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ACCURACY VERSUS SPEED IN THE GENERALIZED EFFORT OF LEARNING-DISABLED CHILDREN

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Reinforcement of effortful performance in a given academic task has been found to increase the subsequent performance of other academic tasks. The learned-effort hypothesis assumes that individuals learn which dimensions of task performance are correlated with reinforcement of high effort, and generalize across tasks. Therefore, reinforcement of increased effort in a given dimension of one task should result in greater generalized effort in the same dimension of transfer performance than in another dimension. In accord with this view, preadolescent learning-disabled students who received points for high reading accuracy subsequently produced more accurate drawings and stories than did students whose points had been based upon high reading speed or upon mere completion of the reading task. Students who received points for high reading speed subsequently constructed stories more quickly than did children whose points had been based upon high reading accuracy or upon reading-task completion. Consistent with the more explicit and frequent feedback for accuracy than for speed in most academic tasks, generalized accuracy was much more durable than generalized speed.

Key words: generalization of effort, speed, accuracy, performance dimensions, learned-effort hypothesis, token economy, learning-disabled children

Why are some students more persistent than others when given difficult academic tasks? Reinforcement interpretations emphasize the previous schedule of reward. Persistence on difficult academic tasks has been found to be greater following intermittent success than after continuous success, which is consistent with well known effects of intermittent reinforcement upon subsequent extinction. For example, Chapin and Dyck (1976; see also Fowler & Peterson, 1981) had elementary school children read aloud sentences simple enough to guarantee continuous success or read a combination of simple sentences and difficult sentences that contained words beyond the children's reading ability. All the children were next asked to read a new set of difficult sentences. The children attempted a greater number of the new sentences following the mixture of success and failure than after success alone.

Recent research indicates that reinforcing various types of increased effort can influence the subsequent performance of other types of reinforced behavior. With rats, for example, requiring a greater lever force or a greater number of lever presses per food presentation increased the subsequent persistence of a running response (see Eisenberger, Carlson, & Frank, 1979; Eisenberger, Carlson, Guile, & Shapiro, 1979; Eisenberger & Masterson, in press; Eisenberger, Masterson, & Lowman, 1982; Eisenberger, Masterson, & Over, 1982; Eisenberger, Terborg, & Carlson, 1979; McCuller, Wong, & Amsel, 1976; Wenrich, Eckman, Moore, & Houston, 1967; Wong & Amsel, 1976). Generalized effects of required high effort have also been found with human populations that ordinarily show low persistence on assigned

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tasks. Depressed psychiatric patients, whose work on a sorting task could produce the approval of a staff psychologist, spent more time and completed more work on that task when they had previously received approval from a ward attendant upon their completions of several custodial tasks than when the attendant's approval had come after the completion of each separate custodial task (Eisenberger, Heerdt, Hamdi, Zimet, & Bruckmeir, 1979). In a second experiment, preadolescent learning-disabled students received reward tokens contingent upon the correct reading and spelling of assigned words. Students for whom an increased number of correct words was necessary to receive points later spent more time working and completed more reinforced work in mathematics and handwriting.

Selective reinforcement of effort also has generalized effects in college students (Boyagian & Nation, 1981; Eisenberger & Leonard, 1980; Eisenberger & Masterson, 1983; Eisenberger, Masterson, & McDermitt, 1982; Eisenberger, McDermitt, Masterson, & Over, 1983; Nation, Cooney, & Gartrell, 1979). For example, students were administered mathematics problems and perceptual identifications with high effort required of one group relative to that required of another group. A control group did not undergo effort training. Next, all students received difficult anagrams. Raising the degree of effort required in the preliminary tasks increased the number of anagrams that the students subsequently solved and increased the time that the students spent working on anagrams they were unable to solve (Eisenberger & Masterson, 1983).

Our interpretation of the preceding findings is that individuals can learn the effort necessary for reward independently of the particular response involved (Eisenberger, Heerdt, Hamdi, Zimet, & Bruckmeir, 1979). Therefore, the degree of energy a person learns to sustain in one task would transfer to another task even if the two tasks involved different response topographies. According to this learned-effort hypothesis, reinforced energy expenditure becomes conditioned in relation to the stimulus situation, and transfers across classes of behavior on the basis of the similarity between the situations. The degree of primary stimulus generalization would depend upon the number of stimulus elements shared between the effort-training situation and the transfer situation. The degree of mediated generalization would depend primarily upon the recall of previously learned verbal labels that incorporate the effort-training task and transfer task into the same category. In educational settings, reinforcement of a student's high effort by a teacher in various tasks may establish that teacher as a cue for generalized high effort on subsequent tasks (Eisenberger, et al., 1983).

Effort may generalize along various dimensions of transfer performance including the force, accuracy, duration, and interresponse time. By performance dimension is meant any behavioral feature that may be scaled ordinally. Generalized effort has been found to appear in two performance dimensions concurrently: (a) Following reinforcement contingent upon increased lever-press force, rats ran more quickly during operant runway shuttling and also paused for shorter durations between successive runs (Eisenberger, Carlson, Guile, & Shapiro, 1979), and (b) with college students, increases in the effort required for the solution of anagrams, mathematics problems, and perceptual identifications produced increases in the length of subsequent essays and in the essay quality per unit length (Eisenberger, Masterson, & McDermitt, 1982).

In appealing to generalization effects, the learned-effort hypothesis predicts that reinforcing increased effort in a given dimension of one class of behavior should subsequently result in more effort in that same dimension of transfer performance than in other dimensions (Logan, 1956, 1960). The present experiment compared the effects of reinforcement contingent upon students' reading accuracy versus speed upon their subsequent accuracy and speed in drawing and story construction. The learned-effort hypothesis predicted that reinforcement of high reading accuracy would result in greater increases in accuracy than in speed of subsequent drawing and story construction. Conversely, reinforcement of high reading speed should increase the speed more than the accuracy of subsequent drawing and story construction.

Which is the more durable, generalized accuracy or generalized speed? Consider the transfer tasks employed in the present experiment—the freehand copying of a detailed picture and the construction of a story from three interrelated pictures. The students' repeated shifts between attending to the supplied pictures and to the partially completed drawing or story afforded feedback concerning accuracy but not concerning speed. The more explicit and frequent feedback for accuracy than for speed in most academic tasks may result in the slower extinction of generalized accuracy than speed. The present experiment provided repeated sessions of transfer performance in order to compare the relative durability of generalized accuracy versus generalized speed of that performance.

Preadolescent learning-disabled students were employed as subjects. Learning-disabled students often score normal or higher on spoken intelligence tests, but their performance in various academic tasks is poor, suggesting both deficiencies in learning processes and deficits resulting from repeated failure. The low academic persistence of such students (Myers & Hammill, 1976) retards the development of learning skills. Thus, an understanding of factors that may increase the generalized academic persistence of learning-disabled students would have practical as well as conceptual significance.

METHOD

Subjects

The subjects were 10 students attending a school for learning-disabled children—the Pilot School, Wilmington, Delaware. Classification of the children as learning disabled by the school was based on a large battery of tests including general intelligence tests, achievement tests, and tests sensitive to specific learning deficiencies. The children ranged in age from 9 to 12 years and lagged academically an average of 2 years.

General Design

The accuracy and speed of story construction and of drawing were examined as functions of prior reinforcement contingent upon reading aloud either accurately or quickly. The various phases of the study are summarized in Table 1.

In pretraining, baseline measures of the accuracy and speed of drawing and story construction were obtained to control for individual differences among the students. Next, to equate training-task difficulty across students, the difficulty of the reading materials was increased or decreased for each child until all the children made similar numbers of errors. In reading training, the children were assigned randomly to three groups and, using a token economy, were given 10 sessions in which reading aloud produced points exchangeable for toys and games. Subjects in the accuracy group received points when they read with fewer errors; those in the speed group received points when they read more quickly; and control-group subjects received points upon completing the reading irrespective of accuracy or speed.

To test for generalized effort, accuracy and speed were measured in drawing and story construction. To assess the durability of generalized-effort effects, each student received two drawing sessions and three story sessions with points given irrespective of accuracy or speed. Each child next received three reading sessions with points given as in the original training of reading. The purpose was to determine whether the absence of reinforcement contingencies based upon high accuracy or speed in the transfer tasks would have generalized effects on reading. In order to determine whether changing the performance dimension correlated with reinforcement of high effort would effect generalized effort, all children

Table 1
Design Summary

Phase	# Sessions	Description
I. Drawing completion baseline	2	Reward irrespective of accuracy or speed
Story construction baseline	3	
II. Reading baseline	3	Difficulty adjusted to produce intermediate number of errors.
III. Reading training	10	Different groups with reward based upon fewer errors, greater speed, or upon simple completion of the task.
IV. Drawing completion test	2	Reward irrespective of accuracy or speed.
Story construction test	3	
V. Reading training	3	Phase III conditions reinstated.
IV. Reading retraining	11	Reward shifted from accuracy to speed or from speed to accuracy. Contingency remained unchanged in group with reward based merely upon task completion.
VII. Drawing completion retest	2	Reward irrespective of accuracy or speed.
Story construction retest	3	

received 11 sessions of reading retraining. Those students who had previously received points on the basis of reading accuracy now received them on the basis of reading speed; conversely, those students for whom rapid reading was previously reinforced now received points based upon accuracy. Students in the control group continued to receive points upon completion of the reading task regardless of accuracy or speed. Finally, the students were retested in two drawing sessions and three story sessions.

Procedures for Selection of Materials

In each reading session, the students received two sets of six unrelated sentences, one set to a page. The specific sentences changed from one session to the next but the reading difficulty remained at each student's previously determined level. In the drawing task, each student was provided with a partially completed line-drawing adjacent to a finished drawing. The finished drawing was used by the child as a reference for completing the partially drawn picture in order to look like the finished one. The drawing used in the first session pictured the front of a house (see Figures 1 and 2), and the drawing for the second session included a butterfly and surrounding foliage. The drawings used in pretraining were also used in test and retest sessions. For story construction, the experimenter placed in front of the student a piece of paper containing a series of three related pictures, and told the student to use all three pictures to make up a story. The first set of pictures concerned ants, the second set involved travel in outer space, and the third set concerned animate fruit. The children's stories were recorded for later analysis, using a concealed cassette recorder. Because the first story generated by a series of pictures might simply be repeated upon subsequent presentations of the pictures, the details of the story pictures differed from pretraining to test and from test to retest. However, to ensure that the baseline measures of story telling would control for pretreatment individual differences in the children's speed and accuracy, the general subject matter of each picture set was retained. For example, in the case of the animate fruit, one picture set concerned a variety of fruits that climb out of their basket

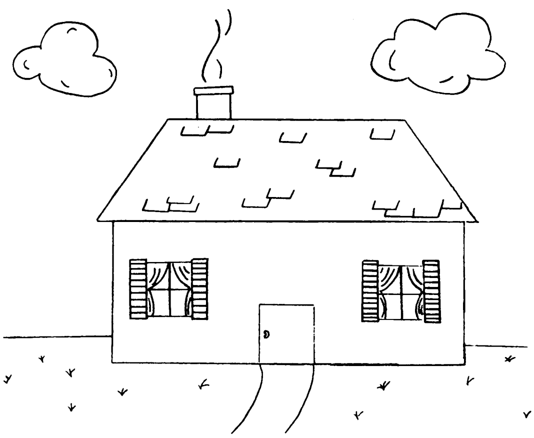

Fig. 1. The completed house picture used in the drawing task.

at night to dance. Another set involved a banana that is first peeled, expresses dismay at the prospect of being eaten, and ultimately is left alone. The third set involved a boy standing on another boy's shoulders to pick

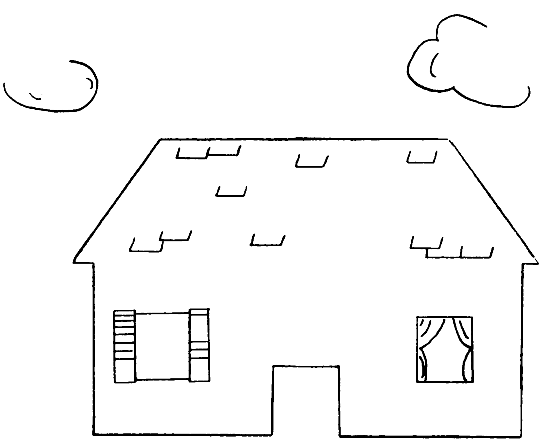

Fig. 2. The partial drawing of the house which the students completed in the drawing task. Each omission or incorrect orientation of the following parts of the picture constituted an error. Each rounded edge of the perimeter of the clouds (4 points) and each curved line inside (3 points), each curved segment of smoke (3 points), each line segment of the chimney (6 points), the bottom of the roof (1 point), each line segment of the shingles (14 points), each line of the drapes (13 points), each line of the windows (8 points), each horizontal line segment of the shutters (33 points), the vertical lines of the shutters (6 points), the bottom line of the door (1 point), each line making up the door handle (2 points), each line constituting the ground leading away from the house (2 points), each line of the path (2 points), and each blade of grass (34 points).

apples from an apple tree. The apples smile and move higher in the tree, only to return once the boys leave. The time taken to complete each experimental task was recorded by a stopwatch located in plain view of the child.

Thus students accumulated points contingent upon reading, drawing, and story construction. The points could be exchanged on any day for toys and games. There were 22 toys and games from which to choose, ranging in price from one to eight dollars and having an exchange value of from one to 28 points. The point value of each item was printed on an attached label. After children received toys, the supply was replenished with additional toys and games.

Specific Procedures

Pretraining

In all phases of the research, the student was seated across a table from the experimenter in an otherwise unoccupied room. There were two baseline drawing sessions and three baseline story-construction sessions, conducted one per day. In the drawing task, the experimenter handed the student two pictures, one of which was a partially completed copy of the other. The experimenter said, "Look at the pictures. I'd like you to take this pencil and complete the unfinished picture so that it looks just like the completed one." The stopwatch was then started. When the drawing was completed, the experimenter stopped the watch, placed the pictures in a folder, and said "Okay, fine." For story construction, the experimenter placed a piece of paper containing the series of three pictures in front of the student and said, "Look at these pictures and make up a story to go with them. Be sure to tell a complete story using all three pictures. When you're done, say 'The end.' You can start whenever you're ready." The experimenter then started the watch. After the student finished, the watch was stopped, the picture page was placed in a folder, and the student was told, "Okay, fine." The use of points as reinforcers was instituted after pretraining.

The reading grade level of each student, based upon the teachers' estimates, determined the difficulty of the student's sentences in the first baseline reading session. The sentences, designated by reading grade level, were taken from books in the Allyn Bacon Reading Series and from the Scott Foresman Reading Series. The sentences differed from one session to the next and were adjusted in grade level of difficulty across sessions until, by the third and final baseline session, each student made a total of from 5 to 10 errors on the six sentences. The minimun of five errors was selected in order that each student would have room for improvement, and the limited error range served to equate task difficulty across the students.

In each session of baseline reading, the student was presented the six sentences on a single sheet of paper, and told, "I'd like you to read these sentences. If you come acŕoss a word you don't know, skip over it." The time taken to complete the reading was measured with the stopwatch. As the student read, the experimenter scanned a copy of the sentences, and recorded errors by drawing a slash through words that the students mispronounced or skipped. A slash was also drawn each time the student added a word that did not appear on the page. Following the final baseline reading session, the students were randomly assigned to the accuracy group (N = 4), the speed group (N = 3), and the control group (N = 3).

Reading Training

The reading-training sessions each involved two successive readings of six sentences. Each sentence presented to a student was new. There were two sessions per week for 5 weeks. Prior to the first session, the students were individually brought to an open cabinet containing the toys and games to be used in the token economy. The students were told:

> These are prizes for which you can trade in points. For instance, this matchbox car [experimenter points to object] can be yours to keep if you save up and trade in 8 points, and this frisbee [experimenter points to object] can be yours if you trade in 20 points. If you want to trade in your points for a prize, then you can start saving again for something else. For instance, you can save up 4 points and get a deck of cards, then start saving up to get 10 points for a puzzle. Each time you use all your points for a prize, you must start saving at zero again. Any questions?

All questions were answered and then the experimenter brought the student over to the desk and, when both were seated, said, "You are going to be able to get points for reading. Each person will get points in a different way. I'd like you to read these sentences. If you come across a word you don't know, skip over it." The purpose of stating that each student would obtain points in a different way was to reduce the influence upon a student's performance of any comments by other students concerning the way in which they earned points.

Next the student was handed the first page containing six sentences, and was told how he or she might obtain points. Students in the accuracy group were told, "Last time you read all the sentences, you made [*X*] number of errors. If you don't make any more than [$X - 1$] number of errors this time, you will receive one point." The numerical value of X was the number of errors made by the student in the last pretraining reading session. Members of the speed group were told, "Last time you read all the sentences, you finished them in [*Y*] number of seconds. If you don't take any longer than [$.86Y$] number of seconds this time, you will receive 1 point." The numberical value of Y was the number of seconds taken by the student in the last baseline session. The value .86 was the average proportional improvement of performance from pretraining required of students in the accuracy group. Thus, students in the accuracy group and in the speed group were required to show the same proportional improvement in performance if they were to obtain points in the first reading session. Students in the control group were told, "If you read all the sentences you will receive 1 point." After the first training session, the students were no longer told how many errors they had made or how many seconds it had taken them to complete the task in the previous session. They were simply told what they were required to do if they were to receive points in the current session.

Each student was informed of his or her cumulative number of points at the beginning of each session. If a student in either the accuracy group or the speed group received a point in only one of the two readings of a session, the performance criterion for earning a point remained the same in the next session. If two points were earned in a session, the criterion was increased as follows. Each accuracy student was required to make one fewer error in a reading than the student's average in the preceding session. Any accuracy student who made no reading errors in a given session was required to maintain this performance in the next session in order to receive points. The speed student was required to read faster than his or her average in the preceding session. If no points were earned in a session, the performance criterion was reduced as follows. The new criterion for students in the accuracy group was the larger number of errors of the two readings performed in the preceding session. The new criterion for students in the speed group was the larger duration of the two readings performed in the preceding session. Each control student received at the end of a session the average number of points earned by members of the other two groups in the previous session, rounded to the nearest whole number. In order to equate the cumulative number of points earned by the three groups, the performance criterion was occasionally increased for the accuracy group or the speed group at a rate slower than indicated above.

Test

Each student was given two drawing sessions and three story sessions conducted as in pretraining, except that the student received points regardless of speed or accuracy. The house picture was used for drawing session 1, and the butterfly picture for drawing session 2. The topics for story sessions 1, 2, and 3, respectively, were ants, outer space, and fruit.

Posttest Reading, Reading Retraining, and Retest

Following the test, each student received three sessions of posttest reading, with points given as in reading training. All students then received 11 sessions of reading retraining conducted as before except that those whose points were previously based upon reading accuracy were now based upon speed, and conversely for the alternate group. Students in the control group continued to receive points irrespective of speed or accuracy. All students continued to be presented with new sentences each session, at the original level of difficulty. In retest, each student was given two drawing sessions and three story sessions conducted as in test.

RESULTS

Reinforcement of high effort in a given performance dimension produced greater generalized effort in that same dimension of transfer performance than in another dimension. Students whose accuracy of reading was reinforced subsequently produced more accurate drawings and stories than children for whom reinforcement was contingent upon high reading speed or upon the mere completion of the reading task. Students for whom high reading speed was reinforced subsequently produced stories more quickly than students for whom reinforcement was contingent upon high reading accuracy or upon reading-task completion. There was a speed/accuracy trade-off in reading so that, for example, the accuracy group made fewer errors than the control group but read more slowly. There was also some evidence of a speed/accuracy trade-off during test, with the accuracy group's reduction of drawing errors balanced by a lessening of drawing speed. Generalized accuracy was much more durable than generalized speed, occurring in all three drawing test sessions and in both story test sessions. This effect continued in lesser degree following a switch of the reinforced reading dimension from accuracy to speed. In contrast, the generalized speed effect died out after two drawing sessions, followed by a temporary decrement in reinforced reading speed.

Reading Training

Individual students are designated by number and group prefix. The accuracy group consisted of students A1 through A4, the speed group S5 through S7, and the control group C8 through C10. Figure 3 gives the reading error rate and speed throughout training for one student from each of the three groups. The students represented in Figure 3 were selected on the bases of similar, intermediate performance levels

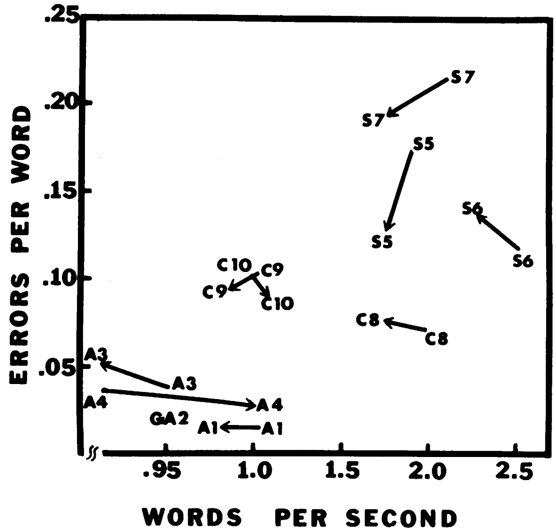

Fig. 4. Reading error rate plotted against speed for each student in the final pretest training session (origin of arrow) and the first posttest training session (end of arrow).

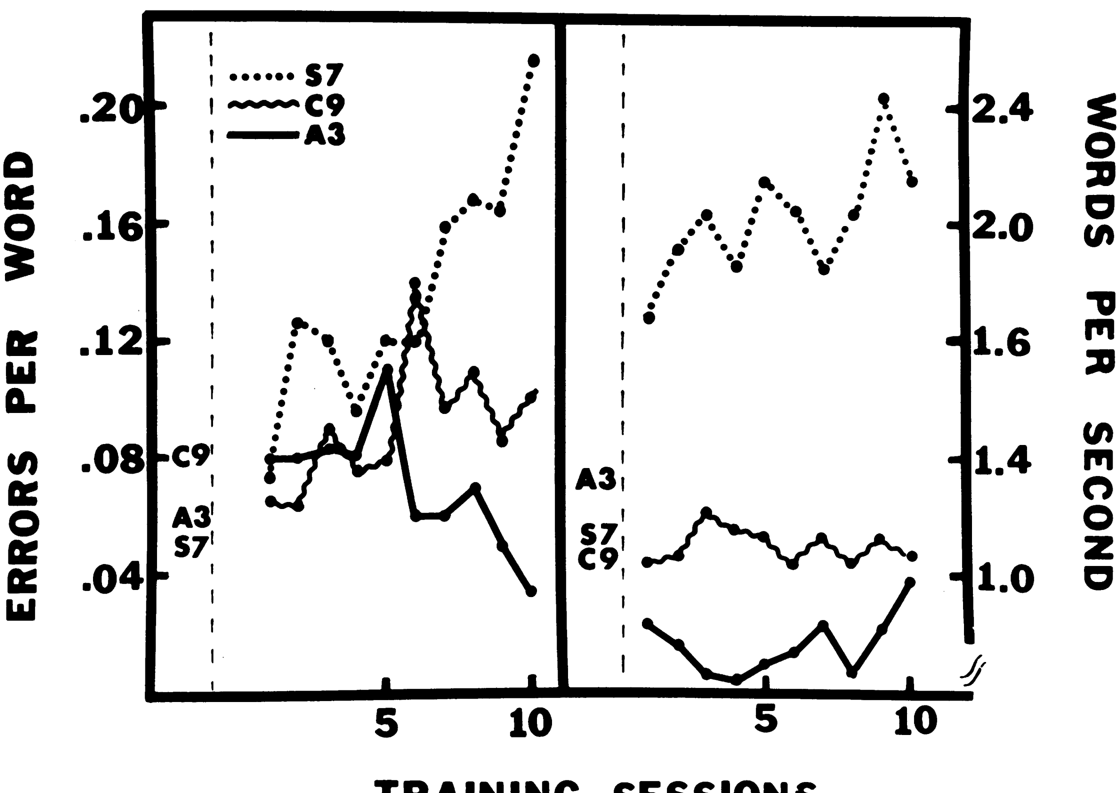

Fig. 3. The average number of errors per word (left panel) and words per second (right panel) in each training session for one student from each group. Students were chosen for their similarity of terminal pretreatment reading performance (left portion of each panel).

during pretraining reading sessions. Figure 3 illustrates that S7 read faster than A3 or C9 throughout training, whereas A3 required six training sessions before consistently making fewer errors than S7 or C9. Further, there was a speed/accuracy trade-off: S7 developed the greatest reading error rate and A3 became the slowest reader. In Figure 4 the origin of each arrow gives the reading error rate and speed for each student in the last training session. All four accuracy students displayed greater accuracy than did the speed students and the control students. All three speed students read faster than did the accuracy students and two of the three control students. A speed/accuracy trade-off is shown by the high error rate among the speed students and by the low speed among the accuracy students.

All statistical tests are two-tailed. The number of reading errors by the three groups did not differ significantly in the last baseline reading session, $F(2, 7) = .95$. The mean number of words read per second by the three groups in the last baseline reading session also did not differ significantly across groups [$F(2, 7) = .86$]. A 3(Groups) x 10(Sessions) x 2(Readings within Sessions) factorial analysis of covariance was carried out on the number of reading errors, with the number of errors in the last pretraining reading session as the covariate. There were significant effects for Groups [$F(2, 6) = 11.5$, $MS_e = .00776$, $p < .01$], Sessions [$F(9, 62) = 3.86$, $MS_e = .000648$, $p < .001$], and the interaction between Groups and Sessions [$F(18, 62) = 7.95$, $p < .001$]. To break down this interaction, simple-effects tests were employed, using the covariate-adjusted means and the appropriate pooled error

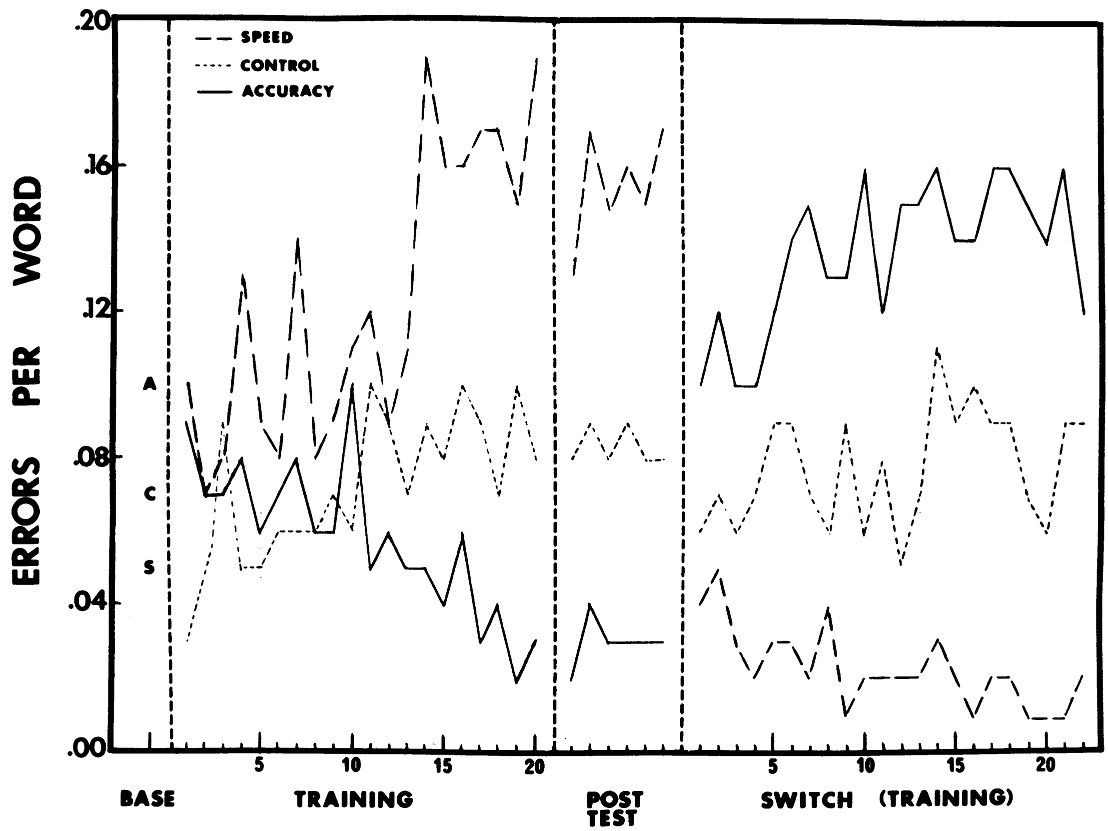

Fig. 5. Mean error rate per reading by the accuracy group, speed group, and control group in Baseline Reading (*BASE*), Reading Training (*TRAINING*), Posttest Reading Training (*POST TEST*), and Reading Retraining (*SWITCH*). There were two readings per session.

term ($MS_e = .00127$). The planned comparisons incorporated Kirk's (1968, pp. 267-268) recommended conservative minimum value of t for cases in which the individual error terms that contribute to the pooled error have different numbers of degrees of freedom. As illustrated in the left panel of Figure 5, in the first reading-training session, the control group made fewer average errors than the speed group ($p < .01$) and did not differ significantly from the accuracy group. By the 10th reading session, the accuracy group made fewer errors than the control group ($p < .01$) which, in turn, made fewer errors than the speed group ($p < .01$).

A similar analysis of reading speeds revealed significant effects for Groups [$F(2, 6) = 17.5$, $MS_e = .644$, $p < .005$], Sessions [$F(9, 62) = 5.17$, $MS_e = .0280$, $p < .001$], and the interaction between Groups and Sessions [$F(18, 62) = 1.90$, $p < .05$]. Planned comparisons, employing the pooled error term ($MS_e = .0819$), were used to break down the interaction. In the first reading session, the speed group and accuracy group did not differ significantly from the control group. As illustrated in the left panel of Figure 6, by the 10th reading session, the speed group read faster than the control group ($p < .01$) which, in turn, read faster than the accuracy group ($p < .05$).

Test Sessions

Accuracy. To determine drawing accuracy, one error was scored for each detail missing from the picture and one error for each detail included that did not exist in the original drawing. The more errors the student made, the higher the error score. The total errors assigned to the drawings of all the students by two judges, who worked independently, were found to correlate highly; $r = .94$ for the

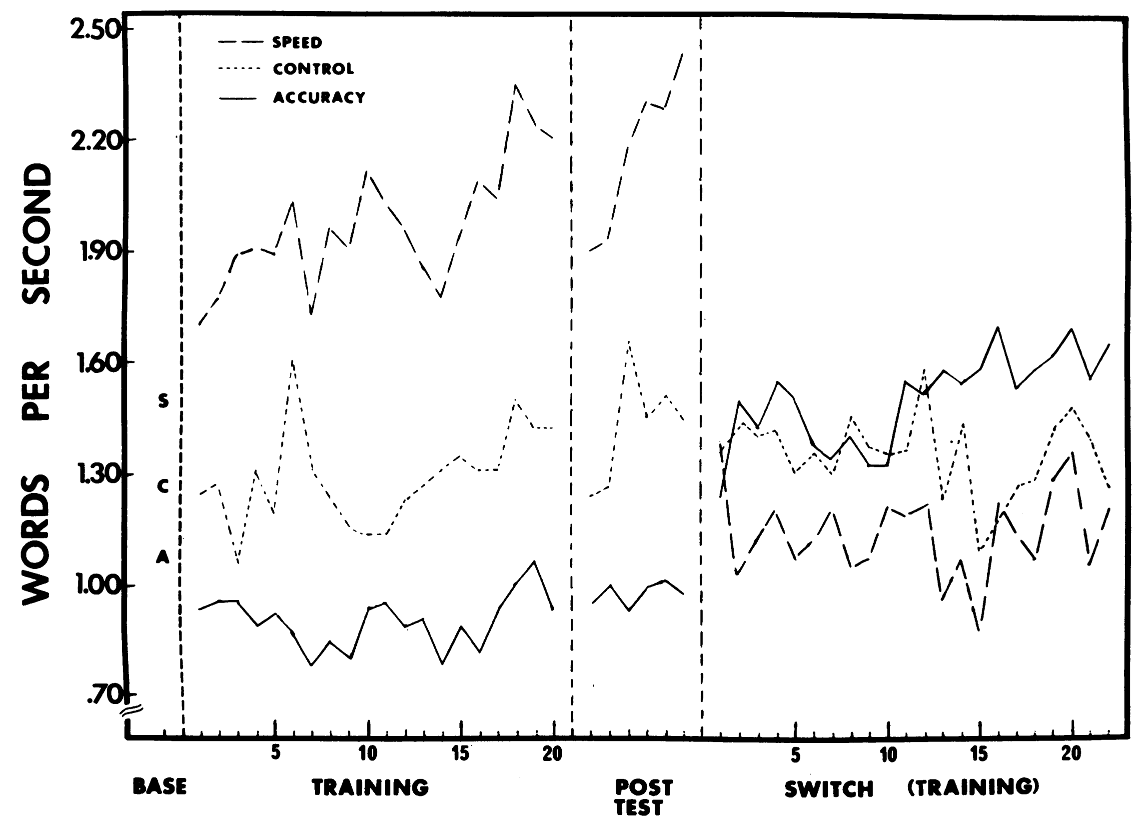

Fig. 6. Mean speed per reading by the accuracy group, speed group, and control group in Baseline Reading (*BASE*), Reading Training (*TRAINING*), Posttest Reading Training (*POST TEST*), and Reading Retraining (*SWITCH*). There were two readings per session.

Table 2
Drawing Error Scores for Each Child in the Accuracy Group, Speed Group, and Control Group

		Drawing Session 1 (House)			*Drawing Session 2 (Butterfly)*		
Group	*Subject #*	*Pretraining*	*Test*	*Retest*	*Pretraining*	*Test*	*Retest*
Accuracy	1	41[a]	12	22	20	14	13
	2	39	32	17	27	18	12
	3	29	6	7	17	13	23
	4	84	42	26	52	23	13
	Mean	48.3	23.0	18.0	29.0	17.0	15.3
Speed	5	42	37	28	27	23	10
	6	52	48	30	10	22	13
	7	49	63	59	30	37	40
	Mean	47.7	49.3	39.0	22.3	27.3	21.0
Control	8	71	62	59	45	40	22
	9	17	54	38	13	13	18
	10	38	48	33	19	28	27
	Mean	42.0	54.7	43.3	25.7	27.0	22.3

[a] The higher the number, the lower the degree of accuracy.

house baseline drawing, and $r = .97$ for the butterfly baseline drawing (Pearson product-moment correlations). The mean error scores did not differ reliably across judges. The list of possible errors used to score the accuracy of the house drawing is given in the caption for Figure 1. Drawing errors in the two pretraining sessions and in the two test sessions are given in Table 2. All four students in the accuracy group markedly decreased their numbers of errors from pretraining to test sessions on each of the two drawings. In contrast, a majority of children in the speed group and in the control group produced roughly the same number of errors or increased their numbers of errors on each drawing.

To control for pretreatment individual differences in accuracy on the first drawing, a one-way analysis of covariance was carried out on the numbers of errors made by the three groups in the first drawing test session, with the number of baseline errors for that drawing as the covariate. A comparable analysis for the second drawing test session used the number of baseline errors for the second drawing as the covariate. The resultant covariate-adjusted scores were employed in a 3(Group) x 2(Sessions) factorial analysis of variance, with Groups as a between-subject factor and Sessions as a within-subject factor. There were statistically significant effects for Groups [$F(2, 7) = 16.2$, $MS_e = 69.2$, $p < .005$], and Test Sessions [$F(1, 7) = 24.8$, $MS_e = 67.6$, $p < .005$]. Planned comparisons indicated that the accuracy group made fewer errors than either the control group or speed group: respectively, $t(7) = 5.10$, $p < .01$, and $t(7) = 4.46$, $p < .01$. The control group did not differ significantly from the speed group, $t(7) = .59$.

To assess story accuracy, several criteria were derived from the *Test of Written Language* (Hammill & Larsen, 1978), and other criteria were added. For example, 5 points were tallied if the story followed logically from the pictures, 4 points if all three pictures were included, 4 points if the story integrated the three pictures, 3 points for each object named, and 2 points for each adjective used to describe any object. The total accuracy scores assigned the stories of all the students by two judges who worked independently were found to correlate as follows for the three respective baseline stories: .93, .92, and .96 (Pearson product-moment correlations). The mean accuracy scores did not differ reliably across judges. Each child's accuracy scores in the three pretraining sessions and three test sessions are given in Table 3. In contrast to the drawing results, the accuracy children generally showed little change in story accuracy from pretraining to test sessions. But the accuracy children did construct more accurate stories in the last two test sessions than did the speed students, as a result of a marked decline of the speed students' accuracy from pretraining to test sessions. The control children also declined in accuracy on at least two of the three stories, although the effects were generally small. The analysis of variance on the covariate-adjusted scores revealed a significant effect only for Groups, $F(2, 7) = 9.40$, $MS_e = 14.3$, $p = < .025$. Planned comparisons indicated a higher average accuracy score by the accuracy group than either the control group or speed group: respectively, $t(7) = 2.62$, $p < .05$, and $t(7) = 4.25$, $p < .01$. The latter two groups did not differ significantly, $t(7) = 1.52$.

Speed. Among the speed students, only S7 drew more rapidly in test sessions than in pretraining, with S5 and S6 showing little change. In contrast, there was a clear decrease of speed by two of the four accuracy students (A3 and A4) and by all three control students. A statistical analysis, comparable to that performed on the accuracy data, was carried out on the number of seconds spent working on the drawings. There was an interaction between Groups and Sessions, $F(2, 7) = 6.79$, $MS_e = 595.7$, $p < .025$. Planned comparisons were used to break down the interaction, employing the appropriate pooled error term ($MS_e = 4289$). As illustrated in Table 4, in the first drawing test session the accuracy group was slower than either the control group or speed group: respectively, $t(7) = 2.83$, $p < .05$; $t(7) = 2.28$, $p = .05$. The latter two groups did not differ significantly, $t(7) = .51$. In the second drawing test session, these differences were no longer reliable: respectively, $t(7) = .96$, and $t(7) = 1.00$.

The speed measure for story construction was the number of seconds from the presentation of the picture series to the student's completion of the story. All three speed students showed sharp increases in story speed, whereas the accuracy children and control children showed smaller, unsystematic changes. The analysis of covariate-adjusted scores revealed significant effects for Trials [$F(2, 14) = 28.0$, $MS_e = 16.2$, $p < .001$] and the interaction between Groups and Trials [$F(4, 14) = 5.88$, $MS_e = 16.2$, $p < .001$]. Each student's speeds

Table 3
Story Accuracy Scores for Each Child in the Accuracy Group, Speed Group, and Control Group

		Story Session 1 (Ants)			*Story Session 2 (Space)*			*Story Session 3 (Fruit)*		
Group	*Subject #*	*Pretraining*	*Test*	*Retest*	*Pretraining*	*Test*	*Retest*	*Pretraining*	*Test*	*Retest*
Accuracy	1	12[a]	11	29	14	17	22	28	24	28
	2	21	19	32	26	33	38	25	26	33
	3	32	30	40	63	32	46	40	38	44
	4	16	19	26	16	21	31	13	11	42
	Mean	20.2	19.8	31.8	29.8	25.8	34.2	26.5	24.8	36.8
Speed	5	33	32	32	51	33	29	43	20	38
	6	12	13	25	15	13	27	22	11	28
	7	17	10	12	18	8	13	14	6	6
	Mean	20.7	18.3	23.0	28.0	18.0	23.0	26.3	12.3	24.0
Control	8	26	16	34	15	13	26	12	14	28
	9	26	22	18	8	16	18	12	11	16
	10	42	39	48	38	27	43	51	34	36
	Mean	31.3	25.7	33.3	20.3	18.7	29.0	25.0	19.7	26.7

[a] The higher the number, the greater the accuracy.

Table 4
Drawing duration (in seconds) for each child in the Accuracy Group, Speed Group, and Control Group.

		Drawing Session 1 (House)			*Drawing Session 2 (Butterfly)*		
Group	*Subject #*	*Pretraining*	*Test*	*Retest*	*Pretraining*	*Test*	*Retest*
Accuracy	1	354	383	343	382	335	360
	2	293	260	272	286	237	244
	3	344	458	403	394	410	418
	4	164	312	236	158	247	240
	Mean	289	353	313	305	307	316
Speed	5	323	339	438	327	345	401
	6	185	233	296	209	207	260
	7	383	152	145	320	185	120
	Mean	297	241	293	285	246	260
Control	8	269	177	303	240	214	277
	9	349	264	278	320	272	250
	10	256	196	255	211	205	265
	Mean	291	212	279	257	230	264

are given in Table 5. Planned comparisons, employing the appropriate pooled error term ($MS_e = 60.8$), were used to break down the interaction. In the first test session, the speed group finished telling the story more quickly than the control group or accuracy group: respectively, $t(7) = 2.64$, $p < .05$, and $t(7) = 2.93$, $p < .05$. The results were similar in the second test session: respective $ts(7) = 2.80$, 2.60, $ps < .05$. However, these effects were no longer statistically significant in the third story session: respective $ts(7) = 1.02$, $.31$.

Posttest Reading

Figure 4 gives the change in each student's reading accuracy and speed from the final pretest training session to the first posttest training session. The only consistent within-group change was the decline of reading speed by all three speed students. The middle panels of Figures 5 and 6 give the group means for the posttest reading sessions. A 3(Groups) x 2(Sessions) x 2(Readings Within Sessions) factorial analysis of variance assessed the change in reading speed from the last reading-training session

Table 5
Story duration (in seconds) for each child in the Accuracy Group, Speed Group, and Control Group.

		Story Session 1 (Ants)			*Story Session 2 (Space)*			*Story Session 3 (Fruit)*		
Group	*Subject #*	*Pretraining*	*Test*	*Retest*	*Pretraining*	*Test*	*Retest*	*Pretraining*	*Test*	*Retest*
Accuracy	1	35	51	22	33	40	55	37	44	26
	2	22	25	27	27	37	52	19	32	26
	3	63	52	26	50	45	23	53	39	19
	4	66	51	25	51	40	33	35	25	27
	Mean	46.5	44.8	25.0	40.3	40.5	40.8	36.0	35.0	24.5
Speed	5	74	56	58	85	70	81	66	53	60
	6	34	19	26	42	23	26	20	23	19
	7	48	19	15	34	17	22	34	16	15
	Mean	52.0	31.3	33.0	53.7	36.7	43.0	40.0	31.3	31.3
Control	8	88	76	40	98	93	64	35	26	18
	9	27	23	6	14	20	8	9	10	5
	10	38	43	38	30	34	42	38	29	25
	Mean	51.0	47.3	28.0	47.3	49.0	38.0	27.3	21.7	16.0

to the first posttest reading session. There were significant effects for Groups [$F(2, 7) = 11.1$, $MS_e = .365$, $p < .01$], Sessions [$F(1, 7) = 13.3$, $MS_e = .0204$, $p < .01$], and the interaction between Groups and Sessions [$F(2, 7) = 4.29$, $p = .05$]. As illustrated in Figure 4, planned comparisons revealed that the speed group underwent a decrement of speed from the last training session to the first posttest training session [$t(7) = 3.99$, $p < .01$], which was reliable even after subtracting the nonsignificant decrement of the control group $t(7) = 2.07$, $p = .07$]. A similar analysis of reading accuracy obtained an effect only for Groups [$F(2, 7) = 26.7$, $MS_e = .00229$, $p < .001$]. As indicated in Figure 5, following test sessions the differences across groups in reading accuracy were simply maintained at the pretest level.

To assess the effects of continued posttest training upon the accuracy of reading, a 3(Group) x 3(Sessions) x 2(Readings Within Sessions) analysis of covariance was carried out, with the number of errors in the last pretraining baseline session as the covariate. There were significant effects for Groups [$F(2, 6) = 64.4$, $MS_e = .00095$, $p < .001$] and Readings [$F(1, 6) = 7.81$, $MS_e = .000410$, $p < .05$]. The large group differences in accuracy established by prior reading training were simply maintained at the same level. A similar analysis of reading speed indicated significant effects for Groups [$F(2, 6) = 11.4$, $MS_e = .225$, $p < .01$], Sessions [$F(2, 14) = 15.7$, $p < .001$], and the interaction between Groups and Sessions [$F(4, 13) = 5.34$, $p < .01$]. Planned comparisons revealed that both the speed group and the control group increased their speeds from the first posttest session to the last posttest session: respectively, $t(13) = 5.27$, $p < .01$, and $t(13) = 2.63$, $p < .05$. The magnitude of the increase of speed was greater by the speed group than by the control group, $t(13) = 2.64$, $p < .05$.

Reading Retraining

Changing the dimension of reading that was the basis for rewarding high effort produced an equivalent change of reading performance. The original group names will be retained in describing the results of the contingency change. For example, the *accuracy* group received points based upon accuracy during reading training and later received points based upon speed during reading retraining. As illustrated in Figure 7, the representative speed student (S7) read accurately during retraining at the expense of speed, and A3 read quickly with many errors. Figure 8 gives the terminal reading speed and accuracy scores for each student during the last retraining session. The three speed students (now receiving points for accuracy) made fewer errors than the control students and accuracy students (now receiving points for speed). Three of the four students now receiving points for speed read faster than the three students who had been switched from speed to accuracy. There was also a speed/accuracy trade-off among a majority of the students, although A1 retained a high accuracy and S6 kept a high speed.

The group means throughout retraining are given in the right panels of Figures 5 and 6. A 3(Groups) x 11(Sessions) x 2(Readings Within Sessions) factorial analysis of covariance on reading accuracy resulted in a significant effect for Groups, $F(2, 6) = 35.3$, $MS_e = .00489$, $p < .01$. Planned comparisons, using the pooled error term ($MS_e = .00121$), indicated that in the first session the speed group and the accuracy group did not differ significantly from the control group. By the 11th session, the speed group made fewer errors than the control group ($p < .01$) which, in turn, made fewer errors than the accuracy group ($p < .05$). A similar analysis of reading speed revealed a significant effect for Groups [$F(2, 6) = 12.3$, $MS_e = .514$, $p < .01$], Sessions [$F(20, 69) = 2.02$, $MS_e = .0381$, $p < .05$], and the interaction between Groups and Sessions [$F(20, 69) = 2.02$, $p < .05$]. Planned comparisons, using the appropriate pooled error term ($MS_e = .07619$), indicated that in the first session the speed group read more slowly than the control group ($p < .01$), whereas the accuracy group did not differ significantly from the control group. By the 11th session,

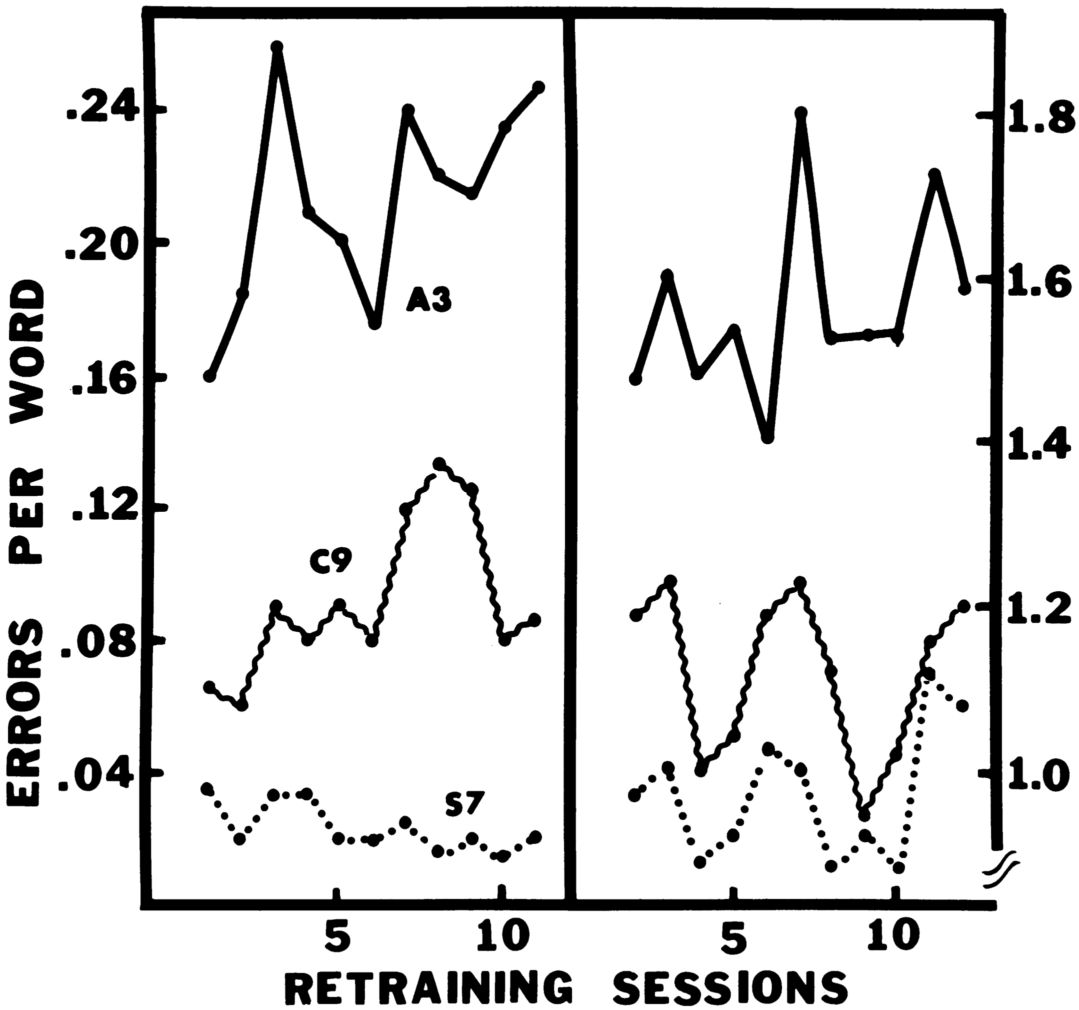

Fig. 7. The average number of errors per word (left panel) and words per second (right panel) in each retraining session for the same students whose training data are given in Figure 3.

the accuracy group had a greater speed than the control group ($p < .01$) which, in turn, had a greater speed than the speed group ($p < .01$).

Retest Sessions

The increased drawing accuracy during test sessions that had resulted from reading-accuracy training also occurred in retest. Thus, the accuracy group's low error rate during test was sustained through reading retraining in which points were contingent upon speed. Table 2 shows that the four accuracy students' numbers of drawing errors did not systematically differ from test to retest sessions. Table 3 demonstrates that the low story accuracy by the speed students during test was largely eliminated in retest. The high speed of drawing and story construction by the speed students in test was no longer present in retest. A 3(Groups) x 2(Sessions) analysis of variance of the covariate-adjusted number of drawing errors indicated significant effects for Sessions [$F(1, 7) = 23.5$, $MS_e = 40.7$, $p < .005$] and the interaction between Groups and Sessions [$F(2, 7) = 4.83$, $MS_e = 4.83$, $p < .05$]. Planned comparisons, using the pooled error term ($MS_e = 103.1$), were used to break down the interaction. In the first drawing session, the accuracy group made fewer errors than either the control group, $t(7) = 3.55$, $p < .01$, or

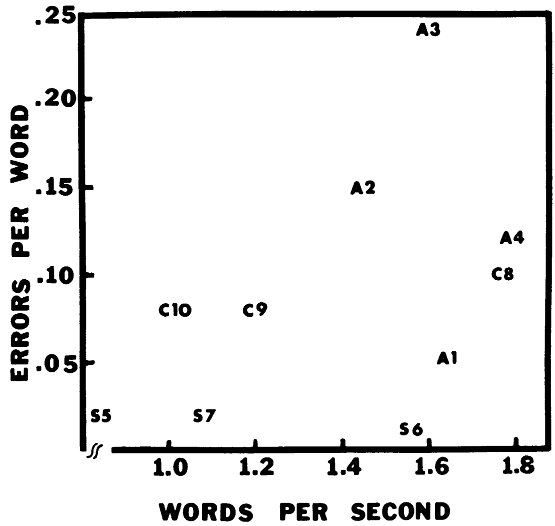

Fig. 8. Reading error rate plotted against speed for each student in the final retraining session.

the speed group, $t(7) = 2.75$, $p < .05$. By the second drawing session, these effects were no longer present: respective $ts(7) = .79, .94$. A 3(Groups) x 3(Sessions) analysis of variance of the covariate-adjusted story-accuracy scores revealed no statistically significant effects. Planned comparisons indicated that, collapsing across stories, the accuracy group had a higher average accuracy score than the speed group, $t(7) = 2.35$, $MS_e = 107.7$, $p = .05$, and no other differences were reliable. Analyses of drawing speed and story speed revealed a significant effect only for story sessions, $F(2, 14) = 11.1$, $MS_e = 63.1$, $p < .005$.

DISCUSSION

Students who received points contingent upon high reading accuracy subsequently produced more accurate drawings and stories than students who received points contingent upon high reading speed or upon mere completion of the reading task. Conversely, students whose points were contingent upon high reading speed subsequently produced stories more quickly than students whose points had been contingent upon high reading accuracy or upon reading-task completion. Thus, reinforcement contingent upon increased effort in a given dimension of behavior in one task channeled effort more into the same dimension of transfer performance than into another dimension. This supports the assumption of the learned-effort hypothesis that individuals learn particular dimensions of effortful task performance when those are reinforced and generalize this learning across tasks (Eisenberger, Heerdt, Hamdi, Zimet, & Bruckmeir, 1979).

It should be noted that although the accuracy group's drawing accuracy increased from pretraining to test sessions, this group showed little change in the accuracy of story construction. However, there was a decrease in story accuracy by the speed group and by the control group. All three groups increased their accuracy from test to retest, with only the accuracy group's retest accuracy surpassing the pretraining level.

There was a speed/accuracy trade-off in reading training. High reading accuracy interfered with speed, and vice versa. As a consequence, the students who received points based upon high reading accuracy received those points when reading slowly, and the students who received points based upon high reading speed received those points when reading accuracy was low. A speed/accuracy trade-off also affected drawing performance: The accuracy students made few errors at the cost of drawing speed. This illustrates that generalized high effort in one performance dimension can result in low effort in an incompatible performance dimension.

Because academic tasks usually provide more frequent and explicit feedback concerning accuracy than speed, generalized accuracy may extinguish at a lesser rate than generalized speed. In this experiment generalized accuracy was, in fact, found to be much more durable than speed. The generalized accuracy effect lasted across all the drawing and story sessions in test, whereas generalized speed no longer occurred in the last drawing session. After test sessions, the students who originally received points for high reading accuracy were effectively trained to read more quickly but less accurately.

The continued high accuracy of drawing and story construction by these students in the subsequent retest sessions further illustrates the greater durability of generalized accuracy than speed.

The occurrence of generalized high accuracy in drawing and story construction did not alter the subsequent reinforced reading accuracy from its already high level. In contrast, the speed group's rate of story construction decreased across sessions relative to the baseline levels, and this was followed by a temporary reduction of reinforced reading speed. The reduced reading speed was not accompanied by any reduction of reading accuracy. Therefore, the extinction of generalized speed in the transfer task led to reduced effort primarily in the same dimension of the training task. In sum, reinforced high effort and extinguished effort in a given performance dimension affected generalized effort more in the same performance dimension than in another performance dimension.

Although the preceding results follow from the learned-effort hypothesis, there are alternative interpretations. Amsel's (1972) general theory of persistence assumes that the failure to readily achieve a goal results in an innate frustration reaction. Frustration initially disrupts performance. But because periodic reward gradually conditions task performance to the cue of frustration, the frustration eventually comes to evoke persistent task performance. The frustration reactions produced by different tasks are assumed by Amsel to have somewhat similar stimulus properties, so that rewarded high effort in one task would reduce the disruptive effects of frustration in subsequent tasks. A related view is that intermittent reward teaches an individual to sustain a general goal orientation ("try strategy") in the presence of frustration (Wong, 1977, 1978, 1979). According to these frustration theories, a student who was accustomed to receiving high grades in, say, mathematics would become upset if the usual amount of study began to produce low math grades. The disruptive effects of frustration would recede if the student were successful following additional math study. This experience would reduce the disruptive effects of frustration in subsequent academic tasks.

The implication of the present findings for the frustration theories is that the reward for high effort in a given performance dimension reduces the disruptive effects of frustration more in that dimension than in other dimensions. This would occur if the stimulus properties of frustration in one performance dimension (e.g., accuracy) were quite different from the stimulus properties of frustration in other performance dimensions (e.g., speed). Then, learning to cope with frustration in a given dimension would reduce the disruptive effects of frustration primarily in the same dimension of subsequent tasks.

The present findings have implications for educational practice. A learning-disabled student may be deficient in the same performance dimension of several academic tasks. For example, a student who performs inaccurately in spelling may also perform inaccurately in math and history. Reinforcement of increased accuracy in spelling should raise accuracy in spelling, math, and history. Some students may be deficient in one performance dimension for several tasks and deficient in a different performance dimension for other tasks. For example, a student who works inaccurately in history and spelling may work too slowly in math and handwriting. The present experiment indicates that generalized high effort in a given performance is correlated with low effort in an incompatible performance dimension. Thus, reinforcement of a combination of increased accuracy and lowered speed in history assignments might help ameliorate the accuracy deficiencies in history and in spelling but, to the extent there is a speed/accuracy trade-off, exacerbate the speed deficiencies in math and handwriting. Because students can learn which dimensions of behavior are correlated with rewards for increased effort, math and handwriting might be protected to some extent from generalized low speed by reinforcing increased speed in math and handwriting.

The absence of frequent and explicit feedback for speed in most academic tasks suggests that in order to ameliorate a student's general speed deficiency, reinforcement contingent upon high speed should be frequently reinstated, and the academic tasks restructered to provide feedback contingent upon greater speed. Finally, the accuracy training employed in reading taught the students to attend more carefully to every word in reading assignments. Future research might investigate the generalized effects of differentially reinforcing behavior identified with greater text comprehension, which is a fundamental component of reading training.

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