Length	Total	Ave.	Per Cent.
II. .	3	25.8	8.6	39.1	13.7	68.2	4.9	59.0
III.	5	40.2	8.04	50.5	13.9	45.8	3.3	43.9
IV.	7	39.6	5.65	42.2	10.2	62.1	6.1	72.2
V.	14.9	87.5	5.9	60.0	2.6	32.5	12.5	92.6

period. The second column gives the total number of errors prevented by vision during this period. The third column states the average saving of errors per trial, while the fourth column states the total saving in terms of its percentage relation to the number of errors made by the standard group for the corresponding period of learning. The remaining four columns give the same values for the post-visual period. The data of this table justify the following conclusions:

1. Vision is invariably effective in reducing the error scores for both the visual and the post-visual periods of learning.

2. Measured in terms of the total number of errors pre-

vented and the percentage of saving, vision exerted its greatest effect during the post-visual period in three of the four cases. Measured in terms of the number of errors prevented per trial, vision was most effective during the visual period for its shorter lengths, but when the visual period is long the subsequent effect of vision is the greater.

3. With the exception of the records for group IV., the total and the percentage values for the visual period increase with the amount of vision permitted. With the same exception, the opposite relation obtains for the average values.

4. Measured in terms of the average and percentage values, the influence of vision during the post-visual period at first decreases and then increases with the amount of vision permitted. No very definite statement can be made concerning the relation between the total values and the amount of vision, unless the values for group IV. be regarded as an exception.

These values for the post-visual period are complicated by the fact that the length of this period is highly variable from group to group.

5. Vision was not very effective during the initial trial of the visual period. The initial error score of the standard group was 23.7, while the corresponding value for the 62 individuals who were permitted the use of vision was 20.

6. The removal of vision operated to increase the error scores to a slight extent during the first two trials of the post-visual period. The comparative data are not given in the tables.

7. The subsequent effect of a given amount of vision is almost as great as the effect that would have been obtained if the use of vision had been continued until the maze was learned. This statement is based upon the data of Table IV. In the middle columns are given the error records of groups II., III., and IV. for the post-visual period. The error records for the standard group for the corresponding periods of learning are given in the first column, and similar data for the group that was permitted the use of vision for the entire period of learning are given in the final column.

Presumably the records of groups II., III., and IV. would have approximated those of group V. if the use of vision had not been discarded. In other words, three trials with

TABLE IV
ERROR RECORDS FOR POST-VISUAL PERIOD

Group I.	Group II.	Group III.	Group IV.	Group V.
115.6	47.3	54.6		28.2
100.4				23.6
88.0			25.8	21.0

vision (group II.) operated to reduce the error record during the post-visual period of learning from 115.6 to 47.3, while the continuance of vision throughout this period would have further reduced this score by 19.1 errors. Likewise a continuance of vision would have reduced the error scores of groups III. and IV. by 31.0 and 4.8 respectively.

8. The mastery of the maze in visual terms does not necessarily enable the subject to traverse it successfully with vision excluded. Group V. that was permitted the use of vision until each individual was able to run three perfect trials in succession required on the average 2.6 more trials to learn to run it when vision was excluded. Individuals differ in their ability in this respect. Of the seventeen subjects, nine ran the maze perfectly when the possibility of vision was eliminated, while five required from 8 to 15 trials with an average of about one error per trial to relearn it under the new conditions.

There are several ways in which vision may manifest its effectiveness during the visual period. It may give the subject greater confidence and assurance and thus eliminate much of the futile and aimless exploration characteristic of the periods in which the subject becomes confused, lost or discouraged. It may permit of a more accurate and definite localization of the goal and enable the subject to attain a better conception of the course of the true pathway. It may also aid in the definition of the cul de sacs.

On the basis of the above conceptions, one might expect

that vision would be effective as long as its use is permitted; and hence that the total number of errors prevented would increase with the length of the visual period. With the exception of the records of group IV., this assumption is justified by the data of Table III. However, one cannot assume that the number of errors prevented will be proportional to the number of trials, for naturally more errors will be prevented in the initial trials in which many errors are normally made. Rather one should expect that the number of errors prevented per trial will decrease as the amount of vision is increased, and with one exception this assumption is also justified by the records.

The exceptional records of group IV. for the visual period may find their explanation in the following conception: During the course of the experiment, it was observed that the subjects invariably watched their movements very closely during the first few trials, then attempted to dispense with its use for several trials, and finally employed it again in the later trials. On the basis of this observation, it is suggested that the relatively poor records of group IV. may be due to the fact that they attempted to dispense with the use of vision from the fifth to the seventh trials, while the excellent records of group V. are due to the fact that vision was again employed after the period in which its use was discarded. Of course it is also possible that the records of group IV. may be due to some chance factor.

The effectiveness of vision during the post-visual period is due to one or both of two factors: (1) A memory of the visual data concerning the maze pattern acquired during the preceding period, and (2) to a more perfect tactual motor coördination resulting from the previous visual guidance. There are no data which indicate the relative effectiveness of these two factors. So far as the first factor is concerned, we would assume that the more adequate and accurate the conception, the greater will be its effectiveness, and that its accuracy, within limits, will vary directly with the length of the visual period. The effectiveness of the tactual motor coördination will vary with the degree of its perfection, and

this latter may be expected to vary with the number of trials in which vision is permitted. In other words, it may be assumed that the effectiveness of the two factors during the post-visual period will increase in a general way with the length of the preceding visual period, and hence that, all other variables being neglected, the total number of errors prevented during the post-visual period will increase with the number of trials in which the use of vision was permitted.

The influence of these factors is, however, to a considerable extent counterbalanced by several other variables: One is the length of the post-visual period. It is obvious that, other things being equal, the shorter the visual period, the longer will be the post-visual period, and the greater will be the number of errors prevented. A second is the position at which the post-visual period begins. With a short visual period, the after effects of vision will be exerted at a time when more errors are normally made than is the case with a longer visual period. Third, the factor of visual memory is likely to disintegrate with time. So far as the first two variables are concerned, it is evident that the total number of errors prevented during the post-visual period will vary inversely with the length of the previous visual period. As to the third variable, it is evident that its effectiveness will tend to decrease with the length of the post-visual period and hence to vary inversely with the length of the visual period.

The total amount of error saved during the post-visual period is thus related to the length of the preceding visual period in two opposing ways,—one in which the number of errors saved will vary with its length, and one in which the number will vary inversely with the length. These two antagonistic tendencies may well account for the fact (Table III.) that no definite relation obtains between the amount saved during the post-visual period and the number of trials in which vision was permitted. The lack of any correlation between the two sets of data may also be due, in part, to the peculiar records of group IV. for the visual period. If vision was not effectively utilized throughout the visual

period, this fact would obviously complicate its post-visual effect.

As a subsidiary experiment, we investigated the influence of the sudden introduction of vision upon the performance of a thoroughly mastered act, and the relation between the amount of such disturbance and the extent to which vision was employed in its acquisition.

Group I. had been required to master the maze without any visual aid. After the maze was learned in this manner, the screen was removed and the subjects were required to run the maze with vision permitted. Likewise all those groups that were permitted the use of vision during the initial trials and had acquired the ability to run the maze with vision excluded were now tested as to their ability to perform this act while visually observing it. In all cases the subjects were tested until all disturbance due to the introduction of vision was eliminated and three perfect successive trials were obtained.

The comparative data are given in Table V. In the

TABLE V
INFLUENCE OF VISION AFTER LEARNING

Groups	Number of Subjects	Per Cent. of Subjects Affected	Ave. Trials	Ave. Errors
I. Standard.....	15	87	6.9	7.7
II. 3 trials.....	15	27	2.0	2.2
III. 5 trials.....	15	53	3.2	3.7
IV. 7 trials.....	15	93	5.5	7.8
V. 14.9 trials.....	17	65	4.1	4.0

third column are given the percentages of the individuals affected for the various groups. The fourth column gives the average number of trials per affected individual required to eliminate the disturbance, while in the last column are found the average number of errors per affected individual involved in learning to adjust to the novel situation. Obviously these values are a measure of the degree of the resulting disturbance. These data justify the following conclusions:

1. The majority of the individuals (65 per cent.) were

disturbed by the introduction of vision, and this disturbance persisted for from one to fifteen trials. Usually not more than one or two errors were made per trial. The disruptive influence of vision was slight but quite difficult to eradicate.

2. A very considerable number of the subjects were immune to this influence and were able to traverse the maze without error.

3. With the exception of group IV., those subjects who had learned the act with visual aid were less disturbed by the introduction of vision than were those individuals (group I.) who had been denied that aid. The standard group (I.) and that permitted seven trials with vision (group IV.) were about equally affected.

4. With the exception of group IV., the amount of the resulting disturbance, measured in terms of the number affected and the number of trials and errors required to readjust to the situation, varies directly with the amount of visual guidance employed in acquiring the act.

The fact that the standard group that had been denied the use of vision in learning the maze was the most disturbed by the introduction of vision is to be explained largely in terms of the illusory conception of the magnitude of the movements which subjects normally develop under these circumstances. It is a well-known fact that subjects who learn a maze with vision excluded build up some sort of a conception of its visual appearance, and that almost invariably they grossly overestimate its dimensions. Naturally all subjects who are permitted the use of vision in learning the maze will develop a more correct conception of its magnitude. As a consequence the members of the standard group, when vision is introduced, will be distracted by the disparity between their conceptual and perceptual impressions, and will make a number of errors in so far as they attempt to guide their movements in terms of vision.

One would naturally expect that the greater the amount of vision involved in the acquisition of an act, the less will be the disturbance resulting from its later introduction. As a matter of fact the opposite relation obtains and the fact

is not readily explained. Two suggestions may be offered: (1) Overconfidence and carelessness. The more nearly the act was learned while vision was permitted, the greater is the subject's confidence in his ability to run the maze correctly when vision is again introduced, and this confidence begets carelessness and resulting error. Especially does this explanation apply to the members of group V. They were permitted the use of vision until they ran three perfect trials in succession, and were then requested to make three more perfect runs with vision excluded. By this time, they were overconfident, somewhat bored and quite careless, and errors were made as a consequence. (2) Inaccuracy of visual conception. While the visual groups developed a more accurate conception of the magnitude of the movements than did the standard group, yet their conception of the details of the maze pattern may be more inaccurate. The greater the amount of vision permitted, the more detailed will be the conceptual schema developed, and it is assumed that the greater the wealth of detail, the more numerous are the possibilities of error. Mistakes will naturally be made in so far as these subjects attempt to guide their movements by means of these erroneous notions.

The fact that such a large number of individuals in all groups were not disturbed by the introduction of vision indicates that individuals differ very materially in the extent to which they normally rely upon a visual control in acquiring and performing such an act of skill.