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Seventeen different versions of a film designed to teach the assembly of the breech block of the 40mm antiaircraft gun were tested on 2377 apprentice seamen in 1948. Each version was shown to at least 100 men, in groups of about 30, in an effort to evaluate the relative effects on learning of certain content and tempo characteristic s of specific instructional films. The film versions differed with respect to six variables, designated as Verbalization, Rate of Development, Nomenclature, Errors, 'How it works', and Repetition. None of the men had ever assembled the breech block or similar mechanisms. They were grouped according to age, length of education, General Classification and Mechanical Aptitude Test Scores. Immediately after the film showing, each man was required to attempt to assemble the parts of the dismantled breech block. Ten trials were given, and a time score obtained for each man. The most significant results were that a slow rate of development, the pointing out of errors to be avoided, and repetition of the assembly demonstration, markedly and positively contributed to the effectiveness of the film. (GO)

TECHNICAL REPORT - SDC 269-7-17

EFFECTS ON TRAINING OF EXPERIMENTAL FILM VARIABLES, STUDY I: VERBALIZATION, RATE OF DEVELOPMENT, NOMENCLATURE, ERRORS, "HOW-IT-WORKS", REPETITION

(Rapid Mass Learning)

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Instructional Film Research Program
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SUMMARY

The purpose of this study was to evaluate the relative effects on learning of certain content and tempo characteristics of instructional films designed to teach an assembly task. Seventeen different versions of a film designed to teach the assembly of the breech block of the 40mm. antiaircraft gun were produced for this study. These film versions differed with respect to six characteristics or variables, designated as Verbalization, Rate of Development, Nomenclature, Errors, "How-it-works", and Repetition.

The film versions were produced by The Pennsylvania State College Motion Picture and Recording Studio during the spring of 1948, and were tested on apprentice seamen at the Great Lakes Naval Training Station that summer. Each version was shown to at least 100 men, in groups of approximately 30. In all, 2377 men participated as subjects. The film groups were equated with respect to age, length of education, General Classification Test score, and Mechanical Aptitude Test score. The men were all newly inducted, and none of them had had previous training in assembling the breech block or similar mechanisms. Immediately after the film showing, each man was required to attempt to assemble the parts of a disassembled breech block. Ten trials were given and a time score was obtained for each man.

The most significant results were that a slow rate of development, the pointing out of errors to be avoided, and repetition of the assembly demonstration contributed markedly and positively to the effectiveness of the film. The use or omission of the technical nomenclature, or the use of a high or low level of verbalization did not make significant differences in the effectiveness of otherwise comparable film versions. Presentation of the particular "how-it-works" sequence used in the experiment reduced, on the whole, the effectiveness of those versions in which it was included.

The positive effects of a slow rate of development, the pointing out of errors, and repetition persisted in diminished degree but more or less consistently throughout the ten trials.

The effects of the poor films were most persistent with respect to the poorer learners.

Films which made use of slow rate of development, showing of common errors to be avoided, and repetition, were able, by themselves, to teach assembly of the breech block with a high degree of effectiveness.

EFFECTS ON TRAINING OF EXPERIMENTAL FILM VARIABLES STUDY I: VERBALIZATION, RATE OF DEVELOPMENT, NOMENCLATURE ERRORS, "HOW-IT-WORKS", REPETITION[1]

Nathan Jaspen

INTRODUCTION

Until recently there has been an almost complete lack of research that studied the characteristics of films themselves. The question of how much "better" or "worse" instructional films are than some other medium had been dealt with often. The question of what are the necessary characteristics of a "good" or "better" or "best" teaching film, however, had been posed only rarely.

Since August of 1947, the Instructional Film Research Program has taken some significant steps in this direction. Several studies have attacked problems of the characteristics of the film itself. Roshal (3) dealt with the relative effectiveness of several ways of handling the visual material or pictures, and Zuckerman (5) dealt with characteristics of the commentary or sound track. These and other studies showed the effectiveness of instructional films is in large measure a function of the film techniques employed. The studies showed clearly that some film variables yielded more learning than others.

STATEMENT OF THE PROBLEM

As an early step in this kind of research, the present study was undertaken to investigate the relative effects on learning of certain characteristics or variables in films designed to teach an assembly skill. A basic preliminary question to be answered was: What characteristics should training films have so that, by themselves and without help from instructors or books, they may be used to teach effectively in an emergency situation?

The particular skill to be taught was assembly of the breech block of the 40mm antiaircraft gun.

The particular variables whose effects on this learning were to be studied were Verbalization, Rate of Development, Nomenclature, Errors, "How-it-works", and Repetition. These were defined as follows:

1. Level of Verbalization is the amount of narration used to describe the action of a film (expressed in average number of words per minute of film).

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1 This report is based on a dissertation by Jaspen (1), completed in May, 1949.

Where the action of a film is the simple demonstration of an assembly task, Level of Verbalization is a relationship between how much is said and how much is demonstrated or done pictorially. If each frame (or each minute) of a film is part of the demonstration, then how much is demonstrated can be expressed in minutes, and Level of Verbalization can be expressed as average number of words per minute of film.

2. Rate of Development is the speed or tempo with which a given amount of material is covered pictorially. If one picture used four hundred feet of film to demonstrate how to assemble a breech block and a second picture used eight hundred feet of film to demonstrate how to assemble a breech block, then the first film had a faster rate of development than the second (i.e., it took half as much time). The increase in film footage (or time) may be the result of (1) taking more shots or (2) letting the camera run longer for each shot or (3) a combination of more and longer shots. In manipulating this variable in the present experiment, sound tracks were varied only as much as necessary to correspond with the pictorial sequences.

3. Nomenclature is the use of the technical names of the parts of the breech block.

4. Errors is the showing of common errors to be avoided in performing the assembly task.

5. "How-it-works" is the use of a film sequence showing the principles of operation and function of the breech block.

6. Repetition is the number of times the basic demonstration of the assembly task is presented in a film.

With verbalization and rate of development, degrees were established for comparative investigation: high and low verbalization, slow and fast rates of development. In the case of nomenclature, errors, and "how-it-works", the presence or absence of these variables in the film were to be compared. (A film has, or does not have, the sequence showing errors to be avoided; a film has, or does not have, the technical names of the parts; a film has or does not have a sequence showing how the device works.) With regard to repetition, a film had one, two, three, or four demonstrations of breech block assembly.

To provide for an evaluation of the effectiveness of these variables, seventeen versions of a film designed to teach assembly of the breech block were produced. A film version contained a planned pattern of variables. These version differed systematically from each other with regard to one or more of the six variables. The problem then was to determine which degree of each variable was the more effective, and which, among the six variables, were the more significant in making an instructional film of this type more effective.

EXPERIMENTAL DESIGN AND PROCEDURES

The Task

The task selected for this investigation had to meet certain requirements:

1. Correct method of performance of the task should not be obvious on inspection, but should depend on definite instruction.

2. The task should be unfamiliar to most persons.

3. It should be neither too difficult nor too easy for the experimental population.

4. An average individual, after instruction, should be able to achieve competent performance within a relatively short period.

5. An objective criterion of successful performance of the task should be available.

Assembly of the breech block of the 40mm. antiaircraft gun was selected as a task appropriately meeting all these requirements. Preliminary try-outs with men at The Pennsylvania State College confirmed the suitability of this task.

Three meaningful and objective criteria of successful learning of the breech block assembly were selected for use in this study.

The first criterion was successful assembly, regardless of speed. (In actuality, of course, it was necessary to impose a reasonable time limit.)

The second criterion was length of time in seconds required for a successful assembly.

The third criterion was a speed score. This score is the reciprocal of the time score (multiplied by 1000 to eliminate the decimal). An individual who failed to assemble the breech block in the time allowed got a speed score of zero; the time score for such an individual was indeterminate (i.e., it might be two hours or two years). Since means and standard deviations of time score distributions could not be computed when failures to assemble the block were included, the means and standard deviations of speed scores could supply critical data that otherwise would have been unavailable.

The Film Variables

Six variables were to be subjected to analysis in this study. These six variables and the design for studying them determined the nature of seventeen film versions which were used in the investigation. Two conditions or "levels" for each variable (except Repetition) were defined for study. These are described below:

Verbalization. According to the average number of words per minute, a film was designated as having a high or low level of Verbalization. "High" and "Low" were relative terms: of two films alike in every other respect, the one that had more words had a high level of verbalization; the one with fewer words had the low level of verbalization.

It should be understood that Verbalization was not expressed as the total number of words: it was expressed as the number of words per minute of film.

It should be further understood that Verbalization in this study did not refer to the rate of speaking as such. The narrator spoke at a normal rate of speed for all the film versions. The differences in amount of commentary from one film to another were controlled by varying the intervening periods of silence.

Rate of Development. According to the speed with which a given amount of material (teaching the breech block assembly) was covered pictorially, a film was designated as having a slow or fast rate of development. In practice, a fast rate of development required that the film present visually (1) only the essential aspects of the action and (2) only for as long a time as necessary to give a reasonably complete presentation of the action. A slow rate of development required that the visuals or pictures give more time to each shot, use additional shots, and generally give a more extended pictorial coverage to the actions to be learned.

Nomenclature. There are seven parts of the breech block; the firing pin, firing spring, firing spring cover, sear, sear spring, inner cocking lever, and outer cocking lever. These seven names were used in the commentary of some films. In other films, common names such as "part" or "piece" were used instead. The disassembled parts of the breech block and a special wrench are illustrated in Figure 1.

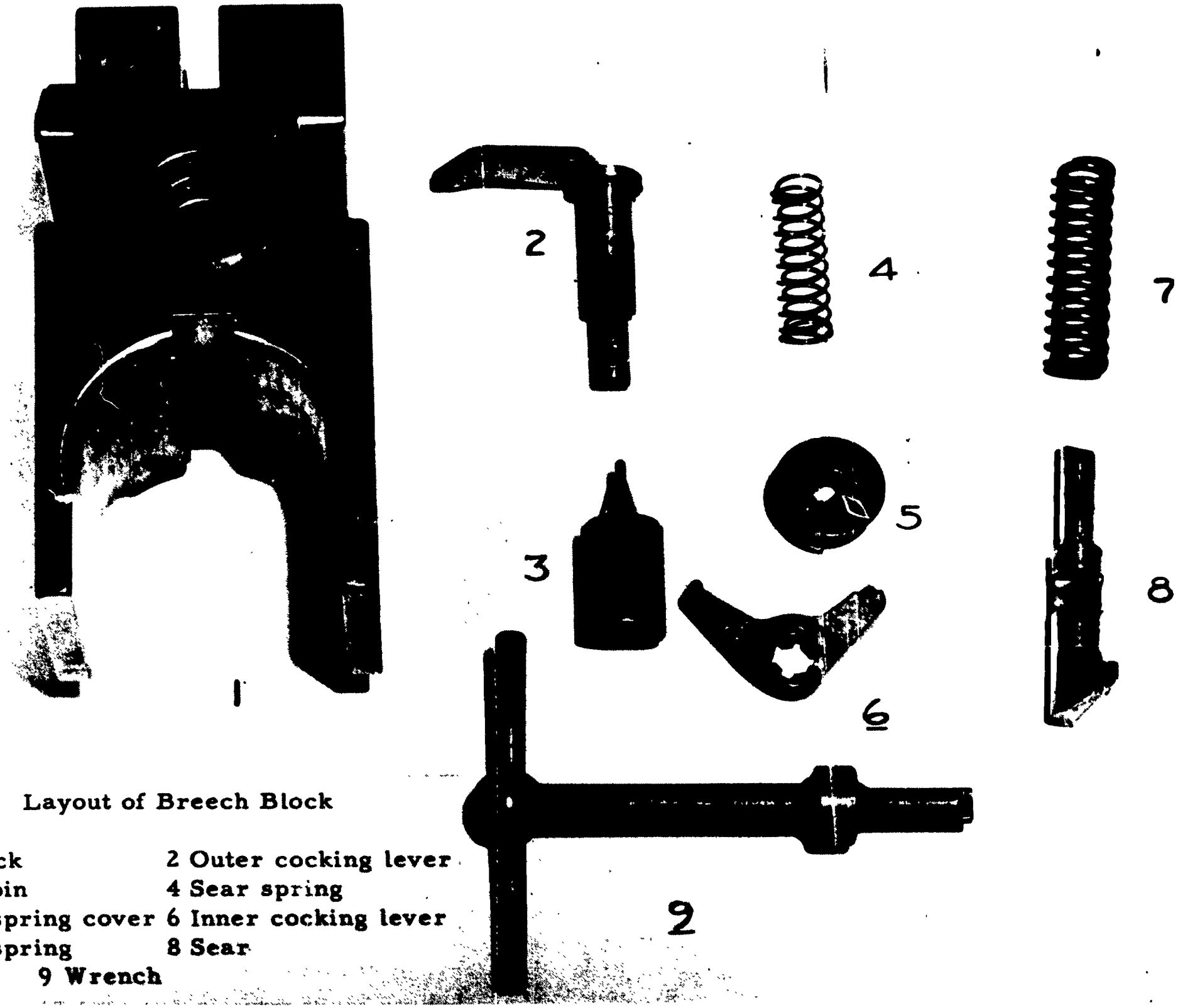

Fig. 1 Layout of Breech Block

1 The block
2 Outer cocking lever
3 Firing pin
4 Sear spring
5 Firing spring cover
6 Inner cocking lever
7 Firing spring
8 Sear
9 Wrench

Errors. Each film included or omitted a sequence showing common errors to be avoided. In film versions which included showing of errors, the wrong method of performing a part of the assembly was, in each instance, inserted immediately after the demonstration of the right method, and was clearly cautioned against as a wrong method.

"How-it-works". Some film versions included a "How-it-works" sequence which showed the operation and "logic" of the breech block. Other films omitted this sequence.

The hypothesis underlying the inclusion of the "how-it-works" variable in this study was that the showing of meaningful relations between the elements of the task would facilitate the learning of the task (2, pp. 167-168). The more meaningful the problem is to the learners, the more readily it is learned (4). A question remains, however, whether the relations shown in the particular "how-it-works" sequence used in this study were not more appropriate to learning the breech block as an operating mechanism in a gun rather than to learning the breech block as an assembly task. Conclusions concerning this variable therefore should probably be limited and related to the specific sequence used in this study.

Repetition. Repetition for the present experiment is defined to mean repetition of the demonstration of the assembly and not repetion in practice of the assembly. Repetition, as defined, was achieved by demonstrating the assembly of the breech block more than once in some film versions. In addition, one film version was produced which also repeated the "how-it-works" sequence and Errors as well as repeating the demonstration of assembly.

The Film Versions

In order to study the six variables, seventeen versions of the film were produced. In these seventeen versions, the six variables were systematically varied to provide a matrix of comparisons.

In order to understand the degrees or levels of each variable and the combination of variables in each film version, it is convenient to assign symbols to each variable and to designate two "levels". Each variable is identified therefore, by a letter: This letter as a capital designates one level of the variable; this letter in lower case designates the other level of the variable:

Verbalization
V - high
v - low

Rate of Development
D - slow (long film)
d - fast (short film)

Nomenclature
N - used
n - not used

Errors
E - shown
e - not shown

"How-it-works"
H- shown
h - not shown

Repetition
1, 2, 3, or
4 sequences

The seventeen film versions were identified by the letters of the alphabet, A through Q. Using the symbols outlined above, the pattern of variables in each film version is presented in Table 1.

In general, Films A and K served as the control versions for the experiment.

General Outline of the Films. The experimental films were made up of the following sequences in the order indicated:

1. Introduction. The anti-aircraft gun is shown in action. The picture dissolves to a close-up of the breech block -- "the heart of the gun". The narrator says: "This film will show you how to assemble the breech block. Then you will be asked to do the job yourself." This sequence begins all of the films. The footage on the gun was taken from Navy stock shots.

2. "How-it-works" sequence (when used). The block is shown disassembled. The principles of operation and the "logic" of the block are shown. In addition, there is an animation sequence showing a "transparent" breech block in which the parts are visible. This sequence came from a military film.

3. Assembly I sequence. This assembly sequence is present in all the film versions. The parts of the block are assembled in order. Errors ar shown in the sequence when the Errors variable is to be included in the film. Otherwise, Errors are not present, and the assembly proceeds straightforwar

4. Assembly II sequence. This assembly sequence is shorter than Assembly I. It is present in all film versions except O. It does not include showing of Errors.

TABLE 1

STRUCTURE OF THE VERSIONS IN TERMS OF THE FILM VARIABLES

Version	Verbalization	Rate of Development	Nomenclature	Errors	How-it Works	Repetition	Running Time (Minutes)
A	V	D	N	E	H	2	18.0
B	v	D	N	E	H	2	18.0
C	v	d	N	E	H	2	11.0
D	V	D	n	E	H	2	18.0
E	V	D	N	e	H	2	15.2
F	V	D	N	E	h	2	13.8
G	V	D	N	E	h	3	15.3
H	V	D	N	e	h	2	11.0
I	v	d	n	E	H	2	11.0
J	v	d	N	e	h	2	4.7
K	v	d	n	e	h	2	4.7
L	V	D	N	E	H	4	26.4
M	v	d	n	E	h	2	6.2
N	v	d	n	e	H	2	9.5
O	v	d	n	e	H	1	7.3
P	v	D	n	e	h	2	10.4
Q	V	D	n	e	h	2	10.4

Variable Symbol	Verbalization	Rate of Development	Nomenclature	Errors	How-it-Works
Upper Case	High	Slow	Used	Shown	Present
Lower Case	Low	Fast	Not Used	Not Shown	Not Present

5. Repetition. Most of the film versions included two assembly sequences (assembly I and assembly II). Three versions (O, L, G) deviated from the general pattern with regard to repetition. Version O omitted Assembly II. In version L, several sequences were added after Assembly II and before the Conclusion. These consisted of a second "How-it-works" sequence (without animation), a second Assembly I sequence (with Errors), and a variation of Assembly II which closely resembles the latter. All of these repetition sequences proceed about twice as rapidly as the corresponding sequences in the first part of the film. Version G included the Assembly II variation, placed before the Conclusion, in addition to Assembly I and II.

6. Conclusion. The parts are shown disassembled once more. The narrator says: "There are seven parts that fit into the breech block. Can you assemble them correctly?" This sequence was present in all films.

Comparisons between versions for each variable. In order to establish the relative effectiveness of the different levels of each variable, the experimental design called for certain primary comparisons between film versions.

Verbalization:

Primary comparisons of the effectiveness of high and low Verbalization were made between versions A and B, in one case, and versions Q and P in the second case. Version A used 146 words per minute; version B used 83 words per minute. Version Q used 137 words per minute; ve rsion P used 73 words per minute. These figures represent average words per minute of film; they are arrived at by dividing the total number of words by the minutes of running time.

Rate of Development:

Primary comparisons of the effectiveness of slow and fast rates of development were between versions B and C, in the one case, and versions P and K, in the second case. Version B (slow rate of development) ran 18.0 minutes; version C (fast development) ran 11.0 minutes. Version P (slow rate of development) ran 10.4 minutes; version K (fast rate of development) ran 4.7 minutes. (Versions B and C were longer than versions P and K, because they included "How-it-works", and Errors.)

Nomenclature:

Primary comparison of the effectiveness of the presence and absence of Nomenclature was made between version D and the positive control version A, in the one case, and between version J and the negative control version K, in the second case. D differs from A, and J differs from K, only with respect to this variable..

Errors:

Comparison of the effectiveness of the presence and absence of Errors was made between four pairs of films which differed only in so far as they showed, or did not show, Errors to be avoided. These four comparisons were between versions A and E, F and H, I and N, and M and K. Versions A, F, I, and M all included Errors. Versions E, H, N, and K all omitted Errors.

"How-it-Works":

Comparisons of the effectiveness of the presence and absence of "How-it-Works" were made between versions A and F, E and H, I and M, and N and K. The first version of each of these pairs (A, E, I, and N) has a "How-it-Works" sequence; the second version in each pair (F, H, M, and K) does not have a "How-it-Works" sequence.

Repetition:

Comparison of the effectiveness of two assembly demonstrations and three assembly demonstrations was made between version F (two demonstrations) and G (three demonstrations). The films were alike in all other respects.

Comparison of the effectiveness of one assembly demonstration and two assembly demonstrations was made between versions O (one demonstration) and N (two demonstrations). The two films were alike in all other respects.

A special comparison was made between version L and version A. Version L used Assembly I and Assembly II, each shown twice (a total of four assembly demonstrations); version A used Assembly I and Assembly II, neither one repeated (a total of two demonstrations). In addition, version L also included a repetition of Errors (as part of the first assembly sequence, shown twice) and a repetition of the "How-it-Works" sequence.

The Test Population

The men to whom the experimental film versions were shown were apprentice seamen at the Great Lakes Naval Training Station, Great Lakes, Illinois.

Thirty men were selected from each of 81 companies, on the basis of age, education, Navy General Classification test score, and Navy Mechanical Aptitude test score. All of the men selected were aged between 16 years, 8 months, and 21 years, 8 months. They had at least six years of formal education; they had Navy General Classification Test scores not lower than 40 and not higher than 60. They had Navy MA scores not lower than 40 and not higher than 60. These requirements insured that the groups selected for training and testing would be comparable and homogeneous. Homogeneity was further achieved by restricting the experimental population to those individuals whose combined General Classification Test and Mechanical Aptitude scores totalled between 90 and 110.

Since 30 men were selected from each of 81 companies, a total of 2430 might have qualified for the experiment. Data for 53 of these men were not used, however, because the men were absent, or had hand injuries, or were found, on review, not to meet the criteria of selection. No man was dropped because of his breech block performance score.

The Proctors

A detail of proctors was assigned to the experiment for each week of the study. Each detail consisted of 36 men. This included a proctor for each of the 30 assemblers being tested at a given time. Proctors were selected only from companies which did not provide assemblers; their "GCT" scores were for the most part superior (above 60).

Each detail of proctors was given four hours of instruction in reading standardized instructions, operating a stop-watch, keeping records, scoring breech block assembly, and other necessary skills.

Experimental Procedure

A standard motivational speech was given to each group of thirty men. The thirty men were then shown one of the film versions. After the film showing the men were directed to the testing room, which was equipped with ten long tables. On the tables, for each man, was a Test Record Sheet, with the man's name and service number and a number identifying the proctor assigned to test him.

When all the assemblers were in their assigned positions, a signal was given for testing to start. Proctors read a standard set of directions, laid out the parts of the disassembled breech block in a standardized pattern and told the assemblers to begin work. An assembler was timed from the moment he touched the first part until he completed the assembly. The proctor recorded his time (in seconds) for each of ten assembly trials. If an assembler failed to assemble the block in ten minutes, it was disassembled and he was told to try again. If he succeeded the second time, he continued for a total of ten trials. If he failed, he was dismissed, and his performance was recorded as a failure.

RESULTS

The Relative Effectiveness of the Seventeen Film Versions

While the main interest of this study is in the relative effectiveness of the film variables, it seems pertinent to inquire, first, whether the film versions resulted in significant learning, and if so, whether there were differences in the effectiveness of the different film versions.

Table 2 establishes that learning does occur exclusively from film instruction. In the case of the most effective films as many as 98% of the subjects succeeded in learning to assemble the breech block, within a time limit of ten minutes. [1]

That the different films varied greatly in effectiveness is also established by Table 2. Less than half the subjects who saw the least effective version (O) were able to complete the assembly within the first ten minutes; the median time for this film group was 749 seconds. The median for the most effective film was 101 seconds.

If we arrange the versions in order of effectiveness as measured by the criterion of mean speed, (Table 2), we find the following to be true:

1. The most effective version (L) had a slow rate of development, showed errors, and included four assembly demonstrations.

2. The second most effective version (G) had a slow rate of development, showed errors, and included three assembly demonstrations.

3. The next four most effective versions (F, D, B, A) had a slow rate of development, showed errors, and included two assembly demonstrations.

4. The following seven versions in order of effectiveness (I, H, P, Q, E, C, M) each included either a slow rate of development or errors, but not both. Each included two assembly demonstrations.

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[1] In Study II it was found that of a control group which received no instruction whatever, only 15% succeeded in assembling the breech block in a ten minute trial.

TABLE 2

RELATIVE EFFECTIVENESS OF THE FILM VERSIONS IN TERMS OF SEVERAL CRITERIA

Film	N	Mean speed score on first attempt	Median time score on first attempt (in seconds)	Percent successful on first attempt 600 second time limit	Percent successful on first attempt 1200 second time limit
A	233	7.5	150	88.0	92.7
B	118	7.7	134	87.3	99.2
C	116	6.5	174	88.8	97.4
D	147	8.2	127	88.4	93.2
E	141	7.1	157	87.9	94.3
F	118	9.3	106	98.3	99.2
G	119	9.9	103	95.8	97.5
H	116	7.4	162	89.7	93.1
I	116	7.5	138	92.2	97.4
J	150	4.8	332	64.7	83.3
K	266	4.6	346	62.4	75.6
L	116	10.5	101	98.3	99.1
M	117	6.5	164	91.5	99.1
N	150	5.6	289	74.7	88.0
O	118	2.1	749	45.8	69.5
P	116	7.3	156	91.4	97.4
Q	120	7.2	152	90.0	97.5
Range of Standard Errors -		.2 to .5	---	1.2 to 4.6	.8 to 4.2

5. The following three versions in order of effectiveness (N, J, K) had a rapid rate of development, did not show errors, and had two assembly demonstrations.

6. The least effective version (O) had a rapid rate of development, did not show errors, and included only one assembly demonstration.

It appears from this tabulation that the most potent variables are a slow rate of development, the showing of errors to be avoided, and repetition. This conclusion is substantiated by the statistical analysis (see Table 4 and 5).

Effects of the Versions on Subsequent Trials.

The analysis for the average learners gives us no assurance that below-average and above-average learners will be affected by films in the same way. If we compare speed scores for the poorest and best assemblers (lower and upper quartiles) from one version to another, do we obtain the same results that we do for median or average learners?

Table 3 shows the speed scores on the tenth trial at the upper quartile; median, and lower quartile, for the seventeen film versions. The range of medians is from 31 to 42. On the first trial the range of median speed scores was from 1 to 10. It would appear from this that while the differential effects of the films do diminish, on a relative basis, they nevertheless persist in some degree even until the tenth trial. Approximately the same range is found in the distribution of upper quartiles in the tenth trial.

On the other hand, the lower quartile scores diverge much more widely from each other. Figure 2 illustrates the learning curves for versions A and K at the median, the upper quartile, and the lower quartile. The greater divergence at the lower quartile is well illustrated in this graph.

It would, therefore, appear that the least effective films persist in their negative effects, especially on the poorer learners.

Relative Effectiveness of the Levels of each Film Variable.

To determine the effectiveness of the levels of each variable, comparisons were made between pairs of versions which differed from each other only with respect to this variable. These comparisons were based on mean speed scores on the first successful assembly.

TABLE 3

SPEED SCORES ON TRIAL 10 FOR THE SEVENTEEN FILM VERSIONS: UPPER QUARTILES, MEDIANS, AND LOWER QUARTILES

Speed Scores (1000 divided by time in seconds)

	Upper Quartile	Median	Lower Quartile
A	43	37	29
B	43	36	29
C	45	38	27
D	48	38	29
E	48	38	32
F	50	40	32
G	50	42	33
H	45	37	26
I	45	38	30
J	43	33	24
K	43	33	14*
L	48	40	31
M	48	38	29
N	45	37	27
O	38	31	14
P	43	34	27
Q	45	37	29

* Score obtained by extrapolation from earlier trials.

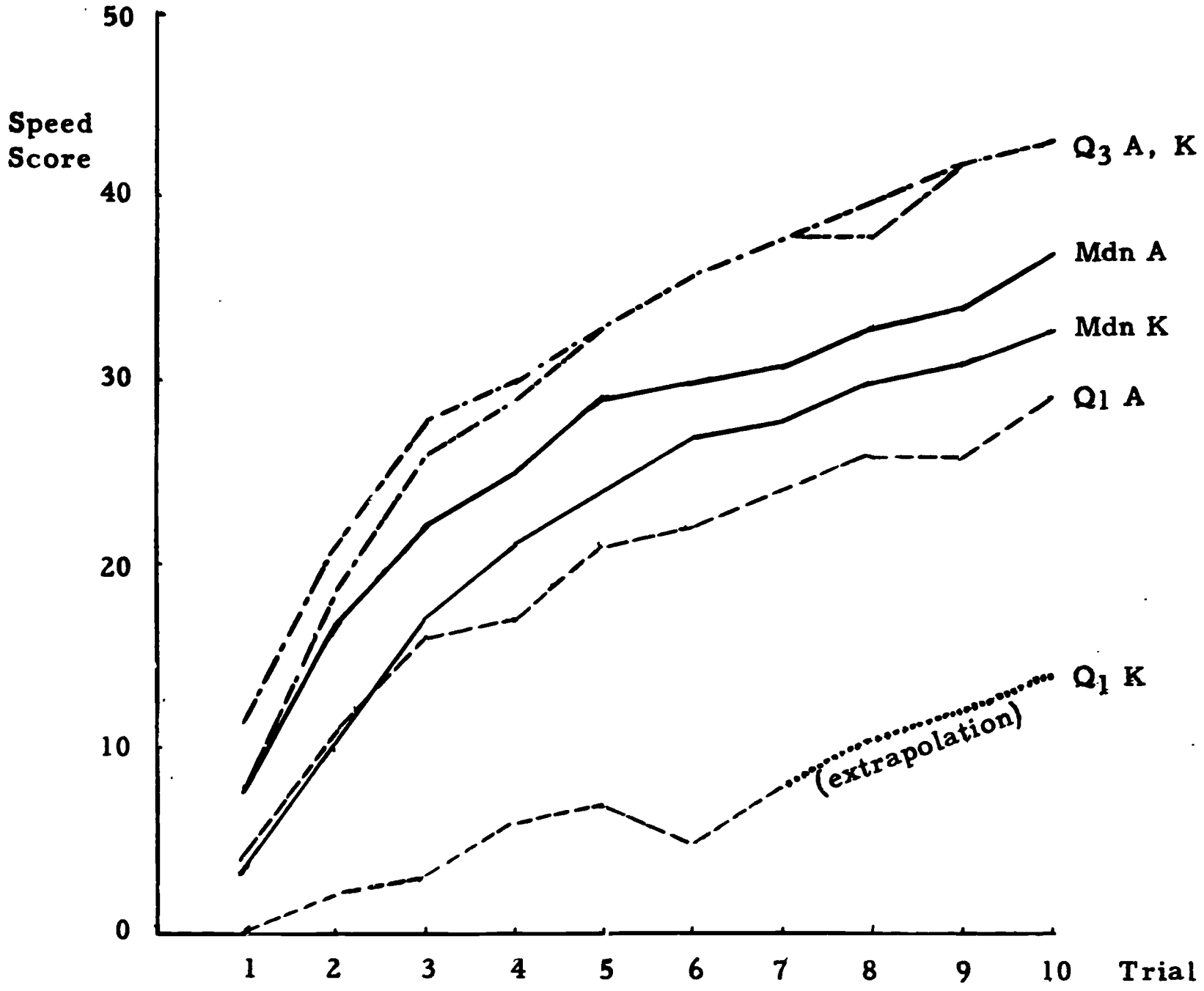

Fig. 2. Learning Curves for Films A and K for Ten Trials: Upper Quartile, Median, and Lower Quartile.

The mean speed score differences between pairs of films alike except for a single variable are summarized in Table 4.

The results of these comparisons and their implications for each variable are discussed below:

Verbalization. Version A was compared with version B, and version Q was compared with version P. In both comparisons, differences in effectiveness between high and low verbalization were not significant.

Rate of Development. Version B was compared with version C, and version P was compared with version K. In both comparisons, the versions with slow development (B and P) were superior to those with fast development. The superiority of P over K was significant to the 0.1% level of confidence.

Nomenclature. Version A, which used technical nomenclature, was inferior to version D which lacks technical nomenclature. Version J, which used nomenclature, was slightly superior to version K, which lacks nomenclature. Comparisons of H and Q, and I and C respectively also yield inconsistent results. No significant differences were established.

Errors. Versions A and E were compared. Version A shows Errors; version E does not. Version A is moderately superior to version E.

Versions M and K were compared. Version M shows Errors; version K does not. Version M is appreciably superior to version K and the difference is statistically significant at a high level.

Similarly, version F was compared with version H, and version I was compared with version N. In each comparison, the version which showed Errors was superior to the version which lacked Errors.

All four comparisons appear to establish the effectiveness of pointing out, in training films, common errors to be avoided on assembly tasks. In three of the comparisons these differences are statistically significant.

"How-it-Works". Four comparisons are available for this variable. Results for two of these are positive; results for the other two are negative. None of the differences is significant.

TABLE 4

DIFFERENCES AND SIGNIFICANCE OF DIFFERENCES BETWEEN CONTROL AND EXPERIMENTAL FILMS WITH REGARD TO EACH FILM VARIABLE CONSIDERED SINGLY, IN TERMS OF THE MEAN SPEED SCORES EARNED ON THE FIRST ASSEMBLY ATTEMPT

Variable and Version Pairs	M_1	M_2	Diff. [1]	σDiff.	Degrees of Freedom [2]	t-ratio
Verbalization						
A and B	7.50	7.69	-.19	.86	10	.22
Q and P	7.19	7.27	-.08	.49	6	.16
Rate of Development						
B and C	7.69	6.48	1.21	.55	6	2.20
P and K	7.27	4.60	2.67	.56	11	4.77**
Nomenclature						
A and D	7.50	8.21	-.71	.93	11	.76
J and K	4.78	4.60	.18	.62	12	.29
H and Q	7.36	7.19	.17	.74	6	.23
C and I	6.48	7.48	-1.00	.49	6	2.04
Errors						
A and E	7.50	7.12	.38	.96	11	.40
M and K	6.48	4.60	1.88	.59	11	3.19**
F and H	9.29	7.36	1.93	.61	6	3.16*
I and N	7.48	5.57	1.91	.78	7	2.45*
"How-it-Works"						
A and F	7.50	9.29	-1.79	.81	10	2.21
N and K	5.57	4.60	.97	.66	12	1.47
E and H	7.12	7.36	-.24	1.08	7	.22
I and M	7.48	6.48	1.00	.53	6	1.89
Repetition						
L and A	10.50	7.50	3.00	.92	10	3.26**
G and F	9.90	9.29	.61	.45	6	1.36
N and O	5.57	2.09	3.48	.72	7	4.83**

* Significant at the 5 percent level
** Significant at the 1 percent level

1 Sign of difference is from "positive" version minus "negative" version.
2 Degrees of freedom are based on the number of subgroups (details) that saw each version.

Repetition. Version L, with four assembly sequences, was compared with version A, with two assembly sequences. Version L was appreciably superior to A. The difference was significant at the 1% level of confidence.

Version G, with three assembly sequences, was compared with version F, with two assembly sequences. Version G was moderately, but not significantly superior to version F.

Version N, with two assembly sequences, was compared with version O, with one assembly sequence. The superiority of N over O was extremely great and was significant to at least the 1% level of confidence.

It is clear that this variable is one of the most effective of those studied.

Summary of Effectiveness of the Variables

Of the six variables studied in this research, clear-cut positive results were found for three: a slow rate of development, the showing of common errors to be avoided, and repetition. All three significantly facilitated learning of the assembly of the breech block.

Findings for the other three variables tend negatively, but are somewhat ambiguous. Further study seems necessary in order to establish conclusive results with regard to Level of Verbalization, "How-it-Works", and Nomenclature.

Over the range studied in this experiment, varying the level of verbalization resulted in no differences in measured learning. The use of technical nomenclature did not help learning nor significantly hinder it. The "How-it-Works" sequence used in this experiment yielded inconsistent results.

A Comparison of the Effectiveness of the Film Variables

It is desirable to expand the foregoing analysis in two directions. First, we should like to know the impact of each film variable on all of the films, rather than on only those used in the controlled comparisons. Second, we should like to evaluate the relative effectiveness of the variables in terms of a variety of criteria, e.g., proportion successful on first attempt, time required for assembly, speed on later trials. The problem reduces to one of determining the weights representing the relative effectiveness of the six film variables. Multiple regression analysis is a technique for obtaining such data. The data obtained from this analysis were Beta weights. Table 5 presents the Beta weights of the film variables for each of fifteen criteria.

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1 The Instructional Film Research Program has done this in Study II. See Technical Report SDC 269-7-11.

TABLE 5

BETA WEIGHTS OF FILM VARIABLES FOR VARIOUS CRITERIA

Criterion	Level of Verbalization	Rate of Development	Nomenclature	Errors	How it Works	Repetition
Percent pass-600 sec.	-.092	.502	-.029	.472	-.141	.219
Percent pass-1200 sec.	-.086	.139	.029	.151	-.045	.055
Median time-first attempt	-.124	.442	.023	.411	-.203	.273
Mean speed-trial 1	.004	.512	-.053	.402	-.101	.408
Mean speed-trial 5	.051	.492	.071	.452	-.144	.119
Mean speed-trial 10	.009	.406	-.001	.397	-.034	.230
Median speed-first attempt	.049	.521	-.097	.543	-.126	.288
Median speed-trial 5	.113	.386	.196	.558	-.209	-.152
Median speed-trial 10	.273	.226	-.095	.457	.036	.312
Q_3 speed-first attempt	.082	.456	-.106	.339	.061	.423
Q_3 speed-trial 5	.312	.405	-.170	.279	-.420	.186
Q_3 speed-trial 10	.319	.186	-.198	.346	-.179	.352
Q_1 speed -first attempt	.117	.498	-.132	.403	-.103	.372
Q_1 speed-trial 5	.030	.468	.169	.384	.084	-.064
Q_1 speed-trial 10	-.052	.424	.144	.320	.099	.090

These weights partial or cancel out the effect of all the variables except the one to which each weight applies. They overcome, therefore, the limitations of an experimental design which would otherwise permit comparisons only between pairs of films which are identical except for a single variable.

On the whole the results with regard to the Beta weights confirm those of the film-by-film comparisons. The highest Beta weights are associated with rate of development, errors, and repetition, generally in that order. The weights for verbalization and nomenclature are substantially zero. The weights for the "how-it-works" variable are slightly negative. Fig. 3 graphically illustrates the relative magnitude of the Beta weights or the potency of each variable, for two criteria: (a) per cent of assemblers succeeding on the first trial, and (b) mean speed on the first trial. Since the criteria are not perfectly correlated, some differences in the weights for each are to be expected.

As we go from earlier to later trials, the weights become uniformly smaller, although not to any marked extent except for Repetition. It is possible that additional trials act as an additional kind of repetition. Since the weights decrease from the earlier to the later trials, one may conclude that practice itself increasingly determines performance, and that the effects of the film variables diminish. However, even at trial 10 the Beta weights are still high, indicating that one can predict fairly well, from a knowledge of the structure of the film, the performance of a group that has had as many as ten trials after seeing the film. This finding confirms the conclusion previously reached that poor films encourage the persistence of inferior performance.

The Beta weights associated with the quartiles are in the same direction as the weights associated with the measures of central tendency. The differences in magnitude may be due to the greater instability of the quartiles, or they may indicate real differences in the effects of the film variables with different segments of the population.

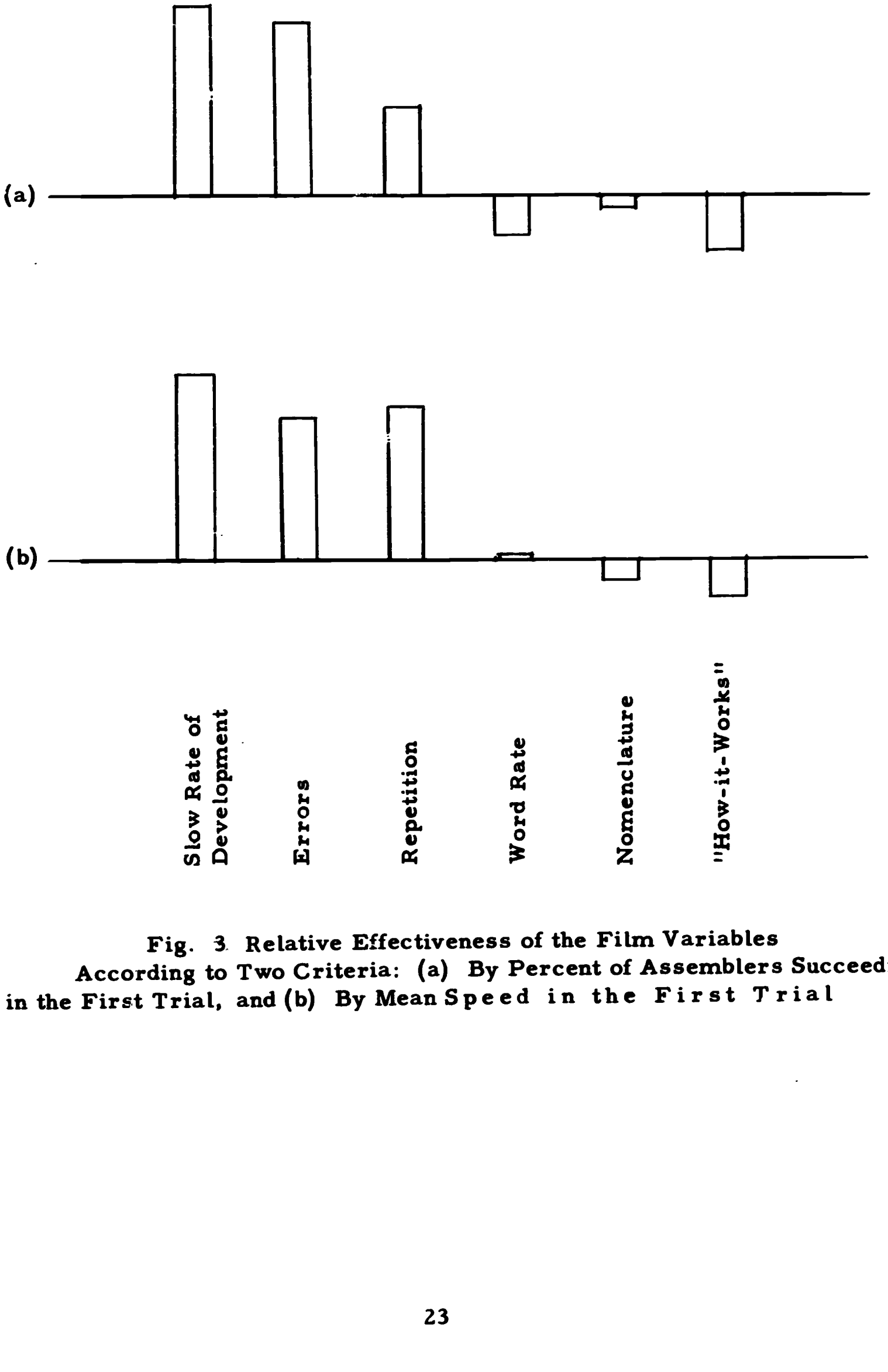

Fig. 3 Relative Effectiveness of the Film Variables According to Two Criteria: (a) By Percent of Assemblers Succeeding in the First Trial, and (b) By Mean Speed in the First Trial

CONCLUSIONS AND RECOMMENDATIONS

The results of the present experiment appear to justify the following conclusions and recommendations concerning films designed to teach an assembly task of the kind used in this study:

1. A slow rate of development is a most important factor in making a teaching film effective. New material in films should be covered pictorially at as slow a speed as is consistent with other considerations. In general, this speed would be slower than is customary in present production practice.

2. Repetition of the demonstration of the task will add considerably to the teaching effectiveness of a given film, even when the film is otherwise already effective. It is recommended that repetition of basic sequences within the film, perhaps with variations, be made part of the design of films which are intended to teach assembly tasks.

3. Showing common errors to be avoided increases the instructional effectiveness of a film. It is recommended that, in addition to showing right ways to perform a task, films also point out common errors to be avoided.

4. The use of technical nomenclature does not appear to facilitate the learning of an assembly skill and may actually interfere with such learning. If technical nomenclature must be used in films, it should be recognized as constituting an additional teaching burden and the film treatment should be extended accordingly.

5. Results on the "How-it-Works" variable are inconsistent. It is questionable that the sequence used to study this variable was optimal in its orientation of meanings to the breech block. Further study of this variable has been undertaken.

6. Results on the Verbalization variable are inconclusive. Further study, which examines intermediate levels of this variable, has been undertaken.

7. A suitable film which makes use of a slow rate of development, repetition, and errors, can, by itself, teach with a high degree of effectiveness. In this experiment, 98% of the men who saw a single showing of such a film and who received no other instruction learned how to assemble the breech block.

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