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THE RELATION OF POSTTEST PERFORMANCE TO RESPONSE-CONTINGENCIES IN PROGRAMMED INSTRUCTION

Mark A. Sherman

JUNE 1965

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L. G. Hanscom Field, Bedford, Massachusetts

Project 7682, Task 768204

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(Prepared under Contract No. AF 19 (628)-2404 by
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FOREWORD

This report covers a portion of the applied research program of the Decision Sciences Laboratory. The research was conducted under Contract AF 19(628)-2404 in support of Project 7682, Man-Computer Information Processing, Task 768204, Automated Training for Information Systems.

This experiment was conducted by the author, Mark A. Sherman, under the general supervision of the contract's principal investigator, James G. Holland. Dr. Sylvia R. Mayer of the Decision Sciences Laboratory was the Air Force technical monitor.

Facilities used in this research were provided by the Harvard Committee on Programmed Instruction which is supported by the Carnegie Corporation.

This technical report has been reviewed and is approved.

Donald W. Connolly

DONALD W. CONNOLLY
Project Officer
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Colonel, USAF
Director, Decision Sciences Laboratory

ABSTRACT

Two programs, containing fictitious subject matter, were employed in a study designed to compare the teaching effectiveness (as measured by posttest) of textual material presented (1) as contingencies for responses in a program, or (2) as material upon which responses were not contingent. The content of the programs was identical, and they differed only in that material whose reading was necessary for correct responding in one program was not necessary for correct responding in the other and vice versa. The posttest was the same for all subjects. Half of the posttest related to material which was response-contingent in one of the programs, and the other half related to material which was response contingent in the other program. Results indicate that response-contingent material leads to higher posttest scores than the same material when it is not necessary for correct responding within the program. The probability of information being acquired from a program is increased when this information is response contingent.

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SECTION I

INTRODUCTION

In a programmed frame, the correct response should be contingent upon the student reading all the frame. If the student responds correctly after reading merely part of the frame, only that part serves as the contingency for the answer; the remainder is unprogrammed in the sense that the answer does not depend on it. (Holland, 1964; Skinner, 1963.)

The relative amount of material not serving as contingencies for the correct answers can be expressed as a "blackout ratio" (Holland and Kemp, 1965). This measure is the ratio of the non-response-contingent material to the total amount of material in the program. It has been found that different programs vary greatly in blackout ratios. In some programs more than half the textual material has been shown to be unnecessary for correct responding. The present experiment attempts to show that material on which correct answers in the program depend leads to better posttest performance than does material on which such answers do not depend. Such a difference would be expected in view of the fact that only the response-contingent material must be carefully read.

Using series of nonsense syllables or three-letter words, Eigen and Margulies (1963) showed that recall is better for items which were necessary as responses in learning than for those which appeared without being required as responses. Though this result gives evidence favoring our hypothesis, the fact that the materials used bore little resemblance to material in a typical program limits the generality of the finding.

Holland (1964) developed an experimental version of The Analysis of Behavior which differed from the original only in the location of the blank, which was changed to greatly reduce the dependency of the answer on the textual material. This experimental version, in which answers were not contingent upon reading more than a small portion of the textual material, yielded lower posttest scores than the normal version. This experiment compared programs differing in the amount of material necessary for correct responses, but left unanswered the question of whether this variable influences teaching efficiency when varied within the same program, or even the same items.

The present study attempts to determine whether a similar difference in posttest performance occurs for necessary and unnecessary material when they exist together in the individual items of the same program. For such an experiment, it is necessary to use programs containing both kinds of material, and to use posttests with some questions on response-contingent material and others on the non-response-contingent material. A balanced design is necessary to control for differences in posttest question difficulty. An apparent difference in performance on the two types of posttest questions might reflect either the response-contingency variable or differences in test item difficulty unless the material to which each test item refers is response contingent for some subjects and not response contingent for others.

SECTION II

METHOD

Materials: Two programs and a posttest were used in this study. All frames in both programs contained some material necessary for the answer and other material not necessary for the answer. The content of both programs was identical (i.e., there was no sentence in one program which was not in the other), but the programs differed in that all material which was response contingent in one program was not response contingent in the other.

Fictitious "medical" subject matter was used in preparing the programs. The use of such subject matter had two main advantanges: first, it insured virtually the same preprogram knowledge for all Ss at a level very close to zero, thus eliminating the need for pretesting and grouping on the basis of pretest performance; second, as will be seen below, it made possible the writing of sentences with the relationships necessary for construction of the experimental programs. The raw materials from which the two programs were constructed consisted of 200 one-sentence items containing blanks that were as nearly as possible contingent upon reading the entire sentence. The following example presents a sequence of 5 items from this set. "Smoker's palatitis," a fictitious disease caused by cigar smoking is discussed:

52. This inflammation is generally not caused by _____ or pipe smoking.

    Ans. cigarette

53. The occasional cigar smoker really needn't worry, because to inflame the palate requires the smoking of from 6 to 10 cigars per _____ .

    Ans. day

54. The major symptom is similar to that of t_____ _____ except that the roof of the mouth, or the palate, is the location of the burning sensation.

    Ans. trigeminal obnoxia

55. In accordance with the popular image, one finds the majority of cases of smoker's palatitis among _____. (professors/doctors/businessmen)

    Ans. businessmen

56. The affliction most commonly occurs between the _____ of 40 and 50.

    Ans. ages

It is important to note that these "programmed sentences" form a sequence only in that they refer to the same topic; however, the correct response for any one of them does not require reading the item directly preceding it. In this sense, there is relative independence between odd- and even-numbered items for most items throughout the set.

To construct the programs actually used in the study, consecutive items were paired and the blank from the first item of each pair filled in, giving two-sentence frames with the blank for each frame in the second sentence. It was possible to create two programs by making odd-numbered items the first sentences of frames in one case, and even-numbered items the first sentences in the other. The following corresponding segments from the two programs illustrate the procedure. Note that the items come from the previous example.

Program I

27. This inflammation is generally not caused by cigarette or pipe smoking. The occasional cigar smoker really needn't worry, because to inflame the palate requires the smoking of from 6 to 10 cigars per _____.
Ans. day

28. The major symptom is similar to that of trigeminal obnoxia except that the roof of the mouth, or the palate, is the location of the burning sensation. In accordance with the popular image, one finds the majority of cases of smoker's palatitis among _____ . (professors/doctors/businessmen)
Ans. businessmen

29. The affliction most commonly occurs between the ages of 40 to 50. (Next sentence has blank.)

Program II

26. (First sentence without blank.) This inflammation is generally not caused by _____ or pipe smoking.
Ans. cigarette

27. The occasional cigar smoker really needn't worry, because to inflame the palate requires the smoking of from 6 to 10 cigars per day. The major symptom is similar to that of t_____ _____ except that the roof of the mouth, or the palate, is the location of the burning sensation.
Ans. trigeminal obnoxia

28. In accordance with the popular image, one finds the majority of cases of smoker's palatitis among businessmen. The affliction most commonly occurs between the _____ of 40 and 50.
Ans. ages

The content of the two programs was identical, but every sentence containing a blank and, thus, a contingency for correct responding in one program appeared as a sentence without a blank and therefore, was non-resonse-contingent in the other program.

The posttest contained 44 objective questions all directly related to material in the programs. Most test items were interrogatives requiring one or two words for answers, but a few were of the completion type. There were no multiple-choice items. Half of the test items referred to material which was necessary for correct responding in

Program I, but unnecessary in Program II, while the other half related to material which was unnecessary in Program I, but necessary in Program II. Thus, every posttest question related to material necessary in one program and unnecessary on the other. The order of questions was random, but the same order was used for each S.

A modified blackout technique was applied to determine whether the answers for the blanks on the program were independent of first sentences as assumed. For each of the two programs, the first sentence of every frame was covered with black crayon and, thus modified, each program was tested on 10 subjects. The error rate for these subjects was 21.0 percent as compared with an error rate of 14.5 percent for the subjects using the normal program in the experiment proper. Hence, the assumption that answers for blanks in the program were independent of the reading of the first sentences is not completely valid. However, when only those frames on which posttest items depended were compared, no significant difference in error rate was found between blacked-out and normal programs. Therefore, the programs seem appropriate for the experimental comparisons using this posttest.

Procedure: Twenty Harvard Summer School students were randomly assigned to two groups of 10 each. S was exposed to his appropriate program on a Didak teaching machine and, upon completion of the program, was given the posttest, presented in the form of a mimeographed booklet with one question on each page. Every subject was given the same posttest regardless of which of the two programs he had taken. At no point in the experiment were time limits imposed.

SECTION III

RESULTS AND DISCUSSION

Posttest results appear in Table I. For both programs, scores on questions related to material serving as response contingencies in the program were higher than scores for those test items which related to material not serving as response contingencies. All but three subjects showed this effect; two of these did equally well on the two sets of test items and one reversed the usual effect. The difference in scores is significant for both groups (Group I: $p < .005$; Group II: $p < .02$; Wilcoxen test). Acquisition is greater for the information on which an answer depended than for information on which no answer depends. Possibly this is because the subject can skim or ignore the unessential parts of frames and concentrate only on the part which must be read carefully to produce the right answer. Since the blanks and critical material were always in the last portion of the frames, such selective reading would not have been difficult.

Alternative explanations might be that second sentences of two sentence frames are learned better than first sentences or, that proximity to the blank contributes to learning irrespective of the relation of the material to the answer. But the results of this study, taken together with those of Eigen and Margulies (1963) and Holland (1964) lend support to the position that, in programmed material, a person learns best those things he must do to reach a correct answer. Thus, the degree to which material is programmed, which can be measured by the blackout ratio, is a variable of importance in acquisition.

Table I

Number correct on the posttest for each S. The first column contains the score (number correct) for test items related to response-contingent material; the second, the score for those items related to non-response-contingent material. The actual set of questions related to each type of material is reversed for the two groups. The maximum score in either column is 22. The third column shows the difference between the two scores.

	Subject Number	Response Contingent	Non-Response Contingent	Difference
Program I	(1)	15	13	2
	(2)	20	20	0
	(3)	17	13	4
	(4)	17	12	5
	(5)	15	11	4
	(6)	14	12	2
	(7)	17	11	6
	(8)	18	17	1
	(9)	16	8	8
	(10)	12	11	1
Medians		16.5	12	3
Program II	(11)	10	8	2
	(12)	9	7	2
	(13)	17	13	4
	(14)	13	15	-2
	(15)	20	14	6
	(16)	14	11	3
	(17)	10	10	0
	(18)	13	11	2
	(19)	19	10	9
	(20)	10	6	4
Medians		13	10.5	2.5

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13. ABSTRACT

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