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EFFECTS OF INTERVAL PACING ON THE ACQUISITION OF TYPEWRITING SKILL. FINAL REPORT.

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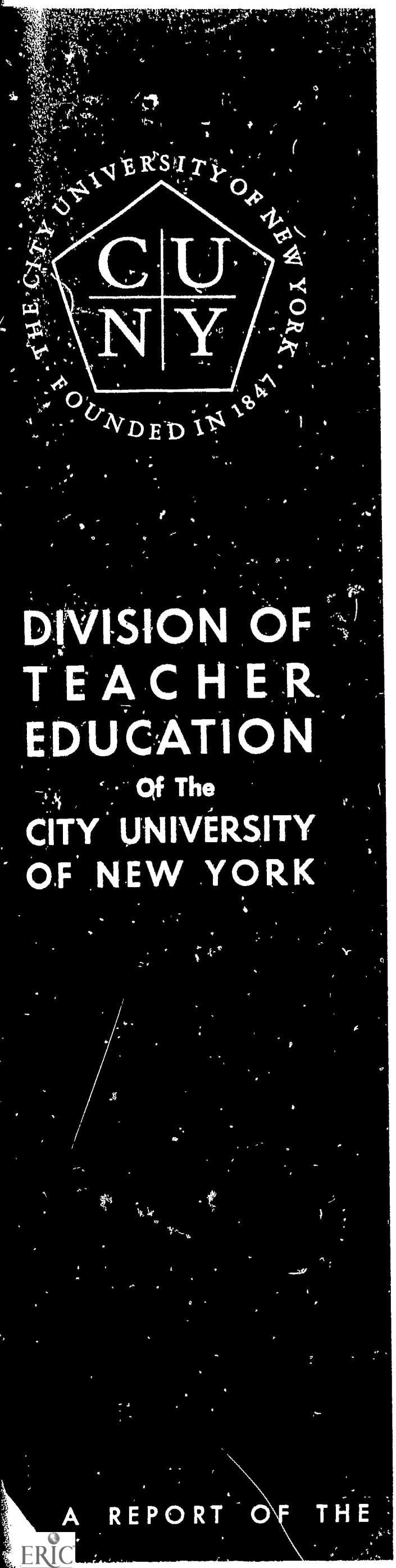
DESCRIPTORS- *TYPEWRITING, *BUSINESS EDUCATION, *SKILL DEVELOPMENT, *INTERVAL PACING, MOTIVATION, *TEACHING METHODS, HIGH SCHOOLS, EDUCATIONAL EXPERIMENTS, COMPARATIVE ANALYSIS,

HIGH SCHOOL TYPISTS AT FOUR STAGES OF TRAINING PARTICIPATED IN AN INVESTIGATION OF THE RELATIVE EFFECTS OF EXTERNALLY-PACED VERSUS SELF-PACED PRACTICE ON SPEED AND ACCURACY IN ORDINARY TYPEWRITER COPY WORK. TWO TEACHERS IN EACH OF FOUR SCHOOLS TAUGHT BOTH AN EXTERNALLY-PACED AND A SELF-PACED CLASS TO A TOTAL OF 120 STUDENTS PER TREATMENT IN 16 CLASSES. A MEAN OF FIFTY 5-MINUTE PRACTICE TRIALS (3 OR 4 A DAY) UNDER EITHER CONDITION WERE CONDUCTED OVER A 4-WEEK PERIOD ON A BODY OF ORDINARY PROSE PARAGRAPHS PROVIDING FOR 5 MINUTES OF PRACTICE AT EVERY EVEN-NUMBERED SPEED FROM 16-76 WORDS PER MINUTE. FOR EXTERNALLY-PACED PRACTICE, COPY WAS MARKED INTERNALLY IN QUARTER-MINUTE INTERVALS, WHICH WERE LOUDLY ANNOUNCED BY THE TEACHER. SUBJECTS WERE TO ADJUST STROKING RATES UPWARD OR DOWNWARD IN ACCORD WITH TIME ANNOUNCEMENTS. SELF-PACED PRACTICE COPY WAS NOT MARKED INTERNALLY, AND THERE WERE NO TIME ANNOUNCEMENTS. SUBJECTS WERE ASSIGNED TO SPEED OR TO ACCURACY TRIALS AT INDIVIDUALLY APPROPRIATE SPEEDS AND PROGRESSED TO HIGHER SPEEDS AND A CHANGED OBJECTIVE (SPEED OR ACCURACY) ACCORDING TO THEIR PRACTICE PERFORMANCE. COVARIANCE ANALYSIS OF POST-TEST SPEED AND ERROR SCORES SHOWED NO SIGNIFICANT TREATMENT DIFFERENCES. HOWEVER, VARIOUS LINES OF EVIDENCE SUGGEST THAT POSSIBLE TREATMENT EFFECTS MAY HAVE BEEN SWAMPED BY THE EXTREMELY DISADVANTAGEOUS AMOUNTS AND DISTRIBUTIONS OF SPEED AND ACCURACY PRACTICE AND PRACTICE RULES APPLIED TO BOTH PACING MODES. INVESTIGATION UNDER MORE ADVANTAGEOUS PRACTICE RULES WAS RECOMMENDED. (THE AUTHOR)



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A REPORT OF THE OFFICE OF RESEARCH AND EVALUATION

Effects of Interval Pacing on the Acquisition of Typewriting Skill

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Leonard J. West

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INTRODUCTION

This investigation was concerned with the acquisition of speed and accuracy in copying ordinary prose materials at the typewriter. Specifically, the objective was to assess the effects on the straight copy proficiency of persons at various levels of typing skill (i.e., students at various stages of typing training) of self-paced versus externally-paced practice.

Pacing refers to governing the response rate, to controlling the number of responses made within a given time or the time interval between responses. A self-paced task is one in which the operator sets his own response rate according to his level of skill and his set for the task, his perception of what he is to try to do. External pacing refers to the imposition from without of some mode of guiding the operator to respond at a specified rate. Illustratively, the orchestra conductor (and the score) determine, among other things, the tempo at which the music is to be played. In typewriting, the pacing may be on a stroke-by-stroke basis (and, if so, it is usually metronomic--equal time intervals between strokes). Or, as in the present investigation, the operator may aim at some specified number of responses within a given time period, without stroke-by-stroke guidance.

The rationale for the selection of pacing as the training procedure for investigation and for the particular modes of implementing that procedure rest on a body of earlier evidence about the several variables that appear to dominate the acquisition of stroking skill at the typewriter. That evidence is briefly discussed under "Related Research." For the present, there is much to suggest that improved training, leading either to higher proficiency in the training time available or to earlier achievement of sufficient typing skill for occupational or personal purposes, can make an important contribution to occupational and personal needs.

The U. S. Office of Education, among many, has pointed to "the constant demand of employers for competent stenographic and other office assistance" (Wright, 1964, p. 3). More specifically, Cook and Lanham, in their massive study of noncollege-bound high school graduates in Detroit (1966), found that about two-fifths of them entered clerical occupations, for which typing skill was overwhelmingly the most common prerequisite. In fact, typing skill was required for 85 per cent of all jobs that were not for the unskilled. In addition, the typewriter has come to be perceived as an ordinary writing tool, as inferred from the substantial demand for personal typing skills. The writer of a business and economics column for a metropolitan newspaper (Porter, 1966) has estimated that 35 million Americans use the typewriter in one fashion or another for one purpose or another, a number that vastly exceeds the 2.3 million employed typists, stenographers, and secretaries reported in the 1960 decennial census (Rutzick and Swerdloff, 1962). The 1966 sales ratio of 7 portable to every 5 standard machines (U.S. Bureau of the Census, 1967) further attests to substantial personal use of the typewriter.

The sheer volume of typewriter use in this country and the occupational demand for office workers who can operate a typewriter point to potentially important benefits from improved training procedures. The keystroking proficiency that is the focus of the present investigation is one of the two major components of typewriting skill. The other is knowledge of matters having to do with the format or arrangement of materials on the page in accordance with the conventions that apply to the typing of letters, tables, reports, and the like. While it is now known that the knowledge components governing format outweigh stroking skill in accounting for proficiency at real-life typing tasks (Muhich, 1967; West, 1960, 1967), keystroking is a component of all typing activities. Accordingly, increased keystroking proficiency should be expected to contribute to skill at realistic typing activities. In addition, insofar as most typing employment tests tend, unfortunately, to measure "straight copy" proficiency alone (Anderson and Pullis, 1965), greater skill at that task can be expected to furnish a larger supply of competent typists whose readiness for employment is assessed in that way.

Pacing as a Training Procedure

Pacing--the variable investigated here in the context of typewriting--in fact applies to most perceptual-motor skills, of which typewriting is one instance. For skills that include high speeds (response rates) among their objectives, R-R contiguity is a dominating requirement. High speeds mean that each response (R) is brought close in time to the next one; there is less delay or latency between responses. All speed development methods in typewriting and many other skills aim at reduced response latency, increased R-R contiguity. As Rothkopf has pointed out (1960 pp. 319-320): "A most interesting research issue here is how far the carrot should be kept in front of the donkey's nose in order to make him run the fastest for the longest time . . . the relationship between performance, pacing, and learning is at this time one of the most challenging empirical questions for the automation of sensory-motor skills training." Rothkopf was referring to devices that automatically monitor the stimulus display, the rate at which stimuli are presented. The response rate of the learner who attempts to keep up with the stimulus presentation is thereby guided. To express the concept in the terminology of operant conditioning, the response rate is "brought under stimulus control."

Bases for Expected Results. In self-paced work the operator has only a terminal goal. He is given no guidance during the work session, no information as to whether he is responding at the desired rate; there is no feedback, no knowledge of results, until the work session is completed. In addition, in self-paced speed practice aimed at a terminal goal, the operator commonly strives toward the maximum possible rates that create the excessive muscular tensions known to have adverse effects on movements. Similarly, in accuracy practice at a slower rate, he might slow down too much, again using muscular

tensions that have adverse effects. The generalization established by Telford and Swenson (1942, p. 237) is that "There are degrees of muscular tension which are optimal for the performance of particular tasks. Varying the degree of tension in either direction from this optimum results in decreased output." Fitts later stated that "there is an optimum gain or stiffness for any response . . . efforts to produce higher rates may lead to unfavorable muscular tenseness and loss of fine control" (1951, p. 1324). Another feature of accuracy development arises from the hypothesis that stroking accuracy at the typewriter is primarily a function of typing at the right speed. In the absence of guidance for response rates under self-paced work conditions, the typist might slow down too much or not enough.

Under external pacing, on the other hand, the guidance for response rates can be furnished at any desired intervals within the work session; feedback is periodic, so that the operator can make adjustments in his response rate. If the imposed pacing, in both speed and accuracy practice, is at a rate appropriate to the individual, optimal muscular tensions and improved performance should result. These various considerations would support an expectation of superiority for externally-paced over self-paced work.

There are at least two factors that might exert a pull in the opposite direction, leading to an expectation of superiority for self-paced over externally-paced work. One is motivation, which might be superior among self-paced typists for two reasons. First, for them in this investigation, success in meeting the speed criterion in both speed and accuracy trials required typing at least fast enough. In externally-paced practice in this investigation, the requirement was to type just fast enough, not faster. Especially in early trials aimed at readily achievable goals, EP (externally-paced) practice might be more frustrating; the EP typist who overshoots the goal has not succeeded. Second, insofar as some students might be made "nervous" by external pacing (as some students specifically stated) and be unwilling or unable to adjust their stroking rates in response to signals (oral time announcements), motivation again suffers under EP practice rules.

The second factor is "personal tempo," a "natural" rate of speed particular to and preferred by each individual. The typist might resist an imposed rate different from his preferred one. The evidence on the possible existence of personal tempo is conflicting (Lauer, 1935; Wu, 1935), so that the role of that factor in the present experiment is uncertain. However, if that factor is influential, it and motivational factors might be expected to have a negative influence on practice under the imposed rates of external pacing.

The effects of another factor, the known high persistence of a set for speed (Fulton, 1945), are not easily estimated in advance. Practice rules that lead to large amounts of speed practice and large

gains in speed over one's normal, comfortable rate could make the subsequent achievement of accuracy a long, drawn-out affair. In the present investigation, the set for speed applied to both self-paced and externally-paced practice. If the particular amounts and distributions of speed and accuracy practice should differ under the different practice rules for EP and SP practice, the speed-set factor could have a heavier negative influence on the treatment that led to higher ratios of speed to accuracy practice. On the other hand, if these ratios do not differ as between SP and EP practice, then the achievement of an acceptable level of accuracy by either group would depend on whether the practice rules led to an adequate amount of accuracy practice after extensive speed practice. If accuracy practice were insufficient, neither group would achieve acceptable accuracy.

On balance, if the amounts and distributions of speed and accuracy practice that resulted from the practice rules for external pacing are optimal--or, at least, not disadvantageous--the expectation would be for the superiority of externally-paced over self-paced work. The other assumption underlying this expectation is that persuasive explanation by teachers to students of the rationale behind external pacing would overcome the possible motivational difficulties mentioned previously.

Pacing has been investigated in a number of studies that used electromechanical stimulus-display devices to develop stroking skill at the typewriter--sometimes not in optimal ways and at other times on a group rather than on an individual basis (see "Related Research"). Besides, devices are expensive--perhaps prohibitively so if, ideally, there is to be a device for each student. In a certain sense, the present investigation, which used low-cost printed materials, was an attempt to implement the functions carried out by high-cost devices using low-cost printed materials.

Related Research

The related research on keystroking skill at the typewriter bears on the issues of (a) separate versus concurrent development of speed and accuracy, (b) methods and materials for speed and for accuracy practice, whether conducted separately or concurrently, and, especially, (c) electromechanical devices versus conventional modes of conducting skill building practice. The findings on these issues provided the basis for the particular modes of implementing the pacing variable used in the present investigation, and the issues are briefly discussed in turn.

Concurrent versus Separate Speed and Accuracy Practice. The typing textbooks of the two publishers whose sales account for a very large proportion of all typing textbook sales exhibit two opposed rationales: separation of speed from accuracy practice versus concurrent development of higher speeds together with good accuracy. The

latter tactic appears to be in direct conflict with one type of evidence bearing on the issue, namely, speed-error correlations. Dozens of studies, summarized by West (1957, 1962, 1968), show the correlation between stroking speed and number of errors to be essentially zero, i.e., as often positive as negative and, in any case, very low. This is true regardless of stage of training, regardless of training method, and regardless of length of test. Insofar as the essentially zero relationship between speed and errors suggests that the two features of performance are based on different underlying factors, building higher speeds while maintaining good accuracy at the same time (or improving accuracy while maintaining speed) would seem open to question. There have been no classroom comparisons of the two opposed training strategies; the correlational data furnish the only available information on the issue. In any event, the training regimen in the present investigation was based on the correlational data, i.e., it consisted of practice for speed separated from practice for accuracy.

Methods and Materials for Speed and Accuracy Practice. There have been no studies specifically devoted to comparing the effects on typewriting proficiency of various modes of speed building practice. Instead, various amounts and distributions of speed versus accuracy practice have been investigated. In these studies, speed practice characteristically used a verbally-induced set for speed ("try to type faster") and/or involved the setting of speed goals progressively in advance of the trainee's current rate--sometimes with and sometimes without accompanying error limits. The general trend of the findings (summarized by West, 1957, 1962, 1968) supports the superiority of a speed emphasis over an accuracy emphasis. In particular, a study by Kannetz (1955) showed baby-step gains in proficiency when both speed and accuracy practice was done daily, whereas large gains in speed and swift reduction of errors followed from long-term focus on speed before reverting to accuracy practice. The present investigation therefore employed a practice rule that called for substantial gains in speed before switching to accuracy practice.

The research on accuracy development has typically investigated the merits of specially contrived practice materials (finger drills, one-hand words, balanced-movement words, hard words, easy words, et. al.), of metronomic stroking, of repetitive typing of words originally typed incorrectly, and of a verbally-induced set for accuracy carried to the extreme of a goal of "perfect copy." None of these tactics has ever been shown to have the slightest value (West, 1957, 1962, 1968). Instead, as powerfully suggested by Pask's device for training key-punch operators (see Rothkopf, 1960), stroking accuracy appears to be primarily dependent on finding the right speed--presumably one a little below the speed at which errors are excessive. That concept is represented in the typing training materials of at least one major textbook (Lessenberry, Crawford, and Erickson, 1967), which provide for a few trials at a goal 2-4 wpm in advance of one's normal speed at the time, immediately followed by a few trials on the

same copy at a deliberately slower rate, aimed at few errors. Further, the learner is instructed to mark, in advance of typing, the periodic points in the copy that represent typing at the desired rate. The pacing concept is clearly in evidence here, although there has been no research on its merits as implemented in the textbook in question. Further, in the Lessenberry textbook, the practice materials are marked at 2-word intervals in cumulative words, requiring the learner to make pencil marks in the copy representing his particular goals at periodic intervals during the practice timing (e.g., the typist aiming at 24 wpm marks the 6th, 12th, 18th, 24th, 30th . . . word, representing the points in the copy he should have reached at successive quarter-minute intervals of practice). In the present investigation, the practice copy for external pacing was marked in cumulative time intervals in different copy provided at every even-numbered speed from 16 through 76 wpm. The learner needed to do no arithmetic to determine his periodic goals nor to mark his copy in any way; the practice goals were premarked in the copy. The more important distinction between the Lessenberry pacing and that of the present investigation is that in the textbook speed pacing is always done at 2-4 wpm above one's comfortable rate; whereas in the present investigation speed pacing was continued until 8-wpm speed gains were made, before reverting to accuracy practice. In the Lessenberry paced practice, speed pacing is an easy distance above a comfortable rate; in the present experiment, once past the first few trials, speed practice was at rates more and more in advance of comfortable rates. For many students, final practice speeds were about 15 wpm in advance of their entry rates and about 8-10 wpm above their final "comfortable" rates.

Another characteristic of the research and conventional instructional practices bearing on development of speed and accuracy in ordinary copy work at the typewriter concerns individual differences. Conventionally, speed practice or accuracy practice is applied to all persons in a class at any given time. That some persons might more profitably practice for speed than for accuracy, or vice versa, tends to be disregarded. In the present investigation, on the other hand, the practice goals were individualized. Each learner practiced either for speed or for accuracy according to his needs, as inferred from his pretest and subsequent practice performance.

A final feature of conventional instruction is the restriction of practice durations to 1-3 minutes throughout the early months of training. The assumption appears to be that typewriting is a fatiguing task and that endurance is gradually acquired as skill increases. Recent research has shown that assumption to be wholly faulty (West, 1967); there is no reason to restrict practice durations among beginners to just a few minutes--not for reasons of supposed fatigue. Besides, since straight-copy employment tests characteristically involve 5-minute timings, the requirements for maximum positive transfer from practice to test performance demand a match between practice and test durations. Accordingly, in the present investigation all <u>testing</u>

was for 5-minute durations; self-paced practice trials were for 5 minutes and externally-paced practice trials centered around 5 minutes (specifically, they ranged between 4½ and 5½ minutes).

Electro-Mechanical Devices for Typing Skill Development. A number of studies have contrasted the effects on straight copy performance of the use versus nonuse of such devices as (a) the tachistoscope (Palmer, 1955; Winger, 1951), (b) the Skill-Builder Controlled Reader, which is a filmstrip projecter in which a moving slot exposes materials from left to right at rates calibrated in 6-wpm steps (Kline, 1961; Perkins, 1963), and (c) the Strong Pacer, in which the practice copy is hung over the front of the machine while a dial calibrated in 2-wpm steps[1] governs a pointer that drops to a new line, with an audible click, to signal that the preceding line should just have been completed if the typist has performed at the desired stroking rate (Bryson, 1965; Tranquill, 1965). The tachistoscope and Controlled Reader were used as group devices, one per classroom; the Strong Pacer is an individual device, one per student.

The investigators in the tachistocope and Controlled Reader studies rather questionably attributed results to a change in perceptual (reading) habits. The greater S-R and R-R contiguity fostered by rapid stimulus-display rates (i.e., short interstimulus intervals) would seem a more persuasive explanation. In any event, the studies that favored the device (Palmer, Winger, Kline) were badly confounded with variations in practice materials and in some procedural aspects. Perkins, on the other hand, explained his no-difference findings with the observation that the human who can behave like a device can get the same results as a device. Bryson found no differences in his Strong Pacer investigation, while Tranquill's differences in favor of the device were small in size, although statistically significant. Both of these studies used a devastating "perfect copy" rule: you do not proceed to the next higher speed unless the preceding (up to 5-minute) trial is error-free.

The variations in findings accompanying the varying ways in which these devices operate and the varying practice procedures or rules make it apparent that one cannot test a device as a device, or "pacing" as a training tactic independent of the procedures surrounding the practice. Individualized practice is clearly preferable to group practice. The 6-wpm steps built into the Controlled Reader are clearly too large, and better results could be expected from smaller-step calibration. The perfect-copy rule used in the Strong Pacer studies surely led to smaller gains than could have been achieved under more tolerant error standards. These observations are made to explain two of the procedures used in the present

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[1]The most recent model of the Strong Pacer is calibrated in 5-wpm steps--probably an undesirable change from the original 2-wpm calibration.

investigation: (a) practice copy furnished at 2-wpm steps and assigned to each individual according to his skill level and his need for speed or accuracy practice and (b) an allowance of 2 errors per minute during accuracy practice--an error rate that represents mean accuracy among students completing a year of instruction (De Hamer, 1956; Robinson, 1967; Table 10, this report).

Specific Purposes

The major purpose of the present investigation has already been stated: to assess the effects on the straight copy performance of persons at various levels of typing skill of self- versus externally-paced practice. Pacing is the independent variable of this investigation, represented by two treatments: self pacing (SP) and external pacing (EP). It was hypothesized that externally-paced practice would lead to superior speed and accuracy on criterion tests. The major concepts underlying the particular instructional procedures used have been briefly sketched in the preceding discussion of the related literature and are given in detail in the next section on "Method."

An additional and minor purpose was made possible of fulfillment as a byproduct of the availability of test scores for the subjects of this investigation, namely, assessment of the reliability of two modes of scoring straight-copy performance: one of them involving the use of all of each person's performance; the other, using the error-cutoff procedure advocated in the typing textbooks of a major publisher. In the latter procedure, all the typing that follows the n^{th} error is ignored. For example, if five errors is set as a limit all the work from the sixth error onwards is discarded, and the performance is expressed as the number of words per minute typed up to the sixth error.

METHOD

Design

To estimate the effects of teacher variability and to provide a test of treatment effects across the range of skill typically found among trainees, a pair of instructors of classes at each of four stages of training was used. Each instructor taught one SP (self-paced) class and one EP (externally-paced) class, both at the same stage of training. Each training level was represented in a different New York City high school. There were four schools, eight instructors (two in each school), and 16 classes (a pair of classes for each instructor). That is, in school A, two teachers each had a pair of first-semester classes, one EP and one SP class; similarly for schools B, C, and D for second-, third-, and fifth-semester classes. Assignment of treatments to classes within each pair was by toss of a coin. The school's assignment of students to classes was not on bases that could have any biasing effects on the pacing variable. EP and SP pretest scores, for example, did not differ

significantly. First-, third-, and fifth-semester data were collected during the fall, 1966, semester; second-semester data, during the spring, 1967, semester.

Subjects

Classes at the three lower stages of training were drawn from general high schools that included a commercial program; fifth-semester students were from a vocational high school. Initially, there were from 28 to 36 students registered in each fall class. However, there was formidable attrition (30 per cent of registrants) through excessive absence (more than 5 of the approximately 20 practice days) and flagrant failure on the part of many fall-semester students to obey the rules of the practice, as determined by examination of daily practice papers upon completion of the experiment. These factors, combined with a requirement for an equal-N analysis of data, reduced the number of usable subjects in the fall classes to that in the class with the smallest number of usable subjects, namely, 14. The grave difficulties with fall-semester students led to a number of procedural changes for spring-semester classes that greatly reduced the attrition (to 10 per cent of the 20-29 registrants in each class) and that required spring (second-semester) data to be treated separately. The result was an N for fall classes of 14 per class, 28 per teacher, 56 per school (for first-, second-, and fifth-semester classes), 84 per treatment (SP and EP), for a total fall N of 168. For spring classes there was a usable N of 18 per class and therefore 36 per teacher and treatment, for a total spring N of 72. In the 14 classes with more than 14 (or 18) usable subjects, N was reduced to 14 (or 18) by dropping cases at random via assigning numbers serially to all usable subjects in each class and using a table of random numbers to identify discards.

Instructors and Their Training

The eight instructors were all experienced teachers of typewriting whose department chairmen arranged for their participation. The investigator met with these teachers for a 3-hour session during the weekend preceding the beginning of the experiment to brief them on purposes, procedures, record-keeping, et al. They were also furnished with a procedures manual containing all details and occasional verbatim instructions to be read to students. The investigator visited each class on the first and/or second day of instruction, occasionally participating in the instruction by agreement with the teacher. A number of misunderstandings were cleared up, but a number of others apparently were not--to judge from the infractions exhibited in many practice papers. The investigator was in periodic telephone contact with participating teachers during the remaining weeks.

Practice Schedule

The practice schedule in fall classes provided for a maximum of 65 5-minute practice timings (325 minutes) under SP or EP conditions. Student absences led to a mean of 50.7 timings for SP students and 50.3 timings for EP students. The timings were distributed four a day, except on the first two days, over 20 consecutive school days beginning in mid-November (not including a pair of 5-minute criterion tests weekly and interruptions for holidays, midterms, and other special school events).

To maximize the propriety of attributing results entirely to the differential practice, the class period was deliberately preempted by the experimental practice, especially during the first two weeks of the four to five calendar weeks. Teachers complained of a breathless race to cram the required number of timings into the class period and felt, after the fact, that they were unable to give sufficient time to explaining the practice rules and rationale to students or to checking on adherence to the practice rules by students. To remedy those deficiencies and in recognition of students' complaints of boredom at unrelieved practice of a given kind day after day and of extreme fatigue after three or four 5-minute practice sessions each day, greater distribution of practice was used in the spring (second-semester) classes. In the spring, three 5-minute timings were administered on each day, and the practice days were distributed over a mid-February through early May period: 12 days of experimental practice, followed by 5 weeks devoted entirely to "production" activities (business letters and other realistic typing tasks, with no practice aimed at building ordinary copying skills), before returning to a final 10 days of experimental practice. In spring classes, a maximum of 60 5-minute timings (300 minutes) were provided (not including interim criterion tests); absences led to a mean of 50.5 timings for SP students and 49.3 timings for EP students. All told, SP students in fall classes averaged 2 minutes more of experimental practice than EP students. In spring classes, SP students averaged 6 more minutes of experimental practice than EP students. These differences were judged to be of no practical consequence.

Practice Materials

The pacing practice materials consisted of 5 minutes' worth of ordinary prose paragraphs at each even-numbered speed from 16 through 76 wpm. A sample of the materials for externally-paced classes (at 16-, 18-, and 20-wpm) is displayed in Figure 1 on the next page. As shown, for external pacing the materials were marked in quarter-minute intervals. Self-paced classes used the same materials, but without the internal quarter-minute markings.

Another feature of the practice copy is control for difficulty via syllabic intensity--mean number of speech syllables per dictionary word, a commonly used index of "typewritability" of straight copy

16 wpm

To say that someone has learned something is to say that you can count 71
on him nearly every time to make a certain response on a certain occasion-- 147
as a result of practice. The child who gives eight as the sum of five plus 223
three is said to have learned that sum. In the same way, a person who 294
regularly names Rome, when asked to give the capital city of Italy, has 366
learned the capital city of Italy. 400
(1.33)

18 wpm

Before a youngster has learned to add, he can not tell you the sum of 70
four plus three, for example. Afterwards, he can give you the correct 141
sum. We see, therefore, that learning always involves a change in behavior. 218
But not all changes are due to learning. Some, like blinking when a bright 294
light shines in your eyes, are reflex actions. Still other changes are due 370
to growth. Only certain kinds of changes in your responses are due to 441
learning. 450
(1.34)

20 wpm

In the beginning stages of skill you are thinking and typing letter 68
by letter. Soon you find that you can type parts of words, syllables, and 143
short words without thinking of each letter. With each trial you are 213
thinking and typing larger and larger units. 258

To reach the highest point of skill, where whole phrases and sentences 330
seem to flow across your paper, you must push yourself to fresh levels. 402
Whenever you fail to give your whole mind to your work, there is small 473
benefit from your practice. 500
(1.35)

Figure 1. Illustrative Paragraphs for External Pacing

materials--shown in parentheses below the stroke count to the right of the practice copy (Figure 1). For years, it has been assumed that 1.40 is the mean syllabic intensity for the vocabulary of business communication. More recent research (West, 1967) has shown it to be 1.54. In the paced practice materials, difficulty is graded: syllabic intensity progresses in steps of .01 from 1.33 at 16 wpm through 1.40 at 30 wpm to 1.55 at 60 wpm, remaining at 1.55 thereafter.

Practice Procedures and Rules

As applied to the pacing materials, the practice procedures and rules concern (a) initial assignment of each student to speed or to accuracy practice (b) modes of SP and EP pacing, (c) speed and accuracy practice goals, and (d) rules for alternating between speed and accuracy practice.

Initial Practice Assignment. Students were initially assigned either to speed or to accuracy practice on the basis of their pretest performance on a pair of 5-minute timings administered a day or two earlier. Those who made no more than 2 errors per minute (epm) on the pretest began with speed practice on a paragraph 1 or 2 wpm above their pretest gross speeds. Those who made more than 2 epm were assigned to accuracy practice at a paragraph 1 or 2 wpm below their pretest gross speeds. That is, assignments were made to the nearest even-numbered speed above or below their pretest speeds, depending on pretest accuracy.

Modes of Pacing and Duration of Practice Timings. All teachers used stop watches and, in EP classes during the first 2-2½ weeks, loudly announced the passage of each quarter minute ("quarter . . . half . . . three-quarters . . . 1 (minute). . . quarter . . . STOP"). During the final 1-2 weeks, in order to wean students away from the frequent guidance furnished by ¼-minute pacing, time announcements in EP classes were made every half-minute and then every full minute. EP students were directed to adjust their stroking rates in accordance with these time announcements: to slow down when ahead of the corresponding marked point in the copy, to speed up when behind the corresponding marked point in the copy. The objective was to complete the timing within 5 strokes (one word) on either side of the appropriate point in the copy. Because the student who knows in advance how long the timing is to be can readily misbehave, timing duration in EP classes varied between 4½ and 5½ minutes and was not announced beforehand by the teacher. A typical daily series (averaging 5 minutes) might be 5, 4½, 5¼, 5¼ or 5¼, 4¾, 5. For practice timings longer than 5 minutes, the student started again at the beginning of his assigned paragraph.

In SP classes, on the other hand, there was no mediating announcement of time intervals, and copy was, of course, not marked internally. For SP students, all practice timings were for 5 minutes.

Speed and Accuracy Practice Rules. During speed practice, the SP rule was: "If you complete the paragraph within the 5 minutes--regardless of errors--proceed in the next practice timing to the next longer (2 wpm faster) paragraph; otherwise, repeat the same paragraph in the next practice timing. You move ahead if and only if you complete the paragraph."

In EP classes, the speed rule was: "If you come within 5 strokes on either side of the appropriate marked point in the copy when STOP is called--regardless of errors--proceed in the next timing to the next longer (2 wpm faster) paragraph. If you are more than 5 strokes away (in either direction) from the proper point in the copy, repeat the same practice copy in the next timing." Although EP students complained during the early trials, about not being allowed to progress to the next faster paragraph when they had more than reached the speed goal of the earlier paragraph, it was explained to them that their real objective was to type at a particular rate--neither faster nor slower. The substantive issue that is at stake here is that permitting students to advance when they had typed too fast would not have constituted a test of pacing--of the effects on criterion performance of being required to type just at a specified rate.

Accuracy practice required subjects to meet the dual criteria of typing at the appropriate speed (2 wpm below their previously achieved speed) plus making no more than 2 errors per minute of work. In SP classes, up to 10 errors were allowed in each 5-minute timing. In EP classes, 10 errors were allowed for timings of $4\frac{3}{4}$, 5, and $5\frac{1}{4}$ minutes, 9 errors in $4\frac{1}{2}$-minute timings, and 11 errors in $5\frac{1}{2}$-minute timings. These error standards were tightened during the final week of experimental practice to an allowance, for SP and EP students, of 9 and then 8 errors in 5 minutes of work. Throughout, teachers in EP classes announced the maximum error allowance and the duration of each timing immediately after each timing was completed.

In summary, "success" in speed practice consisted of completing the paragraph (SP) or coming within one word of the appropriate point in the copy (EP). "Success" at accuracy practice involved the same speed criteria plus not exceeding 2 epm. The EP rules make it apparent that the student who suffers some gross interruption (such as jammed typebars) has little chance of meeting the speed criterion during that timing. In such instances, students were instructed to untangle (or otherwise take care of) whatever the difficulty may have been, to wait until the next quarter-minute time announcement, and to continue typing at the corresponding point in the copy. Such efforts, however, were not to be counted as successes because a portion of the copy had been omitted. The intent was merely to preclude sitting idly for minutes because of a gross interruption earlier in the work.

Alternating Between Speed and Accuracy Practice. In accordance with the concept of substantial gains in speed before changing to accuracy practice, a speed gain of 8 wpm (in 2-wpm increments) had to be achieved before changing to accuracy practice--at a rate 2 wpm below the highest successful speed-practice rate. Thus, a student whose pretest speed was 18 wpm and whose errors did not exceed 2 epm began with speed practice at 20 wpm and continued with speed practice until he succeeded at 26 wpm; he then shifted to accuracy practice at 24 wpm. As soon as he could type at the desired 24-wpm speed with no more than 2 epm, he returned to speed practice at 28 wpm, continuing with it until 34 wpm (8 wpm above his previously achieved 26 wpm rate) before again returning to accuracy practice at 32 wpm. The rule for speed, then accuracy, practice was: "Up 8, down 2" or "up 6, down 2" if one counts from the first new practice speed rather than from the previously achieved speed. However, mostly because teachers were disturbed by the increase in errors shown in earlier tests, the final few days of experimental practice imposed accuracy-practice rules on all students. Success at a practice paragraph was followed by accuracy practice at the paragraph at the next higher speed.

Infractions of Practice Rules. Among the various possible ways to disobey the practice rules (e.g., failing to change from one practice emphasis to the other when the criteria for change has been met, changing practice emphases when the criteria for change had not been met, changing in steps or more than 2 wpm), probably the most consequential and clearly the most frequent infraction was changing from accuracy to speed practice even though more than the allowed number of errors had been made. The result of that infraction was less accuracy practice than was called for by the rules, inevitably leading to high inaccuracy on criterion tests. When that and other consequential infractions exceeded ten in number (about one-fifth of the average of about 50 practice timings), the student was dropped as a participant in the experiment. Discarding of such students was on the basis of examination of daily practice papers by the investigator upon completion of the experimental practice. So far as the student and his teacher were aware during the experimental practice, the student was a participant.

The greatly lower attrition in spring classes (to 10 per cent from 30 per cent) probably resulted from two procedures unfortunately not used in the preceding fall classes: (a) arrangements for inspection of practice papers on a daily basis by teachers and student assistants, permitting immediate correction of misbehavior the next day and (b) furnishing each spring student with a 1-page record form on which he entered the speed and objective of each of his practice timings, thereby permitting student and teacher to monitor behavior more closely. A graphic display of criterion test mean speeds and errors week by week was also posted on the bulletin board.

Criterion Measures

Eight ordinary prose selections of 325 to 365 words each, each at syllabic intensity 1.40 for every consecutive 100 dictionary words, were used for testing. A pair of 5-minute timings was used on each testing occasion. Two of the eight pieces of test copy were used as pre- and posttests. The other six were used two a week during the experimental practice program. In the spring classes, the 5-week interval of "production" practice between the two segments of experimental practice was followed by an "interim" administration of the pretest copy. All test papers were scored by the investigator and his staff within 48 hours and test scores were returned to teachers for posting on the class bulletin board.

To provide an informal comparison of the relative effects on criterion performance of paced practice (SP and EP) versus more conventional instructional modes (whatever they may have consisted of in the classes of several teachers), several classes not involved in the experiment were also posttested or both pre- and posttested. Reactions to the pacing practice were also solicited from second-semester students in the form of a brief, unsigned letter addressed by the student to his teacher.

Data Analysis

Scoring was for gross wpm and number of errors in 10 minutes (sum of two 5-minute timings). Speed and error scores were subjected to analysis of covariance, with posttest scores regressed on pretest scores. The analytical model provided for measures of treatment by level and treatment by instructor interaction, as well as for treatment effects. For the ancillary purpose of estimating the relative reliability of scores under conventional versus error-cutoff scoring procedures, reliability coefficients for performance on the two 5-minute pretest timings were computed for each of the two scoring methods.

RESULTS

Results and preliminary discussion are presented in turn for (a) criterion scores, (b) analyses of adjusted posttest scores, (c) practice gains, (d) student reactions, and (e) reliability of two scoring methods.

Criterion Scores

Mean words per minute on the pairs of 5-minute criterion timings administered periodically through the calendar period of the experiment are displayed in Table 1 on the next page. With a few exceptions, gains were registered for all classes weekly, but they are modest in size. More pertinently, there do not appear to be any consequential performance differences between self-paced and externally-paced classes.

Table 1

Mean Words Per Minute on Pairs of 5-Minute Criterion Timings
By Self-Paced and Externally-Paced Classes
(By Semester of Training)

Test[a]	Self Paced					Externally Paced				
	Semester of Training					Semester of Training				
	1	3	5	1, 3, & 5	2	1	3	5	1, 3, & 5	2
Pretest	17.7	36.3	42.9	32.3	29.1	17.8	34.9	43.3	32.0	30.1
Week 1	20.8	37.0	45.1	33.7	30.7	20.6	37.9	44.4	33.2	31.8
Week 2	21.7	40.2	45.1	35.7	30.4	22.5	38.1	46.8	36.0	32.7
Interim					34.1					35.7
Week 3	24.9	40.0	47.2	37.4	34.5	25.1	38.0	48.6	37.1	35.5
Posttest	24.6	41.0	46.3	37.3	35.8	23.9	37.8	47.2	36.3	36.6
Gain[b]	6.9	4.7	3.4	5.0	6.7	6.1	2.9	3.9	4.3	6.5

Note.--Ns of 28 per level for 1st-, 3rd- and 5th-semester classes on pre- and posttests and of 25-26 per level on intervening tests (with the exception of Ns of 12 and 13 in Week 1 tests in 3rd-semester classes). Ns of 36 on 2nd-semester pre- and posttests and of 33-36 on intervening tests. All Ns given here are per treatment (EP and SP).

[a]In fall classes (Semesters 1, 3, and 5), Week-1 testing followed 70 minutes of earlier paced practice (14 5-minute timings); 85 minutes of practice (17 5-minute timings) intervened between each succeeding weekly test. In spring classes (Semester 2), Week-1 testing followed 75 minutes of practice (15 5-minute timings); 80 minutes of practice (16 5-minute timings) were used in Weeks 2 and 3, and 65 minutes of practice (13 5-minute timings) were conducted in Week 4. Between Weeks 2 and 3 in the spring classes, there was a 5-week interval devoted entirely to production typing (no pacing or other ordinary copy practice). The "interim" test was given to spring classes just before resumption of pacing practice after the 5-week interlude of other practice.

[b]Gains are posttest minus pretest means.

Total-error means for the sum of two 5-minute criterion timings administered periodically are displayed in Table 2, below. Large increases in errors for the first-, third-, and fifth-semester classes (from pre- to posttest) are apparent. The modifications in procedures for spring (second-semester) classes apparently permitted teachers to exercise much greater control over student practice behavior (i.e., great reduction in misbehavior), leading to a small absolute increase in errors on criterion tests that in fact represents a small improvement in relative accuracy of about 1½ words typed per error. Even so, there do not appear to be any consequential intertreatment differences.

Table 2

Total-Error Means on Pairs of 5-Minute Criterion Timings by Self-Paced and Externally-Paced Classes[a]

(By Semester of Training)

Test	Self Paced Semester of Training					Externally Paced Semester of Training				
	1	3	5	1, 3, & 5	2	1	3	5	1, 3, & 5	2
Pretest	11.7	16.7	26.1	18.2	20.1	11.8	21.4	24.9	19.3	22.8
Week 1	16.1	25.7	43.3	29.0	22.3	15.6	35.2	26.9	23.8	23.4
Week 2	16.7	32.0	43.9	30.9	23.4	15.9	40.3	44.0	33.6	26.4
Interim					25.3					22.6
Week 3	21.0	37.4	49.0	35.8	19.9	20.8	45.3	45.1	36.9	24.8
Posttest	20.2	37.8	41.9	33.3	22.6	21.8	37.3	40.9	33.3	24.8
Increase[b]	8.5	21.1	15.8	15.1	2.5	10.0	15.9	16.0	14.0	2.0

[a]The Note and footnote a of Table 1 apply also to Table 2.

[b]Increases are posttest minus pretest means.

To provide an informal assessment of the effects of paced practice in relation to conventional modes of training, performance scores for control classes were also collected. These control classes in each school, taught by a number of different teachers, had not been participants in the experiment but were at the same stage of training as the SP and EP classes in that school. Second-semester classes were both pre- and posttested on the same days as were the participating classes; in the other three schools, only posttest scores were available. With a few exceptions, larger speed gains or higher terminal speeds were found on the average in these control classes than in

the combined SP and EP classes. Accuracy was uniformly better in these control classes than in the combined EP and SP classes. Paced practice of either kind did not even lead to any Hawthorne effect. While no information is available on the training methods and materials used in these control classes, some speculations about probable differences between them and the paced classes are discussed later in this report.

Intratreatment Differences. The extent of intratreatment variations, presumably attributable in some part at least to varying success on the part of teachers in explaining the practice rules to students and monitoring practice behavior, is evident in the class-by-class means shown in Tables 3 (speed) and 4 (errors) on pages 19 and 20. For both speed and errors, at three of the four levels of training, difference scores are in one direction for one teacher and in the other direction for the other teacher at that level.

Despite the reversals in the direction of treatment differences between the pair of teachers at each training level shown in Tables 3 and 4, it may be noted that in all classes except those at Level 2 the treatment with the larger gain in speed also shows the larger increase in errors from pretest to posttest. Apparently, the greater gain in speed was at the price of poorer accuracy.

Analyses of Adjusted Posttest Scores

Analyses of covariance for adjusted posttest scores (regressed on pretest scores) for (a) second-semester classes and for (b) first-, third-, and fifth-semester classes formally corroborate the absence of significant treatments effects implicit in the closely comparable treatment means exhibited in Tables 1 and 2. The results of second-semester analyses are shown in Table 5, page 21; of the other three levels, in Tables 6 and 7, page 21.

Despite the intratreatment variations displayed in Tables 3 and 4, Tables 5, 6, and 7 show that these were not sufficient to lead to significant interaction between treatments and levels or between treatments and instructors. The treatments had equal effects at all skill levels, and variation in teacher and student behaviors were too small to suggest insufficient uniformity among teachers in their handling of the two treatments.

Practice Gains

On the question of possible differences in practice gains between the two pacing modes, again there were no clear differences. For each student, his entry speed (in wpm) was subtracted from the speed of his fastest successful practice trial. At Level 1 (first-semester classes) the mean gains were: SP = 13.9, EP = 12.2; at Level 2 SP = 13.2, EP = 14.3; at Level 3 SP = 14.6, EP = 13.4; at Level 5 SP = 11.2, EP = 10.4. Although SP practice gains exceeded

Table 3

Pre- and Posttest Speed Means and Standard Deviations in Eight Self-Paced and Eight Externally-Paced Classes (By Level and Teacher)

Level (By Teacher)	Self Paced						Externally Paced					
	Pretest		Posttest		Difference (Posttest - Pretest)		Pretest		Posttest		Difference (Posttest - Pretest)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Level 1												
Teacher A	15.8	4.8	23.6	4.4	7.8	- .4	16.3	6.2	21.3	7.0	5.0	.8
B	19.5	7.4	25.7	8.0	6.2	.6	19.3	10.2	26.6	11.2	7.3	1.0
A + B	17.7	6.4	24.6	6.5	6.9	.1	17.8	8.4	23.9	9.5	6.1	1.1
Level 2												
Teacher C	27.3	4.3	34.1	4.6	6.8	.3	30.4	6.2	37.4	6.3	7.0	.1
D	30.9	7.2	37.4	5.5	6.5	-1.7	29.8	9.4	35.7	7.6	5.9	-1.8
C + D	29.1	6.1	35.8	5.3	6.7	- .8	30.1	7.8	36.6	6.9	6.5	- .9
Level 3												
Teacher E	38.9	5.6	45.0	4.7	6.1	- .9	33.3	5.5	38.3	5.8	5.0	.3
F	30.9	7.2	37.0	6.1	6.1	-1.1	36.4	7.2	37.3	7.8	.9	.6
E + F	36.3	5.5	41.0	6.7	4.7	1.2	34.9	6.5	37.8	6.8	2.9	.3
Level 5												
Teacher G	42.4	7.6	45.2	7.5	2.8	- .1	43.3	7.0	47.6	6.5	4.3	- .5
H	43.4	8.0	47.3	9.8	3.9	1.8	43.3	3.1	46.8	4.9	3.5	1.8
G + H	42.9	7.7	46.3	8.6	3.4	.9	43.3	5.3	47.2	5.6	3.9	.3
Levels 1, 3, and 5												
All teachers	32.3	12.6	37.3	11.8	5.0	- .8	32.0	12.6	36.3	12.1	4.3	- .5

Note.--At Levels 1, 3, and 5, N = 14 per class and 84 per treatment.
At Level 2, N = 18 per class and 36 per treatment.

Table 4

Pre- and Posttest Error Means and Standard Deviations in Eight Self-Paced and Eight Externally-Paced Classes (By Level and Teacher)

Level (By Teacher)	Self Paced						Externally Paced					
	Pretest		Posttest		Difference (Posttest - Pretest)		Pretest		Posttest		Difference (Posttest - Pretest)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Level 1												
Teacher A	9.8	5.8	17.4	10.0	7.6	4.2	11.0	6.2	18.1	13.1	7.1	6.9
B	13.6	11.4	23.0	14.9	9.4	3.5	12.5	10.5	25.5	19.8	13.0	9.3
A + B	11.7	9.1	20.2	12.8	8.5	3.7	11.8	8.4	21.8	16.9	10.0	8.5
Level 2												
Teacher C	21.4	8.6	23.6	8.3	2.2	- .3	23.8	13.6	22.4	12.2	-1.4	-1.4
D	18.7	11.1	21.6	11.4	2.9	.3	21.8	11.4	27.1	12.8	5.3	1.4
C + D	20.1	9.9	22.6	9.9	1.5	.0	22.8	12.4	24.8	12.6	2.0	.2
Level 3												
Teacher E	18.6	10.4	43.5	23.5	24.9	13.1	22.6	10.5	38.6	19.3	16.0	8.8
F	14.8	11.2	32.1	12.1	17.3	.9	20.1	20.1	36.0	15.9	15.9	-4.2
E + F	16.7	10.8	37.8	19.2	21.1	8.4	21.4	15.8	37.3	17.4	15.9	1.6
Level 5												
Teacher G	26.0	10.3	46.7	25.2	20.7	14.9	22.4	11.6	44.5	22.0	22.1	10.4
H	26.1	15.9	37.1	16.2	11.0	.3	27.4	15.8	37.3	18.9	9.9	3.1
G + H	26.1	13.1	41.9	21.4	15.8	8.3	24.9	13.8	40.9	20.4	16.0	6.6
Levels 1, 3, and 5												
All teachers	18.2	12.6	33.3	20.3	15.1	7.7	19.3	14.1	33.3	19.9	14.0	5.8

Note.--At Levels 1, 3, and 5, N = 14 per class and 84 per treatment.
At Level 2, N = 18 per class and 36 per treatment.

Table 5

Treatment by Instructor Analyses of Covariance for Second-Semester Speed and Error Scores

Source of Variation	df	Speed		Errors	
		MS	F	MS	F
Treatments	1	14.03	< 1	187.70	< 1
Instructors	1	3.60	< 1	223.63	< 1
T x I Interaction	1	206.72	3.135	764.47	1.708
Within	68	65.944		447.719	
Total	71				

Table 6

Treatment by Levels Analyses of Covariance for First-, Third-, and Fifth-Semester Speed and Error Scores

Source of Variation	df	Speed		Errors	
		MS	F	MS	F
Treatments	1	130.592	1.329	28.454	< 1
Levels	2	6291.649	70.450	14837.239	13.526
T x L Interaction	2	155.467	1.582	213.936	< 1
Within	162	98.250		1096.959	
Total	167				

Table 7

Treatment by Instructor Analyses of Covariance for First-, Third-, and Fifth Semester Speed and Error Scores

Source of Variation	df	Speed		Errors	
		MS	F	MS	F
Treatments	1	130.592	1.421	28.454	< 1
Instructors	5	3005.336	32.707	7669.528	7.123
T x I Interaction	5	141.919	1.544	298.040	< 1
Within	156	91.887		1076.742	
Total	167				

EP practice gains (except at Level 2), the differences are trivial and of no practical consequence. On the one hand, then, there is nothing to suggest that the guidance for response rates furnished by external pacing leads to larger gains in stroking rates (during practice trials and regardless of errors) than does self-paced work. In addition, the comparable SP-EP gains in practice speeds suggest that the treatments resulted in comparable strength of the set for speed. In fact, the comparably poor terminal accuracy of both SP and EP subjects strongly suggests that the particular practice rules used (a) did not provide for sufficient accuracy practice and (b) kept the student at speed practice for too long before changing to accuracy practice. These suppositions reinforce the more general point made earlier: that the effects of pacing depend heavily on the distributions of speed and accuracy practice that result from the particular practice rules that are imposed.

Trials to Criterion. On the ancillary question of whether one of the two practice modes leads to earlier achievement of practice goals, mean number of practice trials to reach each successive criterion was computed for the four second-semester classes. (Infractions of practice rules were so numerous at the other three levels of training as to defy an accurate tally.) These means are shown in Table 8 (next page) for the EP and SP classes of the two teachers, individually and combined.

Among other things, the data of Table 8 show that nearly every student gained at least 8 wpm in speed during practice trials, about five-sixths of them gained 10-12 wpm, from two-thirds to three-fourths of all second-semester students gained 14-16 wpm, about one-fifth gained 18-20 wpm, and a small handful gained even more, including one student whose gain was 30 wpm above his entry speed (not shown in Table 8). Of course these performances were replete with stroking errors, but the data do give some indication of the size of gains in stroking rate accruing from sixty 5-minute practice trials--using new copy at each new practice speed.

On the question of whether the guidance for stroking rates furnished by external pacing leads to swifter achievement of practice goals than does self-paced work, the data of the bottom row of Table 8 are pertinent. The S entries represent a larger number of "trials to success" on the part of self-paced typists. It may be seen that the first gains of 2-4 wpm above entry speeds require more (or as many) trials by EP typists as by SP typists. Examination of practice papers for these early trials showed that EP typists were routinely exceeding the speed goal by more than 5 strokes (1 word). Thus, a performance that was counted a success for an SP typist was not a success for an EP typist. Thereafter (from 6 wpm gains over entry speeds onward), 8 of the 9 successive speed steps or goals required more trials by SP than by EP typists. By sign test for that 8-out-of-9 datum, $z = 2.33$, for which $p < .02$ (2-tailed). Accordingly, it may

Table 8

Mean Number of Trials for Success at Accuracy Practice and at each 2-wpm Increment in Speed Under Self-Paced and Externally-Paced Practice Conditions (For Level-2 Teachers, Individually and Combined)

Teacher and Treatment	Accuracy	Gain Over Entry Speed				Accuracy	Gain Over Entry Speed				Accuracy	Gain Over Entry Speed				Accuracy
		2	4	6	8		10	12	14	16		18	20	22	24	
Teacher A																
EP	3.9	4.1	2.6	2.8	3.1	10.6	3.1	3.1	3.6	3.3	13.7	3.0	8.0	1.0	-	16.4
SP	3.0	2.2	2.3	2.9	4.1	12.8	4.5	4.0	4.0	6.2	11.3	3.2	8.0	-	-	11.8
Teacher B																
EP	8.0	2.9	2.1	2.5	3.4	8.0	3.4	2.6	3.2	4.0	12.4	3.3	2.3	2.5	3.0	12.4
SP	7.5	1.8	2.4	3.1	4.2	14.6	2.9	5.9	3.2	4.1	13.7	2.7	6.0	4.0	-	12.0
Both Teachers																
N (EP)	15	34	34	35	33	36	31	30	27	21	33	8	8	5	3	12
EP	5.5[b]	3.5	2.4	2.7	3.2	9.3	3.0	2.9	3.4	3.7	13.0	3.2	3.8	2.2	3.0	14.1
SP	6.3[b]	2.0	2.4	3.0	4.1	13.7	3.7	4.9	3.5	5.3	12.5	3.0	7.0	4.0	-	11.9
N (SP)	8	35	34	36	34	34	30	30	24	15	31	7	2	1	-	7
Higher Mean[a]	S	E	S=E	S	S	S	S	S	S	S	E	E	S	S	-	E

[a]S = Self Paced, E = Externally Paced (for Both Teachers Combined).

[b]Of the 72 subjects in the four classes, 23 began with accuracy practice, the others with speed practice. The higher SP mean for the teachers combined, despite the higher EP mean for the individual teachers, results from EP and SP Ns of 9 and 2 for Teacher A and from EP and SP Ns of 6 and 6 for Teacher B.

be concluded that once past the earlier trials toward goals little in advance of entry speeds--during which externally-paced typists tend to overshoot the goals--external pacing leads to the earlier achievement of each new speed goal than does self-paced practice. (The four segments of accuracy practice furnish too small a sample and, at the end, too small an N, to permit a generalization on the relative effects of self- and external-pacing on number of trials required to reach accuracy goals.)

Student Reactions

Upon completing the posttest timings, students in the four second-semester classes were invited to express their reactions to the paced practice in the form of a brief, unsigned letter to their teacher, composed at the typewriter in class on that day. Student reactions ran the gamut from extreme enjoyment of through extreme displeasure at the paced practice. Some EP students confessed to annoyance at the inability to follow the teacher's periodic time announcements. For them, it may be that meeting the success criterion was fortuitous rather than a consequence of the external pacing. Many EP and SP students expressed frustration at the large number of repetitive trials they needed for success during accuracy practice and at speeds well in advance of their entry speeds. Many reported gratification at substantial speed gains (during practice trials), but pointed to lack of success in improving or even maintaining accuracy. Extreme fatigue ("I thought my wrists would fall off") was complained of by numbers of students in both EP and SP classes. Boredom at day-after-day practice of the same kind was often reported, and greater distribution of practice (fewer trials per class period on fewer days per week) was frequently recommended. Whether potentially better motivation through greater distribution would have permitted an unconfounded test of the pacing variable is, of course, a nice question; sufficient experimental control over nonpaced practice activities would probably be very difficult of achievement, and interaction between paced and nonpaced practice probably could not be assessed.

Some of the student comments point to an unsuspected by-product of the practice. A surprising number of hitherto sight typists claimed that the striving for speed goals during pacing turned them into touch typists. Insofar as "response competition" is invoked here--there is no time to look back and forth between copy and machine when your stroking is being rushed--speed forcing recommends itself as a primary tactic for disrupting sight methods when they have outlived their usefulness. That any sort of practice at that (early second-semester) stage of training might have had the same result is, of course, possible. However, the frequency with which students reported that they "didn't have time to look" lends strong support to the "response competition" hypothesis. Finally, one student reported that he was the only one in his history class who knew of Copernicus--because of his frequent trials at a piece of paced-practice copy dealing with the Copernican revolution in astronomy.

Reliability of Two Scoring Methods

Turning, finally, to results on the minor objective of this investigation--comparison of the reliability of error-cutoff (ECO) scoring procedures versus conventional speed scoring--scores on the two pretest timings that preceded the beginning of paced practice were correlated under both scoring schemes for the 495 subjects in this investigation who were pretested. According to the protagonists of ECO scoring (Rowe, Lloyd, and Winger, 1967), as amount of training increases from one through four semesters, the maximum allowed errors (in 5 minutes) decreases from 5 to 2. The fourth-semester typist computes his speed as number of words per minute typed up to the point of the third error. Since, with ECO scoring, the score is "wpm up to the n^{th} error," the correlations are for that measure; ECO scoring does not provide for any measure of errors. Conventional speed scoring, on the other hand, uses all the words typed and results in "gross wpm." Correlations were computed for the various ECO allowances, for an allowance of 5 errors at all stages of training, and for gross wpm, with results as shown in Table 9.

Table 9

Reliability Coefficients for Speed Under Various Error-Cutoff Allowances and for Gross Speed

(For 5-Minute Timings, by Semester)

Semester of Training	N	Under Error Allowances of 2	3	4	5	Gross
1	125				.706	.970
2	113			.656	.622	.968
3	126		.340		.431	.903
5	131	.360			.679	.938
Total	495				.670	.979

As shown in Table 9, the reliability coefficients for ECO scoring are greatly lower than for conventional speed scoring and grow increasingly lower as the number of allowed errors decreases. Apart from the fact that "wpm up to the n^{th} error" is quite devoid of any useful meaning--that it has no validity--an ECO score is so unreliable, so unprecise from one occasion to the next, that its use cannot be defended on any reasonable basis. Any expectation of good reliability for such scores would be predicated on two demonstrably faulty assumptions: that total-error scores have high reliability and that errors tend to occur, for each individual, at typical periods within the timing. Instead, dozens of studies summarized by

West (1957, 1962, 1968) show total-error reliabilities to be typically in the .40 to .50 range, rarely exceeding .70; and it is common knowledge that a person's typing errors do not tend to be concentrated in the first, or fourth, or any particular minute (or line) of work. Instead, their number and locations vary widely from one occasion to any other. On one occasion, a typist allowed 5 errors will make his sixth error in his thirty-first word, on another occasion not until his eighty-first word. These illustrative performances generate ECO scores of 5 and 16 wpm, neither of which represents that person's actual speed.

With ECO scoring, one knows neither how fast nor how accurately an individual typed--unless his errors did not exceed the maximum allowed. As the typical 1-2 epm rates of typists in straight copy work, precious few are within the ECO maxima, as shown by the right-hand column of Table 10, below. Table 10 also shows the gross underestimation of true speeds in the four columns to the left of the "gross speed" column. Under ECO scoring the typical fourth-semester typist, for example, who in fact typed 42.4 words in each minute is reported as a 15.9 wpm typist. The implication of these findings is unequivocal: there can be no defense for error-cutoff scoring; it has no apparent validity and negligible reliability.

Table 10

Mean Speeds Under Various Error-Cutoff Allowances
and Mean Gross Speed and Total Errors
(For 5-Minute Timings, by Semester)

Semester of Training	N	Mean Speed Under Error Allowances of				Gross	Mean Total Errors
		2	3	4	5		
1	125				15.0	19.0	6.9
2	113			16.4	18.7	29.5	10.8
3	126		19.1		25.1	35.8	10.2
5	131	15.9			26.3	42.4	11.9
All Levels	495				21.4	31.9	10.0

DISCUSSION

Faced with a standoff in results from two training methods that were originally expected to differ in their consequences, the risk of "explaining away" the no-difference findings is present. However, as intimated in the preliminary discussion accompanying some of the results, a number of hypotheses or speculations appear to be tenable ones.

First, despite the discarding of subjects who frequently failed to obey the practice rules, subjects who committed up to ten infractions were retained, and there was hardly a subject who did not commit at least one infraction. In general, but especially for students at Levels 1, 3, and 5, there can be no great confidence that the effects of the two modes of pacing were tested as specified. Inadequate pretraining and supervision of teachers and (except at Level 2) inability of teachers under the practice schedule to monitor student performance sufficiently closely are evident.

The difficulties of exercising sufficient control over events illustrate the thesis held by many that the classroom is not a possible place to conduct rigorous research, under conditions that preclude serious confounding of variables--certainly not investigations of instructional practices (a) that are entirely novel to teachers and (b) that call for student behaviors that strongly contradict their earlier training experiences. This latter point refers to the clear bias in conventional instruction toward extremely high accuracy and against stroking rates accompanied by high inaccuracy, even during practice activities. The general concern of participating teachers about the enormous numbers of errors that necessarily accompany forced-speed practice and about the substantial increase in errors on the Week-1 criterion tests attest to the presence of the conventional view toward accuracy by the participating teachers--and, therefore, by their students.

Other discrepancies between conventional teacher and student views, on the one hand, and the practice rules, on the other, also appear to have been present. Primarily, it is unheard of to conduct "speed drills" for durations as long as five minutes. During the investigator's visit to classes on the first and/or second day of experimental practice, student shock (moans, groans, and literal wringing of hands) followed the teacher's announcement that they were to aim at increased speed for five continuous minutes. Here, the investigator was clearly at fault. The finding of absence of consequential fatigue during 30 continuous minutes of typing (West, 1967) applies to instructions to type at a normal, comfortable rate throughout--not to forced-speed work. Vocal complaints about fatigue during the experiment and in postexperimental letters to teachers by students were no doubt accurate. The 5-minute practice durations under forced-speed conditions very likely were too long. Optimum (and surely shorter) durations of forced-speed practice--whether accompanied by pacing or not--remain to be identified. Possibly a step-by-step increase in the duration of forced speed practice up to five minutes would be optimal.

Another discrepancy between conventional practices and the experimental ones is the experimental massing of skill building practice to consume all or nearly all of each class period, with attendant fatigue and boredom. The disadvantages of massed practice are well known, but the investigator took the calculated risk of these disadvantages in the hope of providing a clean test of pacing, unconfounded by the possible effects of the other kinds of practice that would have taken place in the time not preempted by paced practice. The

compromise in effect for Level-2 classes (a 5-week interlude between 2-week sessions of massed paced practice) did not in the slightest change the massing during paced practice and, in addition, left unspecifiable with sufficient precision the activities during the 5-week interlude and their possible effects on the criterion measures of the present investigation. Here, again, the issue is one of whether it is possible to conduct a "clean" test of some kinds of instructional variables in a "normal" school setting--short of extensive pretraining of teachers, breathing-down-the-neck monitoring or supervision of teacher behaviors, or the selection as participating teachers of those (a) who are reasonably conversant with a variety of instructional practices and (b) who have sufficient appreciation of the rigor required in experimentation and of the sensitivity of learned behavior to a host of potentially confounding factors.

This editorializing aside, it seems apparent that amount and distribution of speed and accuracy practice is a consequential determinant of the effects of pacing (and of many other instructional modes) on criterion performance. The 8-wpm gains in effect for speed practice were probably too high, especially among Level-1 typists and among students at all four levels once past the first gains. Possibly, 6-wpm gains should have been the rule. Or, better, a descending scale of gains for the speed sessions that intervene between accuracy sessions might be tried. For example, work toward an 8-wpm gain in speed (in 2-wpm steps), then practice for accuracy, then work toward a 6-wpm gain in speed, then practice for accuracy, then work toward a 4-wpm gain in speed . . . thereafter maintaining 4-wpm speed-gain goals. In fact, a procedure analogous to that just described was originally proposed, but it was dropped because participating teachers felt it would confuse students. (Specifically, an ascending level of speed gains were to accompany increased levels of training: 6-8-10-12 wpm gains were to be in effect for first-, second-, third-, and fifth-semester students, respectively, on the first speed go-round, followed by reduced goals on the second speed go-round after the intervening accuracy practice.)

Accuracy practice appears to have been insufficient in relation to the amount of speed practice; the step-down of 2 wpm from the previously achieved speed may not have been enough. Still further, success at the stepped-down rate during accuracy practice should probably have been followed by continued accuracy practice at the previously achieved higher speed rate, rather than by returning to speed practice at a rate 2 wpm above the highest speed previously achieved. For example, using S for speed practice and A for accuracy practice (with the numbers representing wpm speeds), a sequence such as . . . 26S, 24A, 26A, 28S would probably be better than the . . . 26S, 24A, 28S sequence called for by the practice rules of the present investigation. The former sequence assigns a new speed goal before acceptable accuracy has been established on the highest earlier achieved speed; the latter sequence provides more accuracy practice and assigns a new speed goal only when satisfactory accuracy has been established at the earlier achieved speed.

The resistance of some students to speed forcing per se and, more particularly, to being asked to adjust their performance rates in accordance with periodic signals (during external pacing) presents problems for which possible solutions do not readily suggest themselves. If the concept of "personal tempo" does have viability, perhaps those who resist or who are upset by speed forcing should not be subjected to speed forcing. If so, more training time or lower proficiency might be expected for such learners. There is no disputing the fact that ever closer R-R contiguity is the basis for the response chaining that defines high stroking skill. Speed forcing is the self-evident tactic for economically bringing about the ever closer interresponse intervals that are desired--among learners who can "take it."

On the other hand, in connection with external pacing as a means of aiding the typist to adjust his stroking rates--upward when aiming for increased speed, downward when aiming for reduced errors--it is difficult to entertain the hypothesis that a temperamental resistance to external signals is not modifiable. Attitudes are learned or acquired and, as such, are presumably modifiable through skillful explanation and persuasion by the teacher of the rationale that underlies external pacing. The effort seems eminently worthwhile in view of the indications in the present experiment that external pacing leads to the earlier achievement of practice goals. In the present instance, however, it seems probable that the negative effects of extreme massing of practice, with attendant boredom and fatigue, swamped the participating teachers' efforts to modify the attitudes of those who were made "nervous" by external pacing.

CONCLUSIONS AND RECOMMENDATIONS

Under the practice procedures of the present investigation, no differential effects on speed and accuracy in ordinary copy work at the typewriter followed from self-paced versus externally paced practice. While the volume of student infractions of practice rules makes the findings of the present investigation somewhat uncertain in the light of its purposes, it is not felt that results would have differed substantially even if the practice rules had been followed scrupulously.

Instead, it is judged that the practice rules that surrounded both modes of pacing were not optimal and that different practice rules leading to more advantageous amounts and distributions of speed and accuracy practice should be investigated.

SUMMARY

The chronic shortage of skilled typists and other office personnel who use the typewriter suggests that anything that increases the supply of competent typists or that leads to the achievement of

marketable skill in less time will contribute to alleviating the shortage and to reducing complaints about inadequate skills.

Concerning the keystroking proficiency that is an integral component of every typing activity, a number of studies have contrasted conventional printed practice materials and procedures with electromechanical devices that display stimuli (copy materials) at a predetermined rate, thereby either guiding or pacing the learner to stroke keys at that rate or creating a set for faster stroking. However, none of these studies was designed to assess directly the external pacing that is the defining characteristic of these devices. Besides, devices are expensive in comparison to low-cost printed materials.

The objective of the present investigation was to estimate the relative effects on speed and accuracy in ordinary copy work at the typewriter of self-paced versus externally-paced practice, using low-cost printed materials specially marked to permit their use for pacing purposes.

To provide measures of teacher variability and to assess the effects of the two modes of pacing at various skill levels, a pair of teachers in each of four high schools was used--each school representating a different one of four levels of typing training (first, second, third, and fifth semester). Each teacher had a pair of classes, one of which was randomly assigned to external pacing, the other to self-paced practice. Attrition through excessive absence and failure to follow the practice rules resulted in a final N of 18 per class at Skill Level 2 and of 14 per class at Skill Levels 1, 3, and 5: an N of 36 per treatment at Level 2 and of 84 per treatment across the other three skill levels.

The practice copy consisted of five minutes' worth of ordinary prose at every even-numbered speed from 16 through 76 words per minute (wpm). For external pacing, each piece of copy was marked internally in quarter-minute intervals. Each quarter-minute was loudly announced by the teacher, and the typist was instructed to adjust his stroking rates upward or downward so as to just reach the point in the copy corresponding to each time announcement. For self-pacing, the copy was not marked internally and there were no mediating announcements of time intervals by the teacher.

The speed objective of the self-paced typist was to complete the copy within the 5-minute practice trial. The externally-paced typist had to come within five strokes (one word) of the precise point in the copy during his $4\frac{1}{2}$- to $5\frac{1}{2}$-minute trials. Accuracy practice retained the earlier speed criterion, plus not exceeding 2 errors per minute of work. Based on pretest accuracy, typists were initially assigned either to speed practice at a rate 1-2 wpm above their pretest speeds or to accuracy practice at a rate 1-2 wpm below their pretest speeds. Thereafter, progress to higher speeds and changing from speed to accuracy practice and the reverse was based

on their practice performance. During speed practice, gains of 8 wpm had to be achieved (in 2-wpm steps) before changing to accuracy practice. Success at the criteria for accuracy practice was followed by speed practice toward another 8 wpm gain, and so on cyclically in this fashion. Under these procedures each typist worked toward an objective (speed or accuracy) and at a rate consonant with his level of skill and his needs, as inferred from his performance.

A total of 65 practice trials was distributed three or four a day over a 4-week period at Levels 1, 3, and 5. At Level 2, 60 practice trials were scheduled, and a 5-week interval--devoted to realistic typing tasks not aimed at ordinary copying skill--separated two 2-week periods of pacing practice. Criterion measures consisted of a pair of 5-minute timings on ordinary prose materials of average difficulty administered as pre- and posttests. Six other pieces of test copy were administered two a week during the training program. Tests were scored for gross wpm and for total errors in the 10 minutes of work.

Posttest speed and error scores were subjected to covariance analysis (regressed on pretest scores), and no significant differences were found. Self-paced and externally-paced practice had equal effects at all levels of skill. However, external pacing led to the earlier achievement of each successive practice goal.

Despite the discarding of subjects who very frequently disobeyed the practice rules governing progress to the next higher speed or changing from one practice objective to the other, it was necessary to retain students who committed up to 10 infractions--20 per cent of the average of about 50 practice trials remaining after absences were accounted for. However, although these infractions mean that the practice was not regularly carried out under the rules as specified, it is not felt that scrupulous adherence to the practice rules would have substantially changed results. Instead, the observations of both teachers and students suggest that the practice schedule and practice rules led to extremely disadvantageous amounts and distributions of speed and accuracy practice. Students complained of boredom at day-after-day practice of the same kind and of extreme fatigue from three or four 5-minute practice trials daily under the specified practice conditions. Accordingly, possible differential effects of self-paced and externally-paced practice were swamped by disadvantageous practice conditions and rules applied to both modes of pacing. It is apparent that the two pacing modes are sensitive to distribution effects, and it is recommended that the pacing modes be investigated under conditions of greater distribution of practice, using practice gains that are less demanding, with provision for larger amounts of accuracy practice.

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TITLE

Effects of Interval Pacing on the Acquisition of Typewriting Skill

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ABSTRACT: Investigation of the relative effects on speed and accuracy in ordinary copy work at the typewriter of externally-paced (EP) versus self-paced (SP) practice used high school typists at four stages of training. Each member of a pair of teachers in each of four schools taught an EP and an SP class (Ns of 120 per treatment across 16 classes). A mean of 50 5-minute practice trials (3 or 4 a day) under EP or SP conditions were conducted over a 4-week period on a body of ordinary prose paragraphs providing for 5 minutes of practice at every even-numbered speed from 16-76 words per minute. For EP practice, copy was marked internally in quarter-minute intervals, which were loudly announced by the teacher. Subjects were to adjust stroking rates upward or downward in accord with time announcements. SP practice copy was not marked internally, and there were no time announcements. Subjects were assigned to speed or to accuracy trials at individually appropriate speeds and progressed to higher speeds and a changed objective (speed or accuracy) according to their practice performance. Covariance analysis of posttest speed and error scores showed no significant treatment differences. However, various lines of evidence suggest that possible treatment effects may have been swamped by the extreme massing and disadvantageous distributions of speed and accuracy practice that resulted from the practice rules uniformly applied to both pacing modes. Investigation under more advantageous practice rules was recommended.